Swan River Restoration

Conceptual Design Plan, Gravel Quantities and Implementation Cost Estimate

Prepared for:
Summit County Government
Open Space and Trails Department

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Executive Summary

The Swan River Restoration Project proposes to restore over one mile of river through 50 acres of land owned by Summit County and the Town of Breckenridge near Breckenridge, Colorado. The property was heavily impacted by dredge boat mining in the early 1900’s and is basically devoid of resource values. Although a few acres of vegetated terrain remain or have developed, the majority of the property is barren gravel and cobble left in stockpiles by the dredge boats after they extracted precious metals. The Swan River flows in a straight ditch adjacent to the county road on the north side of the property. In the upper half of the property, the river only flows at high water, and the remainder of the year is subsurface. Human and wildlife use of the property is almost non-existent.

This report provides a Conceptual Restoration Plan to restore riverine and aquatic functions on the property. The plan is described in narrative and the attached figures depict the proposed restoration. We estimate that between 430,000 to 470,000 cubic yards of gravel is available for sale from the property based on the design elevations in the restoration plan. It is estimated that restoration of the river and the creation of wetland, riverine and upland habitats would cost $3,247,562.00 including permitting, final design, and construction. Options are provided for certain aspects of the channel alignment and alternatives provided that would reduce overall cost to implement the project.

I. Introduction

Summit County and the Town of Breckenridge own approximately 50 acres of land along the Swan River just upstream of the confluence of Muggins Gulch with the Swan. The property was heavily impacted by historic dredge boat mining during the early 1900’s. The dredging left a barren landscape of gravel and cobble with little to no resource value, and a river channel in a straight ditch paralleling Tiger Road.

This report provides a Conceptual Restoration Plan to restore the river channel and aquatic habitats, and create native riparian and upland habitats on the property. This restoration plan incorporates the existing up and downstream boundary conditions, previous studies and data for this and adjacent reaches, existing aquatic, riparian and upland habitats, and engineering characteristics of the site to develop a restoration plan that will restore the reach to near-historic conditions. The report also quantifies the gravel available for sale, and provides a costs estimate to implement the project. We also identify permitting considerations and environmental liabilities.
II. Project Goals

The goal of Summit County and the Town of Breckenridge is to restore a riverine environment and native habitats and to provide recreational opportunities on the subject property. The overall goals of the Swan River Restoration project are to:

- Create a stable natural channel incorporating habitat improvements, based upon the existing and project hydrology and sediment regime.
- Re-establish a river channel in the upper reach of the project
- Improve in-stream aquatic habitat by creating pools, riffles, glides and cover structure to provide spawning and rearing habitat and substrate to promote aquatic macroinvertebrates.
- Restore riparian and floodplain function by removing dredge piles within the river corridor, constructing habitats, and establishing vegetation.
- Improve aesthetics by creating a more “natural looking” channel with sufficient capacity to transport flood flows.
- Design appropriate fishing access and sustainable passive recreation public uses of created riparian and upland habitats.
- Create wetland or riparian habitats to replace habitats lost as a result of relocating the channel, and to attempt to replicate historic natural conditions.
- Create wildlife habitat for variety of species
- Continue to demonstrate stream restoration techniques as a model for on-going efforts to reclaim other stream reaches degraded by historic mining.

The Blue River Restoration at the Four Mile Bridge site we completed for Summit County Open Space in 2006 demonstrates the value of the restoration techniques proposed.

The primary goal of this first phase is the development of a Conceptual Restoration Plan for the Swan River starting at Muggins Gulch Road and extending approximately 5,500 feet up-valley. This Conceptual Plan also should quantify the amount of gravel present available for sale considering the design elevations in the restoration plan, and also provide a costs estimate to implement the restoration plan.

III. Existing Environment

1) Project Location

The proposed reach is located along Tiger Road in the Swan River Drainage approximately 11 miles northeast of Breckenridge, Colorado. The project is located in all or parts of Sections 13, 14, 23 and 24 of Township 6 South, Range 77 West. The lower reach of the project is located at Longitude: 105.97124° West; Latitude: 39.52504° North.

2) Aquatic Environment

The Swan River Restoration Project Area contains a highly disturbed aquatic environment with the exception of two areas. The downstream portion of the project in the vicinity of the confluence of Muggins Gulch with the Swan River is disturbed but native wetland communities...
remain somewhat natural, although the channel upstream of the Muggins Gulch access road is degraded. The southern edge of the project area upstream of County Road 355 also appears fairly natural with a beaver dam/wetland complex supported by groundwater from the toe of slope of the ridge to the south and the alluvial aquifer. The majority of the area was heavily impacted by historic mining activities which dredged the valley bottom of the Swan River, leaving various gradations of river cobbles with little to no organic material remaining. The active channel was pushed to the north paralleling Tiger Road in basically a straight ditch with surface flows non-existent from mid-summer through the winter in the upper portions of the channel.

3) Riparian Habitat
The Swan River Project Area contains minimal riparian habitat with the exception of the confluence with Muggins Gulch, and a narrow band (100 feet wide) of riparian habitat associated with beaver dams upstream of County Road 355 on the southern edge of the project area (Figure 2). In addition, a willow (Salix monticola and Salix geyeriana) dominated habitat is present just upstream of Tiger Road on the western portion of the project area along the southern boundary. Most of the project area other than the aforementioned habitats is devoid of native vegetation. Within the cleared cobble areas on the western end of the project area riparian communities have developed due to the high groundwater. These communities which consist of Drummond willow (Salix drummondiana) and mountain willow (Salix monticola) with an understory of tufted hairgrass (Deschampsia cespitosa) are basically low value wetland habitats with a cobble substrate at the surface rather than true soils. Other areas in the western portion of the project area contain scattered lodgepole pine (Pinus contorta) with willow and more mesic grasses such as slender wheatgrass (Elymus trachycaulm). Although these plant communities contain native species, they are disjunct from other habitats and exist in a disturbed state primarily due to a lack of organic material in the substrate. The ecosystem functions and wildlife habitat values of these communities is very low. Approximately 85-90% of the project area is barren cobble with little to no plant cover.

4) Upland Habitat
There is little vegetated upland habitat existing with the project area. On the southern edge of the project area, the mixed coniferous forest extends into the project area to some extent. This community is primarily lodgepole pine but in the east subalpine fir (Abies lasiocarpa) and Engelmann spruce (Picea engelmanni) is also present. These upland habitats are a small part of the project area.

5) Drainage Basin Characteristics
This section of the Swan River is located in an approximately 25 square mile drainage area encompassing the greater Swan River Valley. It is located on the main stem of the Swan downstream of the confluence of the North, Middle and South Forks of the Swan. Rock Island Gulch enters the Swan just above the project area, and several intermittent drainages enter the Swan in the project area. Browns Gulch and Muggins Gulch enter the Swan at the lower end of the project area.

Much of the drainage area is heavily forested slopes of lodgepole pine (Pinus contorta), with Engelmann spruce (Picea engelmanni) and subalpine fir (Abies lasiocarpa) at higher elevations.
above 10,000 feet, and on northern aspects at lower elevations. At the higher elevations above 11,800 feet, alpine communities persist. Elevations range from approximately 9,600 feet above msl at the Muggins Gulch Road on the lower end of the project area to 13,297 at the summit of Mount Guyot. The valley bottom of the main stem of the Swan was dredged during the historic mining period to approximately ¾ mile upstream of the confluence of the North Fork. The North, Middle and South Fork were not impacted by the dredge boat mining. Four-wheel drive roads are common in the watershed.

6) Existing Reach Characteristics
The existing reach is an entrenched, linear stream channel with low sinuosity due to the forced alignment along the Tiger Road to the north of the historic floodplain. The cause of the existing alignment is the historic dredge mining along the reach. These spoil piles have restricted the available floodplain extents to an average of 40 feet in width with ‘choke-points’ of 15 to 20 feet in width.

The historic flood flows are difficult to calculate based on existing valley characteristics and extensive historic information was not available for this level of review. The existing channel dimensions indicate a base flow between 7 and 20 cfs with bank-full flow estimates of 150 to 275 cfs. Preliminary basin hydrology provides for similar flows. In addition, the variability of existing valley vegetation, infiltration characteristics of the dredge spoils, changing conditions from the continued gravel extraction on this site as well as upstream, and recent drought conditions make the determination of existing flooding conditions or associated hazards impractical to predict.

The existing valley gradient is between 1.8 and 2.3 percent with significant grade breaks at the upper, middle and lower access roads. Whether these grade breaks are artificially created by the historic vehicle access and dredging operations or were naturally occurring and utilized by the mining operations, is unclear.

The hydraulic velocities associated with the dredging process typically resulted in gradation of the spoil piles with pockets of poorly-graded (uniform) materials. In addition, the suspended fines in the hydraulic flow were typically carried down valley in the existing channel or concentrated in the settling ponds surrounding the dredge. These processes have created an artificial flow regime with the majority of the base flows infiltrating into the poorly-graded dredge materials and emerging down valley. Spring runoff conditions provide the only hydraulic connection to the upper reaches. The result is an artificial combination of gaining and losing reach conditions.

7) Existing Groundwater Conditions
Groundwater elevations through much of the reach are inferred by visible water in recent or historic excavations, ‘holes’ left between dredge piles indicating existing conditions, and extrapolation from a monitoring well located west of the mine access road. It is assumed for the purposes of this proposal that the groundwater conditions can be reliably interpolated along the center of the floodplain from these sources and that the adjacent topography to the north and south create a corresponding increased groundwater reading.
Furthermore, it is assumed for the purposes of this proposal that the intermittent drainages of Rock Island and Brown Gulch, to the south create seasonal but not continuous surface flows and groundwater re-charge, and are, therefore largely ignored in the base flow estimates.

IV. Design Considerations

1) Development Philosophy
The philosophy for the proposed restoration design is based on replication of natural processes responsible for a stable channel form within the proposed Swan River reach. Because it relies on and integrates with flow dynamics, particle stability and the continuity of bed-load transport for its efficacy, this approach results in natural and flexible aquatic habitat, better channel function and a more natural appearance than a more engineered approach utilizing large boulders. Unlike the application of the structural controls proposed by previous studies and prevalent on most river projects, this design approach allows the channel to retain its degrees of freedom, and the channel can adjust various behavioral elements in response to flow events. For example, rather than fixing the break between riffle and pool in space and time, this location is allowed and encouraged to adjust from year to year and event to event. In addition, if aquatic habitat is of critical importance, this technique allows a designer to strengthen key behaviors to encourage desired results, like deeper pool depths, longer pool tail-outs or higher riffle frequencies.

Objectives will be achieved by creating sensible natural channel comportment with as many degrees of freedom as location along the belt width allows. This plan, profile and geometry may be a composite analog of nearby natural channels, which are the result of a long history of events and processes active in the drainage. Stability will be provided by delicately balancing anticipated hydraulic forces with factors that provide reasonable resistance to motion. For example, channel volume and shape is adjusted until the conveyance passes the design discharge within given shear limitations. Particle stability is then adjusted by means of dimensionless mobility assessment and relation to a shear stress duration curve, which is painstakingly constructed from hydrologic data. Typical sections for pools, runs, riffles, are then utilized as base templates for use during construction. In turn, these templates are modified as needed, either in response to actual site conditions or to provide maximal habitat diversity and aesthetic appeal. The result is a channel that is stable, but allowed to adjust to flows and sediment loads experienced. In other words, one that behaves and looks like its counterpart natural channel.

Designers must pay attention to boundary materials when utilizing this technique. The benefit of using native material is that the river is capable of adjusting to the events experienced in the basin. However, their use and mobility can also be a large detraction, since by definition, alluvial rivers are self-formed. However, the presence of armor layers, the use of screeners, hydrodynamic shaping, revegetation, geotextile blankets, mechanical compaction and the importation of small amounts of suitable material, can be used to gently control the initiation of motion and the degree of motion during channel forming events. One can also assist these effects by emplacing hydraulic controls, which govern the energy available to do work in a given reach. In this technique, these controls take the form of hardened riffles and adjacent bank sections. A hardened riffle is simply a mixture of native and possibly imported material that is comprised of a higher percentage of D84 material than might otherwise occur in the drainage.
naturally. This mixture is then emplaced into the bed below the anticipated depth of normal scour, and banks are hardened by an appropriate technique complementary to the environment at hand. The idea is to influence grade, not control it, in a way that not only appears natural but also enables natural bedload motion to slide over the hardened surface. This approach is people friendly as well, enabling recreational users to easily traverse the feature.

Once the channel geometry has been sensibly determined, the next task is to design shape of the wetted perimeter to the materials comprising the boundary. As mentioned previously, many restoration projects seek to create highly stable beds and banks, almost to the point that no motion is allowed under the design discharge. In the proposed technique, the boundary is allowed to move, although typically at a slow rate, until such time that vegetation can colonize and provide erosional resistance. By definition, therefore, this type of restoration can experience so-called failure of stream banks, since stream banks commonly erode from place and time in every drainage. The intent is to guide the reach toward natural function, not to force it into a straitjacket. For largely political or economic reasons, however, it is common to err on the side of providing more initial bank protection than less. Gratefully, vegetation eventually masks the work, and with luck, it produces a completely natural appearance.

In practice, the construction of individual layers comprising the wetted perimeter is often too costly, and produces too much sediment impact in flowing waters. It is more common to rely on a mixture of materials to create sufficient resistance to motion resistance in critical areas. The thickness and composition of the mixture is determined by estimating the resistance to motion of native material, the degree of scour resistance required and the amount and character of surface flow to be experienced. The porosity and permeability of this mixture must be addressed, as they affect the degree of subsurface flow, which in turn, affects invertebrate habitat, redd construction and initial rearing success in many fish species. For the most part, a suitable heterogeneous mixture is combined and applied in small lifts. As a general rule, where sub-gravel flow is to be limited, gravel content in these mixtures should be close to 30% to maximize surface flow. With higher gravel concentrations, porosity and permeability vary widely due to the unpredictable way in which larger particles orient and compact.

Although somewhat dependent on material availability, the design discharge and the degree of channel stability sought, the composition of the armor layer should be carefully considered as it plays a large role in determining bed mobility. Bed stability can be provided by creating a balance between the size of material within the channel and the forces generated by the flow. In many alluvial rivers, dilation and disruption of the armor layer occurs as bankfull discharge is approached. In natural rivers, the range of particle sizes in motion may be large, but the actual rate of bedload transport is usually small. In restored reaches, the short-term design goal runs counter, with little initial motion desirable during the design discharge until the banks become more heavily vegetated. In this way, the restored reach is less likely to be overwhelmed by hillslope or upstream processes as the sections and associated riparian areas recover from construction activity. The trick is to control the winnowing rate of the excess armor to coincide with bank strength development.
Clearly there are many considerations in the restoration of sections that replicate their natural counterparts. The foregoing has described some of the more salient points, and outlines how the proposed design to restore this reach is accomplished.

2) Key Engineering Features/Design Constraints

There are several key areas of the proposed reach that present physical, legal and operational design restrictions. The following sections discuss key design components that either have been or will need to be considered in the final engineering design.

a) Upper Access Road

The upper access road, currently shared between the county and a private commercial gravel operation is the upper grade constraint on the project. The access road also provides driveway access to a house on that property. It is envisioned that minimal disturbance to the existing grades will be required in the final design.

The proposed stream channel will connect with the existing alignment along Tiger Road at the northeast corner of the project. In addition, a drainage swale will be constructed along the southern portion of this reach to collect any groundwater flows that may surface from the water impoundments on the southern portion of the adjacent property.

The floodplain excavation will maintain a minimum of 5H: 1V slope from the existing access road and be heavily revegetated to protect visual corridors.

It is possible that the excavated floodplain and proposed channel alignment will lower groundwater elevations on the adjacent property. The implications of this will most likely be positive for the gravel extraction contractor, but are not inherently advantageous. Additional groundwater monitoring wells and modeling may be required to define and minimize negative impacts to the adjacent landowner.

It is envisioned that the connection to the existing channel and collection swale will be modified if reclamation of the reach is extended to the upstream property.

b) Mine Access Road (CR 355)

The existing mine access road connecting to County Road 355 will provide the main access point for the proposed reach. The ingress and egress grades from Tiger Road and County Road 355 respectively are to be maintained with parking areas located on the Tiger Road side of the alignment.

Due to the elevation controls on each side of the proposed project, the proposed stream alignment is forced to the center of the floodplain. Design criteria of 3 and 7 percent grades are proposed for the County Road 355 approaches, respectively. It is our understanding that vehicular access to the southern portion of the project will be limited and the proposed steeper grades will not negatively impact access for light vehicles. Allowances for even steeper grades for this access road would permit construction of shallower channel gradients upstream of the crossing.
The proposed parking areas are designed to accommodate 10 vehicles, additional parking areas can be developed in the existing parking/camping areas directly up-valley from the access road that would be designed to accommodate additional passenger vehicles and RV’s (See Figure 5, attached).

We propose either the installation of a clear span bridge across the new stream alignment with an armored channel on the upstream approach and downstream run out to minimize channel migration and scouring, or a box culvert or a culverted crossing. If a culverted crossing is used, several additional culverts should be installed in the road bed to allow major flow events to access the floodplain. Culvert sizes and location of additional floodplain culverts will be determined at final design.

c) Tiger/Muggins Gulch Road

The Tiger Road crossing presents a downstream physical constraint on the proposed project. Discussions with Summit County Open Space staff have indicated a desire to improve the base flow connection to the downstream reach, and flood conveyance through the Tiger and connecting Muggins Gulch roads. There are several options discussed below that accomplish these goals. A box culvert is proposed for the Tiger Road crossing.

3) Review of Existing Information
a) Wildland Hydrology Data

Data was collected and analyzed by Dave Rosgen and his class in May of 2007 which was summarized in a Power Point presentation given to Summit County. This information was reviewed, compared with existing conditions; portions of the data provided a working basis for the conceptual design.

The data collected by Mr. Rosgen provided detailed measurements of the existing channel as well as comparison information on a nearby reference reach. In addition, preliminary hydrology was calculated for base and flood flows. Mr. Rosgen utilized simplistic hydrology calculations based on the drainage area and presented a dual-channel design based on base and full-bank conditions of approximately 10 and 200 cfs respectively. There are no calculations for 100-year or other interval flood events. The design assumptions (Curve number, Time of Concentration, etc.) were not provided in the data for review.

In general, Mr. Rosgen’s data and analysis indicated an entrenched, linear stream channel with low sinuosity due to the forced alignment along the county road to the north of the floodplain. The cause of the existing alignment is the historic dredge mining along the reach.

In addition to the basic stream characterization and design, rough schematics were provided for cross-vane, J-hook, pool, run, riffle and armored bank criteria as well as a conceptual layout of the new stream alignment through the project.

The conceptual design addressed two problem areas within the reach; the existing mine access road, and the existing culvert crossings of Tiger and Muggins Gulch Road. Mr. Rosgen proposed a boxed culvert and armored crossing, with multiple bypass channels and culverts for flood flows, at the mine access road. The proposed downstream alignment shifts the channel to...
the southern reach of the floodplain, crossing Tiger Road with a new box culvert and eliminating the Muggins Gulch Road crossing for the main channel. It is unclear from the data provided what improvements were envisioned for the Muggins Gulch culverts, if any.

b) Gravel Extraction Reports
Placer mining reports were also reviewed to determine the historic extraction methods and estimate the hydraulic velocities used in extracting and placing the dredge piles. This data was used to provide depositional characteristics of the gravels and estimates of the types of gradation that would be encountered during the excavation (discussed in Appendix D).

c) Site Survey
Mr. Weaver and Mr. Claffey walked the proposed project and the references reach during three site visits. Information was observed and recorded with respect to ground and surface water elevations, seasonal flows, channel condition, sediment size, sediment load, and the existing wetland, riparian and upland habitats.

d) Public Records Review
Federal, state and county records were gathered and reviewed including: USGS Quad Maps, Summit County’s GIS information, existing and historic aerial imagery and technical data from county employees for the project and surrounding areas were collected and reviewed.

V. Proposed Conditions

The project reach has been divided in Construction Phase 1 and 2. Construction Phase 1 starts Muggins Gulch road and extends upstream to the FS Access Road (CR 355). Construction Phase 2 begins at the access road and extends upstream to the property boundary.

1) Aquatic Environment
The proposed aquatic environment is the creation of a natural stable river channel meandering though a mosaic of wetland, riparian and upland habitats. The channel will look and function like a natural channel with a series of pools, riffles and runs whose substrate is established with native river cobble. Constructed riffles and point bars maintain scour in pools and runs provide a variety of aquatic habitats. Willow lined stream banks will stabilize the outside banks of the meanders. It is expected that aquatic macroinvertebrates will quickly colonize the substrate with trout from upstream and downstream colonizing soon after. Based on experience in this type of design at other locations, a naturally reproducing trout population would become established fairly quickly (2-3 years). Colorado Division of Wildlife sampling of the Four Mile Bridge project indicates excellent natural reproduction within 3-4 years of the restoration. Basically, the proposed condition of the conceptual plan is to reestablish a meandering river, and its associated aquatic environment that approximates what was present prior to the historic mining. The restoration techniques proposed allow the river to function as a natural channel.
2) Riparian Habitats
The proposed condition for riparian habitat is to create a mosaic of native riparian communities interspersed with wetland habitats at lower elevations. The riparian communities would include native grasses and forbs with both aspen (Populus tremuloides) and a shrub component consisting of serviceberry (Amelanchier alnifolia) and shrubby cinquefoil (Pentaphloides floribunda). We include constructing approximately 12.2 acres of riparian habitats. Wetlands could be a mixture of sedge, rush and grass dominated systems on point bars and willow stream banks with possible willow and sedge systems on lower topographic positions within the floodplain. We included constructing approximately 5 acres of wetland habitat. This is a conceptual plan, and a diverse array of riparian communities can be created. The only requirements would be willow and riparian shrubs on the streams banks in locations as required for channel stability.

3) Upland Habitats
The proposed condition is to create uplands within the valley bottom on the north and southern boundaries but also within the floodplain to provide habitat diversity. Again, a number of different habitat types are proposed from grassland, shrub-grassland, to forested habitats. To match the sagebrush communities present on the south facing slopes north of Tiger Road, lobes of sagebrush (Artemisia tridentata) and native grass communities could extend into the project area from the north. Upland grasslands can be established along the southern or northern edges with scattered aspen, sagebrush, rabbitbrush (Chrysothamnus sp.), and buffaloberry (Shepherdia canadensis). Approximately 26.3 acres of upland habitat is proposed in this plan.

4) Floodplain, Channel Grades & Elevations
We propose to excavate the floodplain elevations to within one to two feet of the existing groundwater elevations and create a new stream channel elevation below current groundwater levels. This will create a uniform gaining reach along the project intended to extend a consistent hydraulic connection throughout the project reach for fisheries, aquatic habitat, and to restore riverine functions.

As part of the Phase 2 Engineering Design, additional groundwater investigations should be performed into the existing and seasonal groundwater elevations, including additional monitoring wells, and open test pit explorations. The proposed floodplain and stream alignment may alter the valley groundwater gradient and specific attention should be given to the potential for adverse effects from the mine tail water to the south of the mining access road. These investigations may include groundwater modeling.

The existing access road (CR 355) to National Forest System (NFS) lands south of the project area is a physical benchmark that must be maintained to provide access. This creates a valley floodplain grade break, whether natural or created. In addition, the floodplain excavations are limited at the upper project extents by the access road to the adjacent private property and at the lower extent by Tiger and Muggins Gulch Roads.

We are proposing floodplain grades upstream of the access road between 2.2 and 2.4 percent. The transition between the upper and lower reach will have floodplain gradients between 2.2 and 2.5 percent and the lower reaches will have shallower gradients between 1.3 and 2 percent.
5) Proposed Channel Dimensions and Construction

Given the proposed floodplain grades and the assumed base, bankfull and flood flows, the proposed stream alignment will consist of a compound channel designed to accommodate fishery habitat at low seasonal flows as well as pass full-bank conditions during design flow events. Phase 1 is approximately 4,200 linear feet of channel and Phase 2 is approximately 3,500 linear feet. In order to re-create natural valley characteristics, the stream channel will be designed to overtop during flood flows to utilize increased flow area and encourage depositional sediments and infiltration into the groundwater. Grade restrictions such as the mine access (CR 355) and Tiger Road on the downstream end dictate design to eliminate the possibility of overtopping of the roadways, and armored grade transitions will be installed to restrict scouring at these points.

Sinuosity of the proposed channel is between 1.25 and 1.5 depending on floodplain grade. Channel, bank, and overflow dimensions will vary depending on grade, control structures, pool, riffle, and run cross-sections. Typical design dimensions are provided in Figures 4 & 5, and in the attached typical cross-sections.

The channel bed is constructed through excavation to below groundwater. Alignment is set by the staking prior to construction. Shape and final configuration is set in the field by Five Rivers during construction. Grade control is developed with a series of hard riffles constructed with larger cobble (D84 mixed with D50). Pools and runs are developed by excavation, and riffle sections are created through excavation and cobble placement.

The stream bank construction will vary by location and morphology. The four cross-sections depict proposed techniques. The shallow pool and cobble bank method would be used on outside meanders when the meander curve is slight, and when sufficient floodplain on the inside of the meander is available to handle flows above bankfull. On this section, we propose a cobble toe using larger cobble (12-18 inch) with willows planted at the bankfull height elevation. The point bar in this section is wider than other sections to take energy off the bank. The bar is composed of 8 inch and minus cobble.

The riffle section is used in straight reaches where riffles are constructed. The riffle itself is composed of 12 inch minus cobble and the bars are constructed with 8 inch minus cobble. The total cross-section width for base flow and bankfull flow is wider than on the meanders. The banks are vegetated with willows and herbaceous species as energy on the banks is significantly less than on the meanders.

The run or pool tail-out sections are composed of a single coir fabric lift with 6-12 inch cobble for scour protection below the lift. Runs are created between pools at a meander bend and stream energy on the banks is lower than at the apex of the meander. The pool tail-out is in the same location at the downstream end of a meander where the stream energy against the bank is lower. Basically, the pool or run is shallow, and sufficient capacity on the inside of the meander is available for high flows, and flows above bankfull would top the outside bank.

The pool and two coir lift section would be used on the larger meanders at the apex of the meander where stream energy is highest, and the pools are the deepest. The outside bank is only overtopped at significant flow events.

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6) Proposed Alignment Options at the Intersection of Tiger Road and Muggins Gulch Road

Option #1
We are proposing the re-alignment of the channel and floodplain to the center of the valley with a new box-culvert crossing adequate in size to pass the design flood flows (as depicted in Figures 3 & 4). In addition, we are proposing that Tiger Road be lowered from five to eight feet, dependent on design flood flows. The final elevation of Tiger Road may require extending the approach grade to the west beyond the current project limits.

We are also proposing the removal of the existing Muggins Gulch Road and re-alignment as depicted in Figures 3 & 4. The existing road bed is proposed to be reclaimed as wetland habitat with a connecting stream channel designed to connect with the existing downstream channel. The realignment of Muggins Gulch Road will require an agreement between Summit County, the United States Forest Service and the Blue Sky Ranch Development. The benefits of Option 1 are obvious and include improving channel conditions by removing the channel restriction caused by the Muggins Gulch Road culverts, removing fill and restoring wetlands from Muggins Gulch road removal, and improving aesthetics at both Muggins Gulch and looking up valley of the Swan as Tiger Road would be lowered.

Option #2
We propose the following design recommendations if negotiations to re-align Muggins Gulch Road, Option #1 above, are not feasible. In that event, we propose a similar channel alignment near the center of the floodplain, grade reductions on Tiger Road, and box culvert designs, with the addition of a new box-culvert crossing for Muggins Gulch Road designed to accommodate the calculated flood flows. This option may require elevating the Muggins Gulch road grade to accommodate the new box culvert and coordination with the owners of Blue Sky Ranch.

Option #3
If the above options are not viable due to physical, legal or political conditions, we propose the realignment of the proposed stream channel to the south and installation of a new box culvert in Tiger Road (depicted in Figure 4, inset). Placing the crossing at this location will narrow the floodplain, requiring a larger box culvert and possibly eliminating the lowering of Tiger Road. However, it removes the back water created by the undersized culverts at Muggins Gulch Road and eliminates the need for box culvert at that location. Further hydrology and Hec-Ras modeling will be required to quantify the impacts of this option.

VI. Gravel Quantities Available For Sale & Description of Materials

1) Quantities Available for Sale
Estimates indicate that there is between 430,000 and 470,000 cubic yard of material available for sale from the site. Actual quantities will vary depending on the terms of the extraction contract (i.e. excavation of materials greater than three feet thick, proximity to open water or existing vegetation, sensitive areas, etc.). In addition, the potential re-grading of Tiger Road and/or relocation of Muggins Gulch Road will affect the total quantities. The higher range above is
based on the realignment of Muggins Gulch Road and regrading Tiger Road described in Option #1.

The extent of the initial construction phase relies heavily on the quantity and timing of the sales of gravel for local projects. We recommend that areas of less than three feet of excavation above final grade for the restoration plan be excluded from the general excavation contracts, and included in the Phase II construction budget for fine-grading the floodplain and upland habitats. That material would still be available for sale. It is also recommended that the general excavation contracts exclude areas within 25 feet of existing vegetation and open water.

2) Material Description
Historic mining operations in the Swan River Valley consisted of large suction pipes mounted on floating barges with agitator or cutter heads designed to churn up the underlying valley bed materials in front of the suction pipe. The water and sediment was then transported by pipe to offsite locations, sometimes several hundred feet away.

The hydraulic velocities in the dredging process typically resulted in gradation of the spoil piles with pockets of poorly-graded (uniform) materials. In addition, the suspended fines in the hydraulic flow were typically carried down valley in the existing channel or concentrated in the settling ponds surrounding the dredge.

Based in the visual classifications at the site and the historic processes described above, the tailing at this site consist of mostly clean pit run gravels with natural sand contents between 8-22% and little to no fines (<3-5%) in the spoil piles, although pockets of fine grained material may be encountered in old settling ponds as mentioned above. The majority of the material appears to be 4-6” minus with pockets of 8-10” cobble which can be largely avoided, or separated, in the excavation process. The larger material present may be required for the channel restoration work.

The vast majority of the in-situ material is suitable for sub-base structural fill with little to no processing required. A crushing operation would be able to produce any grade or size material required.

There is the possibility of encountering poorly graded cobble in the proposed stream alignment which may cause excessive subsurface infiltration and loss of surface water. If these pockets are encountered during construction, the final design should be flexible enough to over-excavate and fill with finer-grained materials, or alter the stream alignment to avoid these areas.

Fine-grained materials designated to be used as topsoil for the restoration project have been delivered to the site over the last few years. The exact quantity of these soils is unknown. We suggest performing a rough survey of the boundaries of these stockpiles to quantify the requirements of the final restoration. The timing of the contour data and lack of recent aerial imagery precludes an accurate estimate in this phase. Investigations reveal some of the stockpiled material would not be suitable for topsoil but would provide suitable subsoils allowing for the use of less topsoil in the restoration.
3. Logistics and Timing of Gravel Extraction
We have already provided the County with plans for gravel extraction for a potential contract in 2009. Those plans identified areas for removal of approximately 100,000 cubic yards of material that would accommodate the restoration plan. Gravel extraction in excess of that amount would be developed in the Phase 2 Construction area upstream of the mine access road.

Gravel extraction should first be completed in the Phase 1 Construction Area in the areas identified to allow for restoration of the Phase 1 area. Restoration of the Phase 2 area is dependent on sale and removal of gravel (approximately 350,000 cyds) from this area.

VII. Permitting Issues & Environmental Liabilities

1. Permitting
The following permits would be required to implement the restoration of the Swan River and adjacent habitats:

a) Section 404 of the Clean Water Act
Although the project is extensive, we believe the restoration would be authorized under Department of the Army nationwide general permit 27 (NWP 27) for Aquatic Habitat Restoration, Establishment and Enhancement Activities. Based on the nature of the project and the success of the Four Mile Bridge Project, we expect the project would be well received by the Corps. The culverts and box culvert installations and realignment of Muggins Gulch Road would require NWP 14 authorization. Wetland delineation would be required for the entire property, and any wetland impacts from channel construction would need to be mitigated by the creation of wetlands. That creation has been incorporated into the conceptual plan.

b) Forest Service NEPA and Special Use Permit or Easement
Option 1 would require construction of the Muggins Gulch Access road on National Forest System (NFS) lands. Generally, the Forest Service (FS) takes a position that if a private land, in this case public land, alternative is available they would not allow use of NFS lands. In this case the environmental benefits may outweigh that position. We expect an Environmental Assessment would be required to disclose impacts under the National Environmental Policy Act (NEPA), which would include the preparation of a Biological Assessment (BA) and Biological Evaluation (BE). However, it is possible the approval would be completed with a Categorical Exclusion under NEPA with the preparation of a BA and BE. The FS may consider completing these documents in house without the need for a third party consultant.

c) Colorado Division of Reclamation, Mining and Safety (DRMS)
Since the gravel extraction would move material off-site, a Construction Materials Reclamation Permit would be required from the state. The restoration plan would provide the basis for this application. We would expect the application would be well received by the state due to the nature of the restoration and overall environmental benefits.
d) Colorado Division of Water Resources  
Water rights may be required for aspects of the restoration project. Generally, if the wetlands created are at a 1:1 ratio for wetlands lost, a water right is not required. Since we are returning surface flows in the river that are now subsurface there may be water rights concerns in that aspect as well. We also increase sinuosity. In addition, the Colorado Water Conservation Board holds and Instream flow right on the Swan although it is doubtful the project would injure that right. If there are downstream affects, the project could be approved as injury with mitigation.

e) Colorado Department of Public Health and Environment  
A Construction Stormwater Permit (COR 030000) would be required from the state for the restoration project. A Sand and Gravel Mining and Processing Stormwater permit (COR 340000) would be required for the gravel extraction process. The stormwater permits would ensure the control of sediment discharges. A Construction Dewatering permit may be required for the installation of the box culverts, culverts or bridge.

f) Summit County Planning Department  
We do not know if county planning approval would be required for implementation of the project.

2) Environmental Liabilities  
The construction of wetlands as compensatory mitigation for impacts would need to be monitored and maintained. The reclamation plan presented to the DRMS must be maintained as proposed. The conditions of the stormwater permit must be adhered to during construction. The only environmental liability not associated with permit requirements would be the contaminated water from the Royal Tiger Mine interaction with groundwater. The proposed project may change groundwater gradients in the project reach. The concern would be how that change affects the water draining from the mine. Does the creation of a surface channel in the project reach, which will be a gaining reach, pull contaminated water from the mine into the channel? We do not believe the affect would be pronounced enough to create this situation; however, we recommend the installation of a series of groundwater monitoring wells and groundwater modeling to assess this possibility.

VIII. Restoration Cost Estimate

One of the goals of this report was to provide a cost estimate for the restoration. The estimate provided below is based on 2009 costs. We provide varying costs on some features based on the clients’ preference for the infrastructure improvements, and for the Options presented above.

The total cost to implement Option 1 of the restoration plan as proposed is $3,247,562.00. This includes final design, permitting, infrastructure improvements and implementation of Construction Phases 1 and 2. The costs are broken down by major items below. Costs include the cost of field project management by the design team, and a 5% project management fee.
1. Permitting and Final Design

<table>
<thead>
<tr>
<th>Service</th>
<th>Cost</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Design</td>
<td>$15,000.00</td>
<td>River design, final quantity calculations</td>
</tr>
<tr>
<td>Survey Staking</td>
<td>$10,000.00</td>
<td>survey staking for mass excavation &amp; engineering</td>
</tr>
<tr>
<td>Watershed/Hydraulic/Hydrology</td>
<td>$10,000.00</td>
<td>HEC RAS, bridge, culvert and road elevations</td>
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<tr>
<td>Section 404 of the CWA</td>
<td>$20,000.00</td>
<td>wetland delineation, survey, and reports</td>
</tr>
<tr>
<td>Forest Service EA</td>
<td>$50,000.00</td>
<td>EA and reports for Muggins Gulch realignment</td>
</tr>
<tr>
<td>Division of Mine Land Reclamation</td>
<td>$5,000.00</td>
<td>permitting</td>
</tr>
<tr>
<td>Stormwater permits</td>
<td>$3,000.00</td>
<td>permitting</td>
</tr>
<tr>
<td>County Approvals</td>
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<td></td>
</tr>
</tbody>
</table>

Total: $113,000.00

Permitting costs would vary based on options. For instance if Option 2 or 3 is chosen, there would be no need of approvals from the US Forest Service as Muggins Gulch would remain. The cost of the EA is only an estimate; it is possible costs could be substantially lower. In addition, the FS may not require an EA, and may consider completing NEPA work in house. However, we do recommend a box culvert for the existing Muggins Gulch Road so that permitting cost reduction may be transferred to construction. The estimated design cost does not include groundwater modeling to assess the potential affect of the project on mine drainage. We do not include costs for water rights as we do not perform that type of work and would not be able to estimate that cost.

2. Phase 1 Construction

<table>
<thead>
<tr>
<th>Service</th>
<th>Cost</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finish cut to design grades</td>
<td>$119,888.00</td>
<td>(48,000 CYDS)</td>
</tr>
<tr>
<td>New Stream channel construction</td>
<td>$432,030.00</td>
<td>(4,200 LF)</td>
</tr>
<tr>
<td>Floodplain/upland construction</td>
<td>$45,228.00</td>
<td>(90,500 CYDS)</td>
</tr>
<tr>
<td>New Bridge &amp; Install – (CR355)</td>
<td>$77,099.00</td>
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<tr>
<td>New Box Culvert &amp; Install (Tiger Road)</td>
<td>$95,363.00</td>
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<tr>
<td>Tiger Road Cut &amp; Rebuild</td>
<td>$108,166.00</td>
<td>(7,500 &amp; 1,111 CYDS)</td>
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<tr>
<td>Re-Align Muggins Gulch Road</td>
<td>$60,973.00</td>
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<tr>
<td>Parking Area</td>
<td>$6,200.00</td>
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<tr>
<td>Regrade FS Access RD (CR355)</td>
<td>$1,600.00</td>
<td>(800 CYDS)</td>
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<tr>
<td>Topsoil Purchase &amp; Delivered</td>
<td>$508,200.00</td>
<td>(16,940 CYDS)</td>
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<tr>
<td>Topsoil spread and form landscapes</td>
<td>$57,623.00</td>
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<tr>
<td>Revegetation</td>
<td>$151,607.00</td>
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<tr>
<td>Temporary Irrigation &amp; operation</td>
<td>$72,500.00</td>
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</tbody>
</table>

Phase 1, Option 1 $1,736,477.00

5% Project Management fee (without topsoil cost) $61,414.00

Phase 1 -Total Estimated Cost $1,797,891.00
Costs would change with a number of factors. If Option 2 or 3 would be selected, approximately $61,000 would be eliminated as Muggins Gulch Road would not be realigned. In addition, for CR355, if a box culvert is used in place of the bridge, the cost is reduced by $26,640. If multiple culverts are used in place of the bridge, the costs would be reduced by $55,090. Topsoil is a large part of the budget (1/3). We used an estimated cost of $30 per cubic yard delivered which is a price we received in Summit County on recent projects. We provide more discussion of topsoil alternatives below.

3. Phase 2 Construction

<table>
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<tr>
<th>Description</th>
<th>Quantity</th>
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</thead>
<tbody>
<tr>
<td>Finish cut to design grades</td>
<td>44,250 CYDS</td>
<td>110,625.00</td>
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<tr>
<td>New Stream channel construction</td>
<td>3,500 LF</td>
<td>423,500.00</td>
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<tr>
<td>Floodplain/upland construction</td>
<td>73,417 CYDS</td>
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<tr>
<td>Parking Area</td>
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<td>50,331.00</td>
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<tr>
<td>Topsoil Purchase &amp; Delivered</td>
<td>15,327 CYDS</td>
<td>459,800.00</td>
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<tr>
<td>Topsoil spread and form landscapes</td>
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<td>52,877.00</td>
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<tr>
<td>Revegetation</td>
<td></td>
<td>69,040.00</td>
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<tr>
<td>Temporary Irrigation &amp; operation</td>
<td></td>
<td>59,000.00</td>
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<tr>
<td><strong>Total Phase 2</strong></td>
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<td>1,294,881.00</td>
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<tr>
<td>5% Project Management Fee (without topsoil cost)</td>
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<td>41,754.00</td>
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<tr>
<td><strong>Total Cost Phase 2</strong></td>
<td></td>
<td><strong>$1,336,635.00</strong></td>
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</table>

**TOTAL CONSTRUCTION COST**  

$3,134,562.00

Costs are based on 2009 prices for materials, excavating contractors and management fees. Again, topsoil acquisition is a major part of the cost, $968,000 or 31% of the total. We used a depth of 6 inches which is a standard minimum we have used on wetland creations. In upland areas within the project we could use less as typically uplands have less than 6 inches of topsoil. If we change the depth of topsoil in the 26.3 acres of uplands in the plan to 3 inches, the project saves $318,120 on topsoil. We also did not factor in the topsoil stockpiled on site as we could not estimate without the recent imagery. We suggest the clients explore alternative topsoil such as compost, or possibly working with the USFS to utilize beetle impacted lodgepole pine in the area, chipping that material and mixing with subsoils on site to increase organic matter. The client also will likely continue to accept topsoil from contractors. In summary, the topsoil estimates we provide are likely high, and the overall cost of the project can be reduced by using less topsoil in upland areas, obtaining additional topsoil from contractors, and/or using alternatives.

For riparian and upland areas, the revegetation budget can be reduced. For riparian areas we used 500 shrubs (quarts and gallons) per acre and 15 trees (1 inch caliper) per acre planted and
protected from elk. The number of plants can be reduced. We do not recommended changing the willow plantings we propose on stream banks due to the need for channel stabilization. Willow plantings within the coir lifts were incorporated in the stream construction budget. Willows plantings on top of banks and point bars were included in the revegetation budget. We included 5 acres of wetland creation in the conceptual plan at $13,000 per acre planting costs. If less acreage of wetland is included in the final plan, the total revegetation costs could be reduced.

Another costs savings could be found in the final cut to finish grades. The quantities used are based on the mass excavation by the gravel extraction be excluded from cutting below 3 feet to final grade. That minimum depth could be modified to 1 foot or less above final grade, thus saving the restoration budget by approximately $150,000, and generating more material for direct sale. The proposed parking lot in Phase 2 is also optional, or a simple parking area without road base could be established with cobble.

**IX. Recommendations**

Pending adequate funding or contracts from gravel sales, and alterations to the Conceptual Design based on review of this document and additional studies within the reach, the next steps would be:

- Additional feasibility studies, including hydrology, basin characteristics, floodplain modeling, and groundwater monitoring and modeling for the proposed reach.
- A boundary survey or the proposed property extents.
- Initiating discussions with the appropriate parties on the legal and permitting requirement to implement Option #1 on the Tiger/Muggins Gulch Road intersection.
- Final Channel Design based on the proposed alignment, channel design and additional studies.
- Initiate discussions on local, state and Federal permitting.
- Continue to accept topsoil, but assess quality prior to acceptance.
- Explore the use of “manufactured topsoil” to reduce cost
- Assess water rights needs for the project as this would drive some design elements.
- Actively market gravel sales to state or local agencies that may still be able to move forward with large scale construction projects.

In conclusion, we provide a conceptual plan for restoration of aquatic and riverine functions on the Swan River Open Space parcel. The channel alignment and techniques are more than conceptual but can be modified if needed. We present options for the alignment near the confluence of the Swan and Muggins Gulch, and options for infrastructure improvements. The quantity of gravel available for sale is provided, as well as a cost estimate to implement this plan. Alternatives to reduce costs are also included. We are available for further discussions of this plan, and hope to work with Summit County on the implementation of this restoration plan.
SWAN RIVER CHANNEL CONSTRUCTION
PROPOSED CHANNEL GEOMETRY
SAMPLE X-SECTIONS
(ARBITRARY DATUM)

RIPARIAN SHRUB & GRASS PLANTINGS
CONSTRUCTED BAR
(8” MINUS COBBLE)
TOPSOIL
WATER SURFACE 20 CFS

NATIVE SUBSTRATE
SHALLOW POOL AND COBBLE BANK X-SECTION

RIPARIAN SHRUB & GRASS PLANTINGS
CONSTRUCTED BAR
(8” MINUS COBBLE)
CONSTRUCTED RIFFLE
(12” MINUS COBBLE)
TOPSOIL
WATER SURFACE 20 CFS

NATIVE SUBSTRATE
RIFLE X-SECTION