



Restoration of Goose Creek and Big Meadows
Conceptual Design Plan

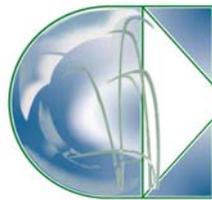
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Introduction

In 2007, the Kalispel Tribe acquired two parcels of land totaling 620 acres in an area known as Big Meadows. Goose Creek bisects Big Meadows prior to its confluence with the Upper West Branch of the Priest River and flows through both parcels of land acquired by the Tribe. Previous management of the parcels included channelizing and dredging portions of Goose Creek in an effort to drain the meadow and create better growing conditions for hay production. As a result of these practices, much of Goose Creek exhibits significantly reduced channel length, lateral and vertical instability, reduced habitat quality, and poor riparian vegetation. Channelization and subsequent vertical erosion have lowered the groundwater table and converted the formerly wet meadow into upland pasture. The Kalispel Tribe has established a goal of restoring aquatic, riparian, and wetland habitats within the newly acquired parcels as well as neighboring properties. This goal can be largely realized by restoring Goose Creek to its historic bed elevation prior to anthropogenic alterations and reconstructing the channel to a more appropriate and stable plan form, profile, and dimension.

A second goal of the restoration of Big Meadows includes incorporating a fish barrier in Goose Creek to prevent further invasion of non-native fish in the watershed. Fish surveys have identified two small isolated cutthroat trout populations in the headwaters of Goose Creek. The populations are isolated by natural barriers and no cutthroat trout were sampled in the downstream sampling sites. These populations are at a high risk of extirpation from stochastic events due to the limited stream lengths (< 2 miles) to which they are confined. The Tribe anticipates implementing a non-native fish removal and cutthroat trout restoration program in Goose Creek which will be dependent on a fish passage barrier to prevent re-invasion of non-native fish species.

The following document provides a conceptual design for restoring aquatic, wetland, and riparian habitats in Goose Creek through Big Meadows. The plan includes dividing the overall project into a series of phases with the goal of accomplishing the entire project within five years. Conceptual designs include typical channel plan views, profiles, and cross section drawings, revegetation plans, and incorporating a fish passage barrier on Goose Creek.

Project Location and Description

The headwaters of Goose Creek lie in the Selkirk Mountains approximately 12 miles southwest of Priest Lake in the northern panhandle of Idaho (Figure 1). The creek originates in Washington and flows roughly six miles before crossing into Idaho. Once Goose Creek crosses the state line, it flows in an east-northeast direction another seven miles through Big Meadows before its confluence with the Upper West Branch of the Priest River. Goose Creek drains 22 square miles and consists of forested timber in the upper elevations and gently sloping meadows in lower elevations. Land ownership includes National Forest in the upper reaches and several private owners further downstream. Land uses include timber management in the forested headwater reaches and hay production in the lower elevation meadows. The parcels owned by the Kalispel Tribe lie in the lower portions of the watershed and include approximately three linear miles of Goose Creek. A privately owned parcel lies between the two Tribal parcels and includes approximately 1.1 miles of Goose Creek.

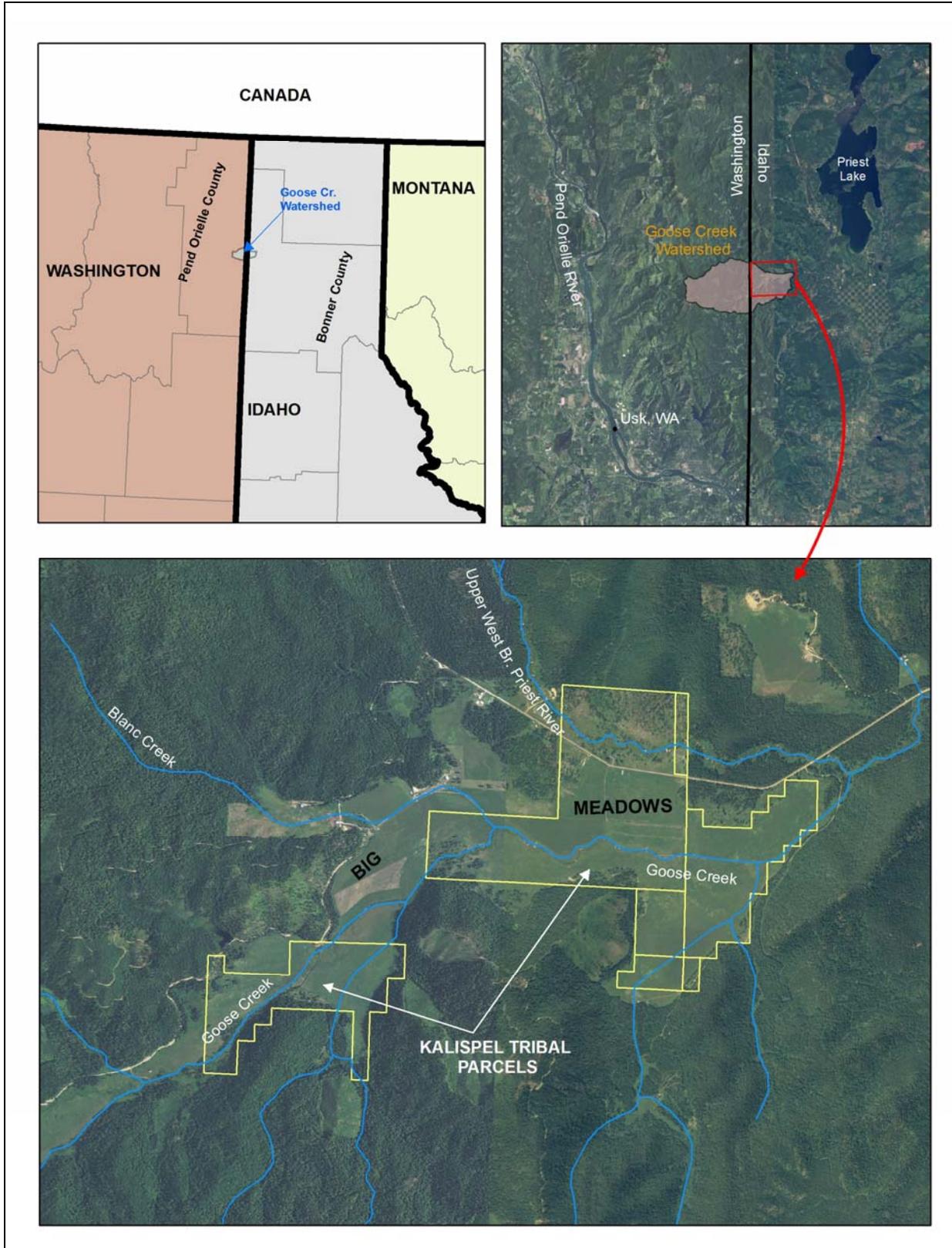


Figure 1. Goose Creek project location.

Geologic and Geomorphic Setting

The geomorphic setting of the project reach reflects both the influences of bedrock geology as an upland sediment source as well as the effects of glacial and fluvial processes on valley fill deposits. Within the project area, Pleistocene and Holocene glacial and lacustrine (lake) deposits have been mapped as the valley fill (Figure 2). These glacio-lacustrine deposits reflect the location of the lower Goose Creek drainage on the southern margin of the Cordilleran Ice Sheet between 12,000 and 16,000 years ago. Carrara and others (1996) concluded that, west of the project area in easternmost Washington, ice extended as far south as Springdale (the Colville ice lobe) and Newport (Pend Oreille River lobe). Just east of Goose Creek, Glacial Priest Lake was a long-lived glacial lake that experienced at least 14 episodes of backflooding from catastrophic flooding from Lake Missoula (<http://vulcan.wr.usgs.gov/>). The project reach is thus located within a transitional area between south-trending ice lobes and ice-margin lake environments (Figure 3). Subsequent deglaciation has been associated with the formation of peat bogs in the Colville Valley (Carrara and others, 1996).

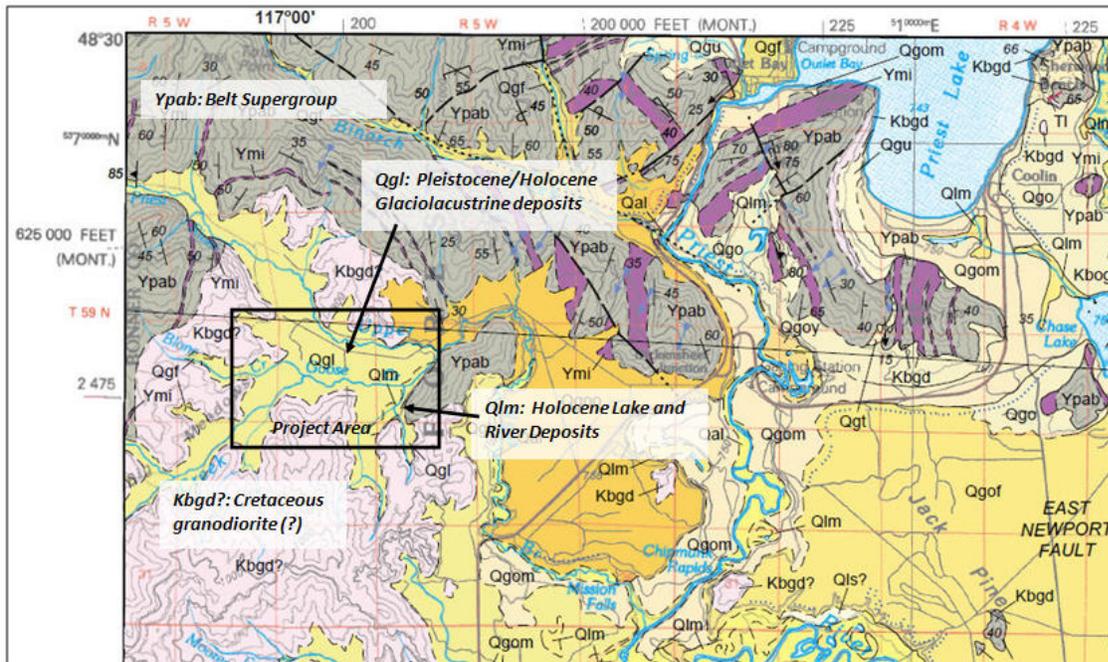


Figure 2. Geologic map of project area (Lewis and others, 2008).

The geologic mapping in the project reach (Figure 2) coupled with pit stratigraphy collected in support of channel design indicate that glacio-lacustrine conditions did exist in the project area resulting in the deposition of fine grained glacial lake deposits, and overlying peats are associated with subsequent deglaciation.

The headwaters geology above the project area consists of Proterozoic-age Belt Supergroup rocks, as well as granodiorites that have been tentatively mapped as Cretaceous in age (Figure 2). Belt geology weathers to predominantly clay and silt sized particles (IDEQ, 2001). The Cretaceous-aged granites, which form the majority of the upper watershed area, weather to very fine gravel and sand-sized particles (1-8mm; IDEQ, 2001). These sands and fine gravels are

observed at depth in soil pits as well as within the current channel bed. In the soil pits a sharp boundary separates peat deposits from overlying fluvial sands and fine gravel. This fluvial sand unit reflects an abrupt transition from post-glacial peat bog conditions to a fluvial environment with a predominantly sand sediment source. Floodplain silts and clays typically overly the sand sequence.

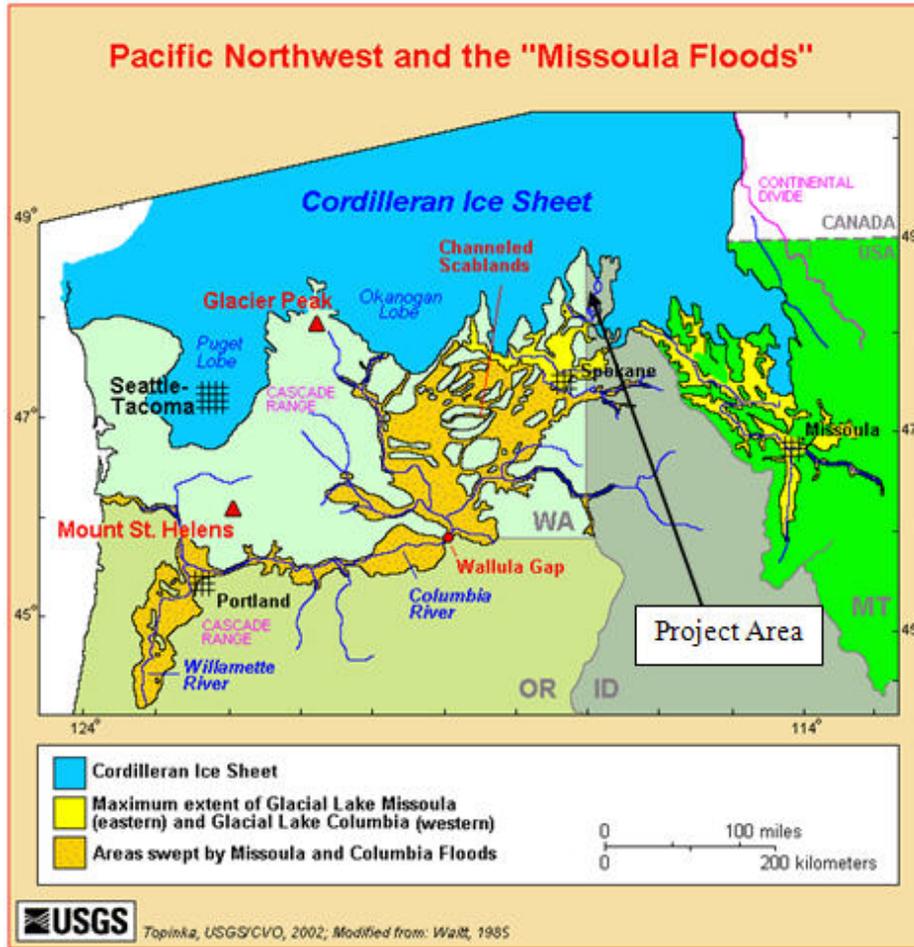


Figure 3. Mapped southern extent of Cordilleran Ice Sheet (www.USGS.gov).

The observed series of sands and overlying silts is consistent with soils mapping in the area. The soil unit mapped in the project reach is the Bonner General Soil Map Unit (IDEQ, 2001). The Bonner unit is of glacial outwash origin, with very deep, level to undulating, well drained soils. Its surface layer is silt loam, subsoil is gravelly silt or sandy loam, and the substratum is very gravelly loamy sand or very gravelly coarse sand.

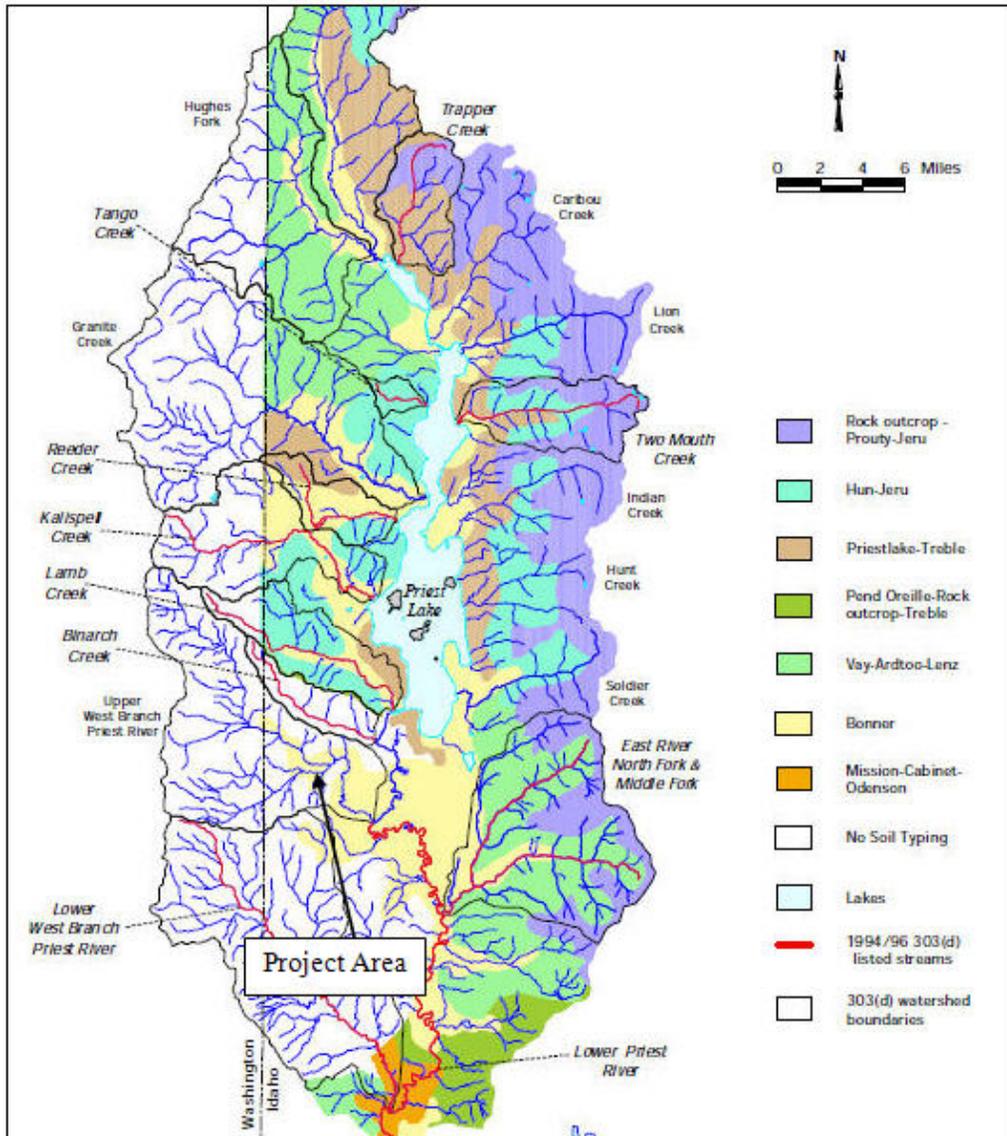


Figure 4. General soil types of the Priest River Basin (IDEQ, 2001).

Existing Habitat Conditions

Due to the considerable length of channel through Big Meadows, aquatic and riparian habitats of Goose Creek vary in quality depending on the location within the valley. In addition, the creek exhibits various geomorphic characteristics which allow it to be divided into shorter sub-reaches for the purposes of habitat descriptions. Figure 5 displays reach breaks as identified by various habitat characteristics during the field survey. The reaches described in this section do not necessarily correspond with channel slope breaks or restoration phases as described in subsequent sections of this report.



Figure 5. Reach breaks for Goose Creek in Big Meadows.

Upstream of Project Reach

As Goose Creek exits the steeper, forested areas of the watershed and enters the flatter meadows, the creek has a high density of beaver complexes and good fish habitat complexity. At the upper Forest Service road crossing (not shown in Figure 5), the channel does not appear incised and has adequate access to a natural floodplain. Stream banks are well vegetated with mature alder providing an overstory layer and mixed grasses and forbs along the stream banks (Figure 6). The channel begins to show signs of incision downstream of the upper road crossing. Once the creek reaches the upper extent of the southwestern Tribal parcel, the channel indicates signs of incision and lateral erosion (Figure 7). Bank heights are much higher and an inset floodplain has formed at a lower elevation than the meadow. Many banks are not as densely vegetated and some near vertical as the channel has dropped in elevation. Vegetation density remains moderately dense and overstory canopy layers provide good shade and cover. Beaver dams remain relatively common and fish habitat complexity is good in Goose Creek upstream of the Tribal parcel.



Figure 6. Goose Creek upstream of the upper Forest Service road crossing.

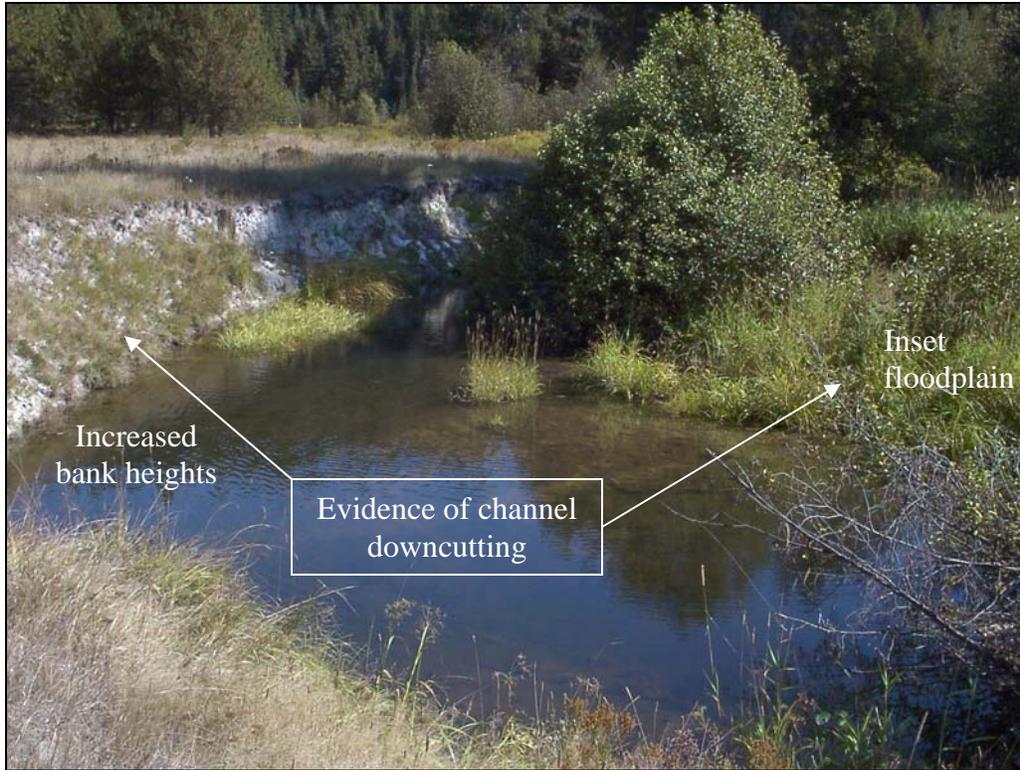


Figure 7. Goose Creek at southwestern Tribal parcel boundary

Reach A

Reach A extends from the upper end of the southwestern Tribal parcel to an access road bridge crossing. As the channel enters the Tribal Parcel, it is incised with an inset floodplain developing approximately eight feet below the meadow elevation. Beaver activity is much less common, therefore backwater pools are less frequently found as compared to upstream. The channel exhibits a natural meander pattern throughout the upper extent of Reach A and provides relatively good habitat complexity and moderately dense riparian vegetation along the inset floodplain.

As the creek approaches the access road, it deviates from its historic meander pattern and enters a channelized reach which continues downstream to the bridge crossing. Once the creek becomes channelized, habitat complexity becomes drastically reduced. Pool quality is degraded due to the absence of meander sequences and shrub cover is reduced to a thin boundary of alders along the fringe of the channel. Much of the creek has been armored along the access road to protect it from eroding at high flows. Overall habitat quality in this channelized reach is poor due to planform simplification and altered riparian complexity.

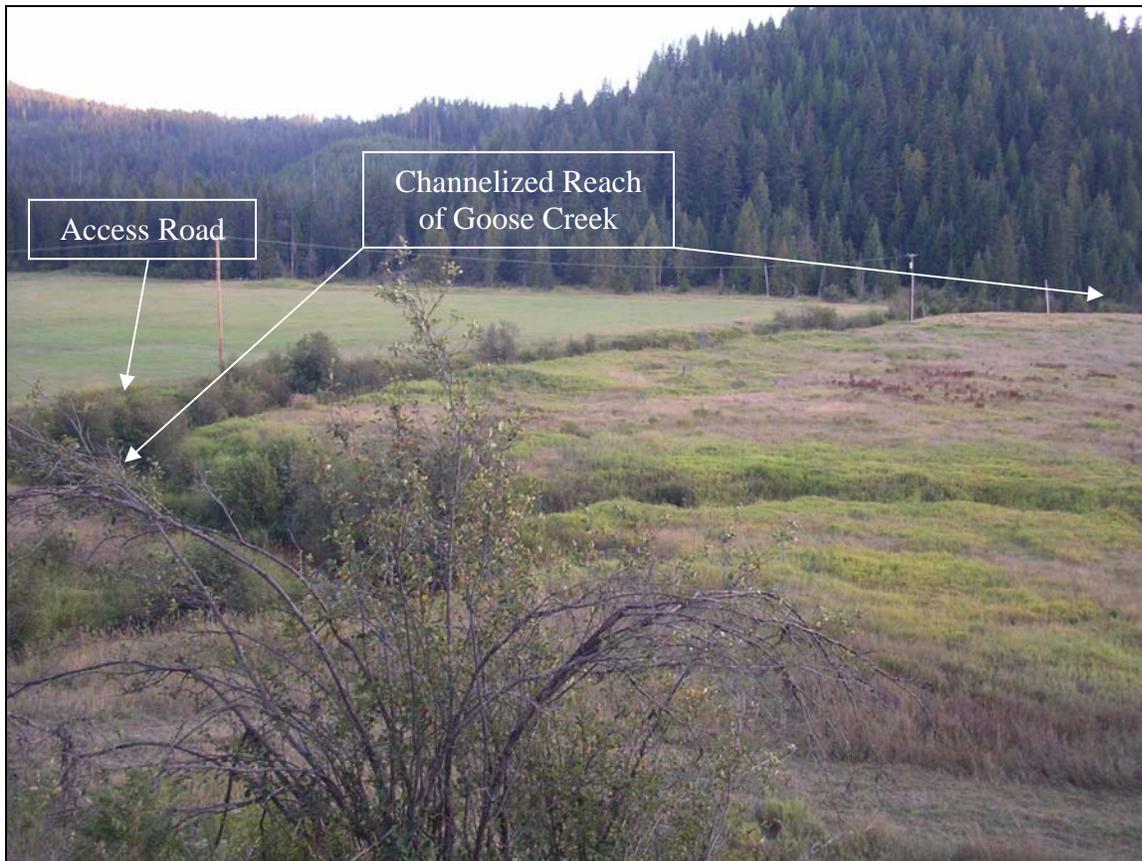


Figure 8. Channelized segment of Goose Creek in Reach A.

Reach B

Reach B extends from the bridge crossing to a forested portion of the valley bottom. The entire length of Goose Creek in Reach B is channelized. The creek acts more like a drain and conveyance ditch through Reach B and has virtually no habitat complexity in the form of riffle/pool sequences. Aquatic habitat is available in the form of woody debris, as the channel is lined with large alders on both banks. The channel is moderately incised and drains adjacent hay pastures. Upland grasses and forbs grow down to the edge of the channel but provide little cover or habitat. Although the creek has been altered to maximize hay production in this portion of the valley, the stream banks have generally maintained lateral stability and riparian vegetation is vigorous along a thin band immediately adjacent to the creek. Overall habitat quality is relatively poor in Reach B due to simplified plan form, lack of a functional floodplain, and reduced riparian vegetation complexity.



Figure 9. Channelized portion of Goose Creek in Reach B.

Reach C

Reach C of Goose Creek flows through a short, forested portion of the valley and continues into the center of Big Meadows. The channel returns to its historic meander pattern through this reach as identified by 1932 aerial photos. Although the channel displays a relatively natural sinuosity in Reach C, it also shows evidence of vertical incision of the stream bed, including an elevated meander cutoff, high banks, and thin band of riparian vegetation along the immediate banks. Habitat complexity improves in Reach C as compared to the channelized portions in Reaches A and B as the channel is able to scour pools on outside meander bends. Although habitat complexity begins to improve, the bed elevation of the creek is very low as compared to the meadow, and therefore acts as a drain for adjacent pastures used for grazing and producing hay. Riparian vegetation is relatively sparse due to a channel which has been disconnected from its historic floodplain. Bank erosion is evident by sloughing along much of the channel, which provides additional sediment inputs to the watershed.

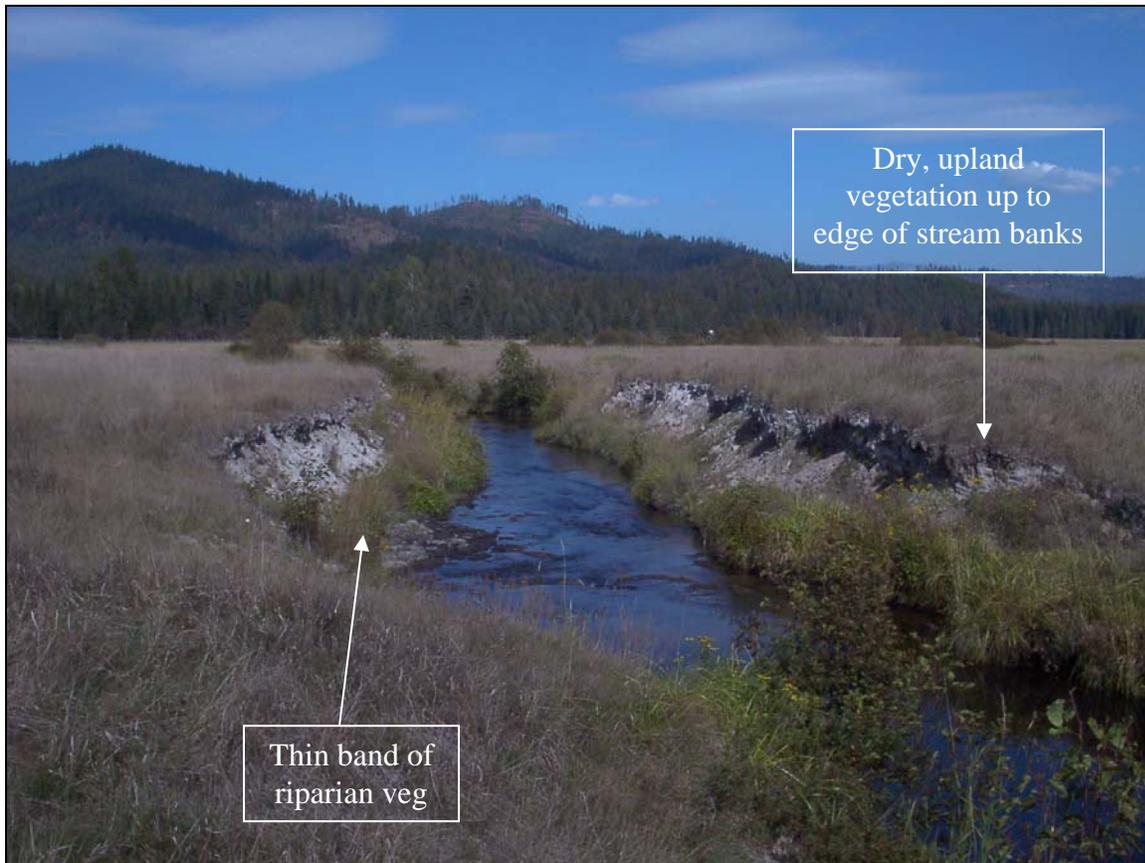


Figure 10. Goose Creek in the lower portion of Reach C.

Reach D

Reach D extends to a culvert which has been placed in the channel to provide a crossing for equipment access. The creek flows along nearly the same meander pattern as shown in 1932 aerial photography, indicating relatively minor lateral movements in the past 70 years. The channel continues to show signs of incision, including high bank heights, inset floodplain formation, and sparse riparian vegetation along the fringes of the channel (Figure 11). The relatively natural sinuosity in Reach D enables pool formation along the outside of meander bends that provide added habitat complexity. However, riparian vegetation throughout the reach has been reduced to a very thin band of grasses and occasional alders which provide little cover and shade. Overall aquatic habitat in Reach D is poor due to eroding banks, poor riparian vegetation density, and reduced floodplain connectivity.

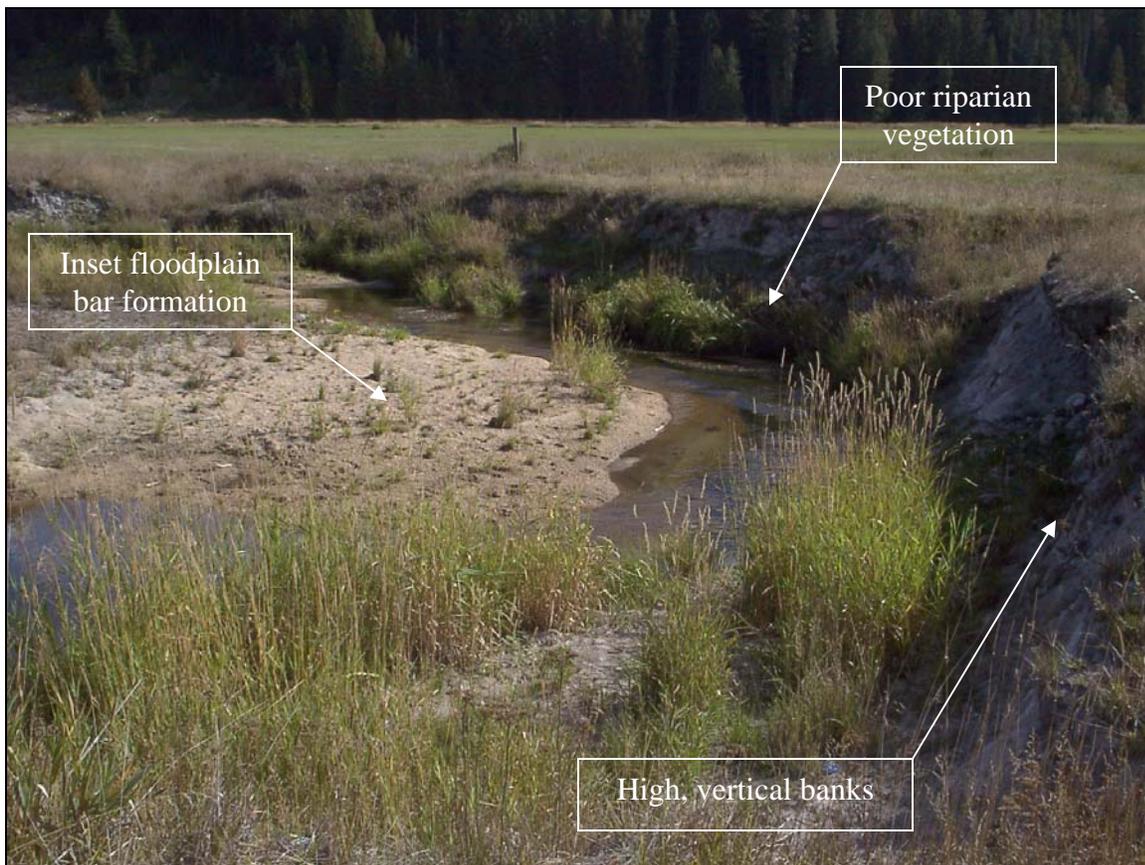


Figure 11. Goose Creek in Reach D showing inset floodplain formation and incised channel.

Reach E

Reach E of Goose Creek extends downstream of the culvert to a bridge crossing at the lower end of Big Meadows. The majority of this reach has been recently channelized and dredged (~10-15 yrs ago) to drain the meadow and improve hay production. As a result, habitat complexity is severely degraded and woody riparian vegetation is nearly absent throughout the reach. Sparse alders remain along the fringe of the channel and provide some cover and shade, but the majority of the channel has little overstory or canopy layer. Immediately downstream of the culvert, the channel remains incised with very high bank heights, one large meander cutoff, and upland vegetation growing up to the channel edge. The degree of incision lessens as the channel approaches the east side of the meadow, although it remains channelized to the bridge. As the channel begins to regain connectivity to its natural floodplain near the downstream end of the reach, vegetation characteristics favor more wetland species, denser alders, and spirea. Habitat complexity in Reach E is poor due to the simplified planform and highly altered riparian corridor.

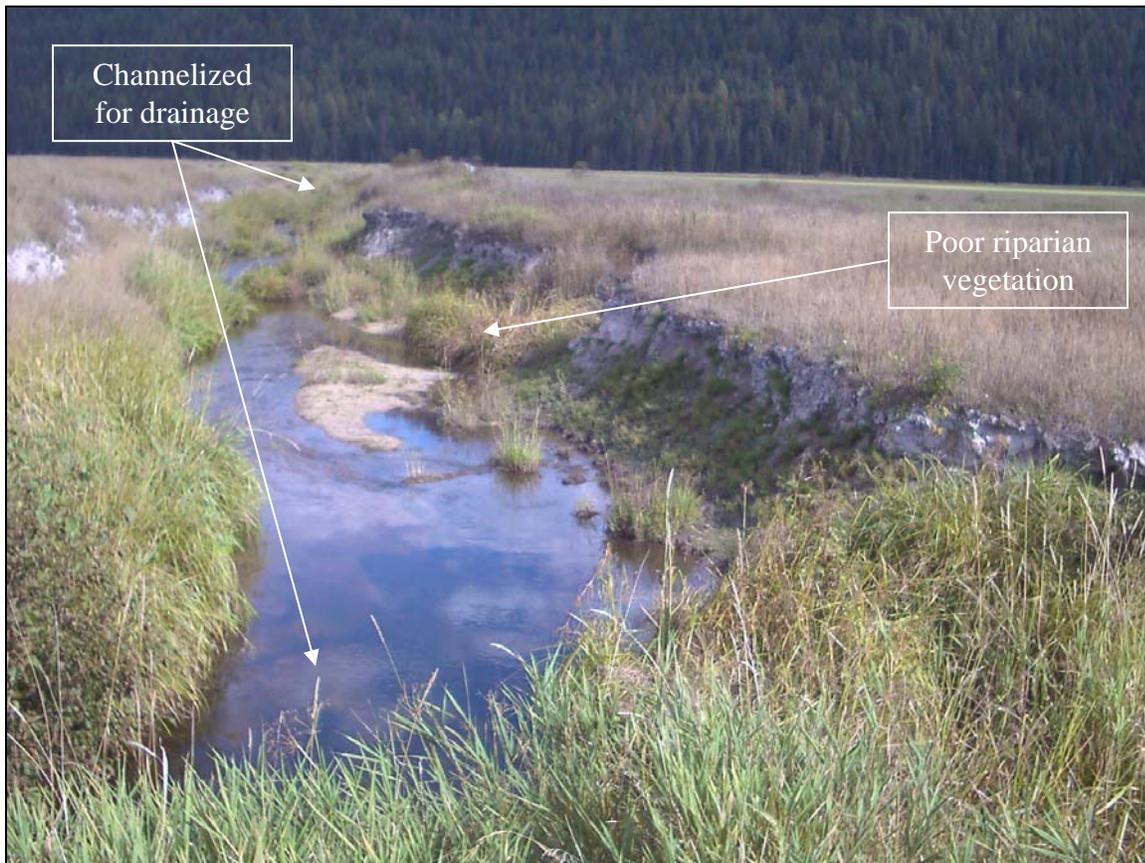


Figure 12. Channelized portion of Reach E.

Reach F

Reach F of Goose Creek extends downstream of the bridge at the east end of the meadow to the confluence of Goose Creek and the Upper West Branch of the Priest River. Although short, this reach exhibits some of the most superior habitat conditions in the lower watershed. The channel has not been mechanically altered downstream of the bridge and channel incision is not evident. Riparian vegetation is dense and provides ample cover and protection from bank erosion. The channel abuts a forested hillside which provides a source of woody debris and habitat complexity. Surveys in Reach F provide potential reference conditions for habitat, channel dimensions, and riparian vegetation composition for other reaches upstream of Reach F.



Figure 13. Goose Creek in Reach F just upstream from the confluence of the Upper West Branch of the Priest River.

In summary, in-stream and riparian habitat quality along the lower five miles of Goose Creek is generally poor due to mechanical alterations to the channel plan form and the drastic reduction of a functional floodplain and riparian corridor. Over 8,000 feet of the creek has been dredged and channelized, resulting in vertical instability and downcutting of the stream bed from the east end of Big Meadows to well above the Tribal parcels. Portions of the channel are developing an inset floodplain and regenerated a healthy riparian zone; however, the majority of the creek has only a very thin band of vegetation along the channel which provides little in the form of cover, shade, and protection from lateral erosion. Within much of the project reach, Goose Creek has

downcut into sands and silts that comprise the upper valley fill stratigraphy; and in some locations, the channel has incised through these units and into an underlying peat horizon.

Modifications to the stream channel over the past 75 years were designed to improve agricultural operations throughout Big Meadows by lowering the groundwater table and draining inundated floodplain soils. The alteration of groundwater hydrology has resulted in the conversion of what was formerly a large wet meadow and wetland complex to a large pasture dominated by upland pasture grasses suitable for grazing and hay production. The loss of wetland hydrology has drastically reduced the acreage of functional wetlands and the associated ecological benefits of water quality, water quantity, stream stability, and waterfowl, amphibian, and fisheries habitat in Big Meadows.

Geomorphic surveys of Goose Creek

In order to begin developing a conceptual plan for restoring aquatic, riparian, and wetland habitats in Goose Creek and Big Meadows, several site visits and surveys were conducted in the fall of 2009. These surveys included:

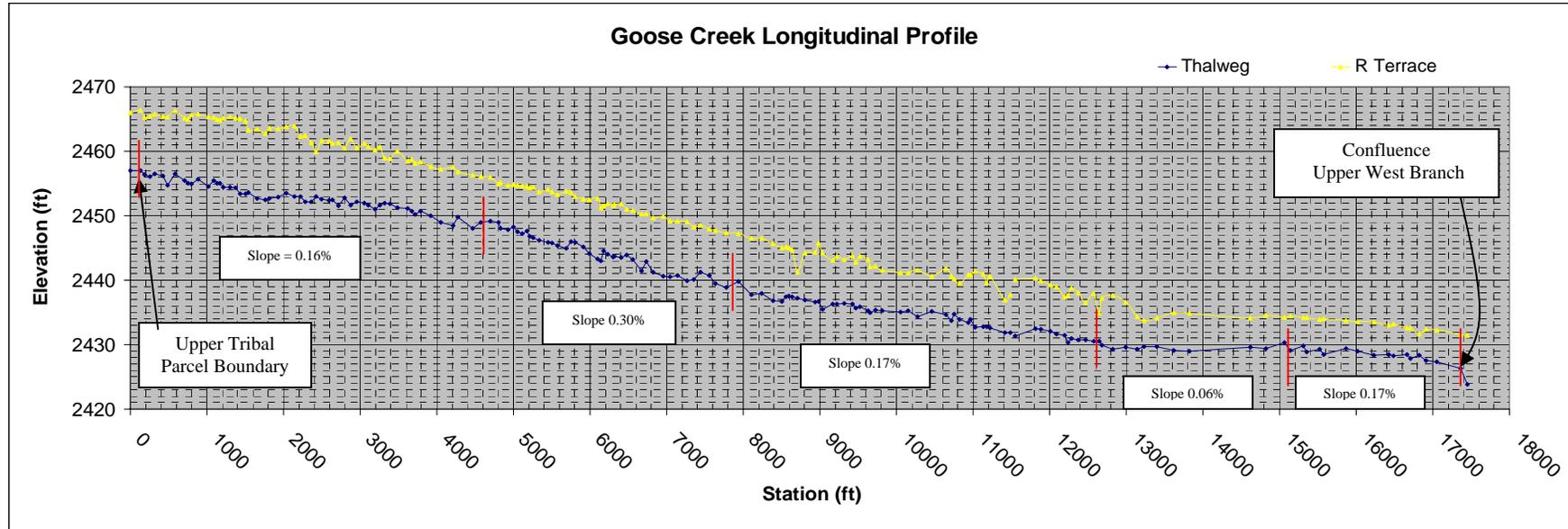
- Project area topography
- 17,500-ft longitudinal profile of Goose Creek thalweg, bankfull, and terrace elevations,
- 29 existing channel cross sections,
- Four historic channel cross sections,
- 13 Wolman pebble counts to document stream bed composition,
- Mapping potential borrow sources of wetland sod,
- Six test pits, one in each of Reaches A, B, C, D, and E.

Results of these investigations are provided in the following sections.

Longitudinal Profile

Tribal fisheries technicians completed a longitudinal profile of Goose Creek, including elevations of terraces, bankfull indicators, and the channel thalweg. Results of this survey allow calculations of channel slope throughout the project reach starting from the upper Tribal parcel boundary to the confluence of Goose Creek with the Upper West Branch (Figure 14). The red lines on this figure delineate breaks in channel gradient and do not correspond to the reach breaks illustrated in Figure 5.

Figure 14. Longitudinal profile of Goose Creek showing thalweg and terrace elevations.



Existing Channel Cross Sections

Cross sections were surveyed in the fall of 2009 to determine dimensions of the channel at varying locations in the valley and the degree of incision, and to assist in developing a hydrologic model for Goose Creek. A total of 29 cross sections were surveyed including four in Reach A, six in Reach B, five in Reach C, five in reach D, four in reach E, and five in Reach F. Results of these surveys include bankfull channel width, bankfull cross sectional area, bankfull maximum depth, bankfull mean depth, and width/depth ratio (Table 1). All dimensions are based on a bankfull discharge estimate of 160 cfs (see Hydrology Section). Cross section plots are included in Appendix A.

Table 1. Cross section parameters surveyed in Goose Creek

Goose Creek Cross Sections						
X Section	Type	Wbf	Max Depth	Mean Depth	XS Area	W/D Ratio
A1	Pool	20.55	2.95	1.86	38.18	11.06
A2	Pool	19.12	3.23	1.96	37.53	9.74
A3	Riffle	26.32	3.58	1.59	41.93	16.52
A4	Riffle	29.09	2.35	1.47	42.86	19.74
B1		25.81	3.07	1.55	39.90	16.70
B2		14.52	3.33	2.32	33.74	6.25
B3		13.80	3.16	2.44	33.66	5.66
B4	Pool	12.77	3.49	2.49	31.76	5.13
C1	Riffle	18.93	2.81	1.54	29.18	12.28
C2	Riffle	23.62	2.60	1.37	32.44	17.20
C3	Riffle	18.09	2.18	1.57	28.42	11.51
C4	Pool	22.90	3.15	1.29	29.56	17.74
D1	Pool	29.13	2.30	1.48	42.97	19.75
D2	Pool	19.40	4.41	2.41	46.82	8.04
D3	Riffle	23.05	2.77	1.71	39.51	13.45
D4	Riffle	29.50	2.46	1.45	42.91	20.28
E1		11.80	3.45	2.27	26.75	5.21
E2		21.01	3.98	2.50	52.47	8.41
F0		27.61	2.43	1.51	41.67	18.29
F1		10.88	5.80	2.90	31.54	3.75
F2		16.82	3.70	2.10	35.38	8.00
F3	Pool	13.98	2.28	1.54	21.54	9.07
F4	Riffle	16.76	2.88	2.07	34.70	8.10
	Average All	20.24	3.15	1.89	36.32	11.82
	Average Riffles	23.17	2.70	1.60	36.49	14.89
	Average Pools	19.69	3.12	1.86	35.48	11.51

Historic Channel Cross Sections

Due to the relatively recent channelization of Goose Creek in Reach E, short portions of the historic, deactivated channel are still intact. In an attempt to document historic channel dimensions, four cross sections were surveyed within a 750-foot deactivated channel segment in Reach E. Results of these cross sections are included in Table 2. Plots of each cross section are included in Appendix A.

Table 2. Cross section parameters for deactivated channel segment in Goose Creek, Reach E.

Goose Creek Historic Cross Sections					
X Section	Wbf (ft)	Max Depth (ft)	Mean Depth (ft)	XS Area (sq ft)	W/D Ratio
Ea	26.48	3.57	2.14	56.59	12.39
Eb	24.66	3.24	1.73	42.63	14.26
Ec	24.05	3.24	1.83	44.13	13.11
Ed	24.78	2.71	1.46	36.14	16.99
Average All	24.99	3.19	1.79	44.87	14.19

Bed Composition

The bed substrate of Goose Creek was sampled using the Wolman pebble count method of sampling particle sizes by size classification. Pebble counts were sampled at 14 locations on Goose Creek and were analyzed to determine the D50 (mean particle) and D84 (84th percentile) size classes (Table 3 and Appendix B). Mean particle size ranged from silt/clay (<0.62 mm) to very fine gravel (4.3 mm). D84 size ranged from medium sand (0.9 mm) to coarse gravel (45 mm). These results suggest the bed substrate is dominated by smaller sized substrate classes including silt, sand, and fine gravels whereas the channel is capable of transporting larger sized classes including coarse gravels (Figure 15). The sand dominated bed of Goose Creek reflects upstream sediment sourcing of primarily Cretaceous-age granodiorites, with some input from of silts and clays from Proterozoic Belt Supergroup rocks (IDEQ, 2001).

Table 3. Pebble count results for Goose Creek.

Pebble Count Location	D50 (mm)	D50 Class	D84	D84 Class
A2	0.9	Medium sand	6.8	Very fine gravel
A4	3.8	Very coarse sand	6.1	Very fine gravel
B3	<.062	Silt/clay	5.5	Very fine gravel
B4	<.062	Silt/clay	4.2	Very fine gravel
C2	<.062	Silt/clay	5	Very fine gravel
C4	0.7	Medium sand	2.33	Very coarse sand
D1	2.33	Very coarse sand	7	Very fine gravel
D2	0.8	Medium sand	45	Coarse gravel
D3	4.33	Very fine gravel	7.5	Very fine gravel
D4	2.66	Very coarse sand	7	Very fine gravel
E1	0.5	Medium sand	0.9	Medium sand
E2	3	Very coarse sand	5.5	Very fine gravel
F3	0.7	Medium sand	0.9	Medium sand
F4	0.9	Medium sand	37	Coarse gravel



Figure 15. Concentrated gravels in channel bed, Goose Creek.

Soil Pits

In the fall of 2009, six soil pits were excavated by backhoe within the project reach to characterize subsurface materials (Figure 16). Pit locations were selected to provide a general representation of subsurface conditions on the anticipated reconstructed channel course (Figure 17). Total pit depths ranged from 6.5 to 9.5 feet; maximum excavation depths were limited by pit wall stability, groundwater levels, or backhoe reach (Figure 18). Appendix C contains the field logs collected for each pit.



Figure 16. Backhoe used in soil pit excavation (Soil Pit 1).

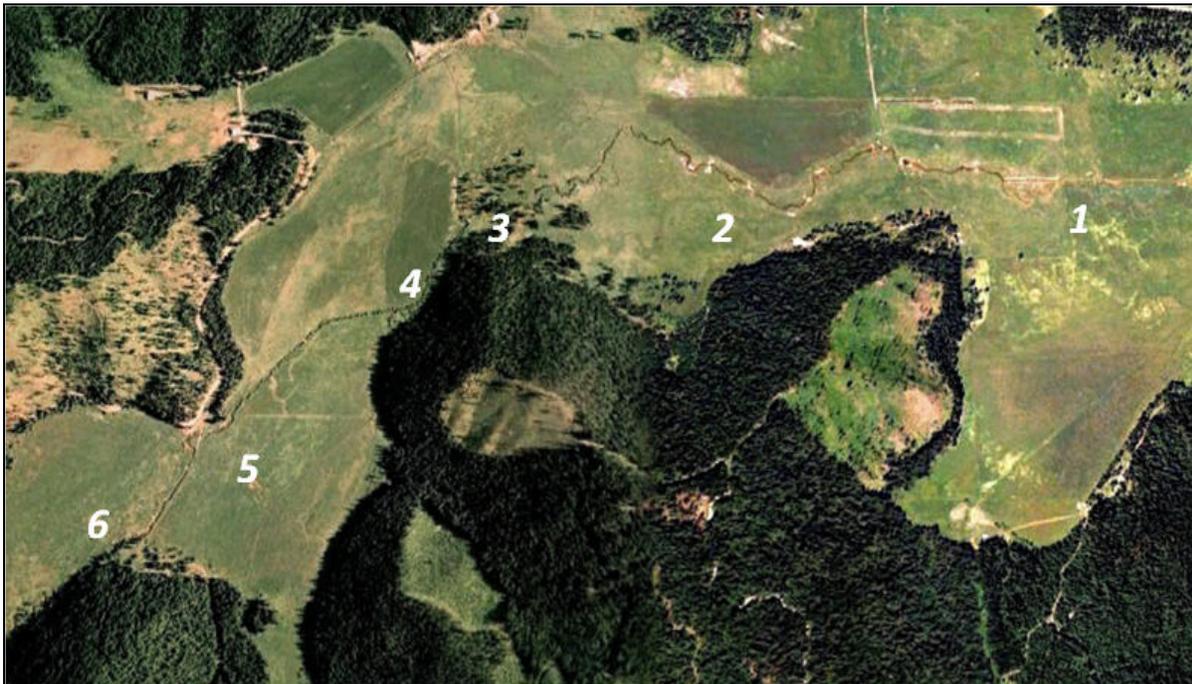


Figure 17. Soil pit locations, Goose Creek project reach.



Figure 18. Backhoe pit showing maximum depth at approximately 7.5 feet (Soil Pit 2).

A generalized profile of the observed pit stratigraphy is shown in Figure 19. The plotted results show that in the lower portion of the valley, clay and peat were encountered in the deepest portion of the section. The clay encountered at the base of both Soil Pit 1 and Soil Pit 2 consists of a blue/gray, highly cohesive massive clay (Figure 20). The unit was 1.0 to 1.3 feet thick, which should be considered a minimum thickness as the lower contact elevation is unknown. In Soil Pit 2, the clay contained some interbeds of gray sand.

Overlying this unit, a peat unit ranges in thickness from 4.5 feet in Soil Pit 1 to 2.0 feet in Soil Pit 2, indicating that the unit may thin in the up-valley direction. This unit consists of a brown peat that has a low density and contains distinct reedy plant fragments (Figure 21). Neither the basal clay nor overlying peat were observed in any of the pits located up-valley from Pit #2. If these units were deposited in relatively flat lake or bog conditions, they likely extend up-valley at a deeper level than that reached by Pits #3 through #6.

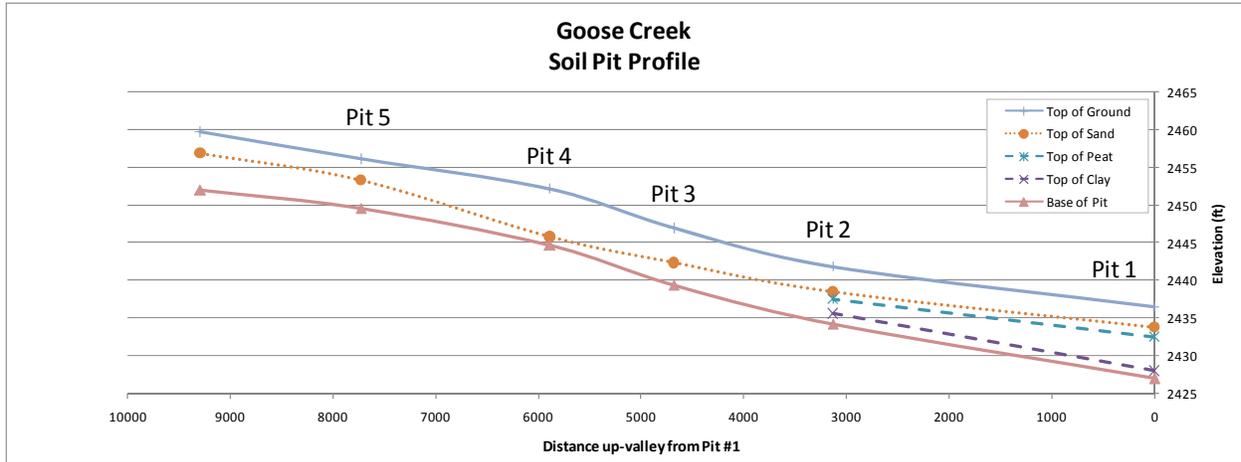


Figure 19. Soil pit profile compiled from pit logs and site elevation survey.



Figure 20. Basal glacial clay, Soil Pit 1.



Figure 21. Peat material excavated from Soil Pit 1.

In Soil Pit 1 and Soil Pit 2, the peat layer was overlain by non-cohesive, granitic sands that contain distinct channels, reflecting deposition in a fluvial or deltaic environment (Figure 22). This sand horizon extends upvalley, forming the basal section of Soil Pits 3, 4, 5, and 6. The concentration of wood fragments in this sand horizon increased markedly in the up-valley direction (Figure 23).

In all of the soil pits, the sand horizon was overlain by variably stratified fine silts. In some locations, a distinct ash horizon was present within the silt. This unit was consistently several feet thick and sufficiently indurated to provide stability to the pit walls. In most cases, the uppermost portion of this unit was massive and structureless, suggesting that it had been tilled as part of agricultural activities in the valley. In Pit 5, the silts overly a non-cohesive, convex bar deposit that suggests overbank infilling of an abandoned channel segment (Figure 24).



Figure 22. Wall of Soil Pit 2 showing non-cohesive, sand channel overlying peat.



Figure 23. Wood fragments excavated from non-cohesive sand horizon, Soil Pit 4.



Figure 24. Massive silts overlying a convex point bar deposit of non-cohesive sands, Soil Pit 5.

The results of the soil pit investigation indicate that the valley fill stratigraphy within the project area is geotechnically quite variable. As a result, the perimeter of the restored channel will vary depending on its vertical location in this stratigraphic sequence. In the eastern part of the valley, the deepest observed unit is comprised of cohesive clays. This unit, which is approximately 8.5 feet below the existing ground surface, is likely a glacial lake deposit, which may be associated with Glacial Priest Lake. The interbedded clay and sand layers in Pit #2 suggest that this area was on the lake margin when these deposits were laid down. The overlying peat unit indicates a post-glacial bog environment, which is consistent with conditions found to the west in the Colville Valley (Carrara and others, 1996). Following peat deposition, the environment became more fluvial in nature, and non-cohesive sands derived from upper watershed granitic sources were deposited across the valley. Silt deposition over the sands indicates a long period of floodplain deposition across the valley, and the disturbance of the upper portion of this unit is indicative of ground leveling or tilling in support of agricultural land uses.

Reference Reach Surveys on Upper West Branch

In addition to the surveys performed along Goose Creek, a potential reference reach was identified on the Upper West Branch (UWB) of the Priest River. This reach of the Upper West Branch also flows through a meadow complex and visually exhibited similar sand-dominated substrate and channel dimension as Goose Creek. The selected reach showed no influence of anthropogenic alterations upstream or downstream and displayed a healthy riparian corridor and intact floodplain. Reference reach surveys included:

- 2,000 foot longitudinal profile,
- 12 channel cross sections,
- 7 Wolman pebble counts to document stream bed composition.



Figure 25. Photo of Upper West Branch of the Priest River in reference reach.

UWB Longitudinal Profile

A 2,000 foot longitudinal profile was surveyed in the selected reference reach of the Upper West Branch. Results of this profile allow for comparisons of channel slopes to those found in Goose Creek. Results of the longitudinal profile are illustrated in Figure 26. Thalweg slope averaged 0.0025 ft/ft for this reach of the Upper West Branch.

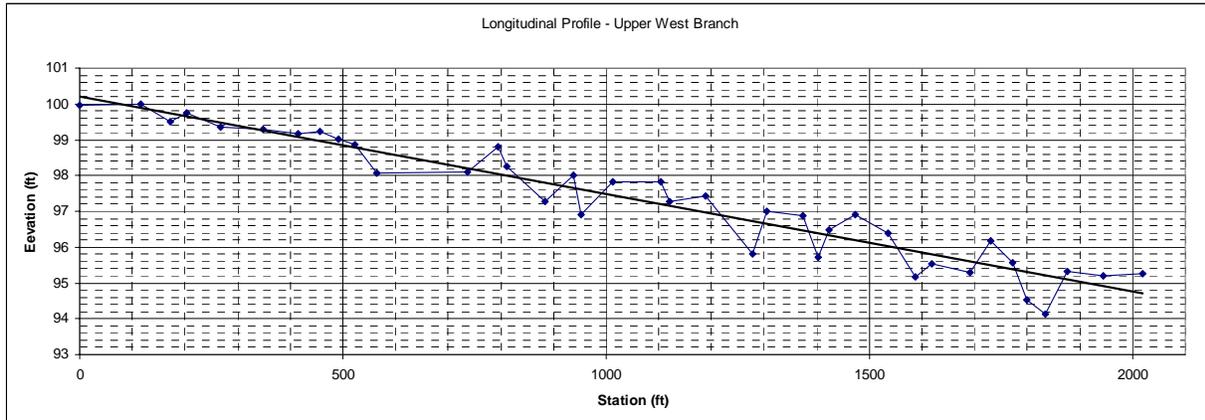


Figure 26. Longitudinal profile of Upper West Branch reference reach.

UWB Cross Sections

12 cross sections were surveyed within a 2,000 foot reach of the Upper West Branch of the Priest River. Cross sections were surveyed at riffles and pools to assist in developing design dimensions for restored reaches of Goose Creek. Analysis of the surveyed cross sections included bankfull width (Wbf), maximum bankfull depth, mean bankfull depth, cross sectional area, and width/depth ratio. Results of this analysis are included in Table 4.

Table 4. Reference reach cross section parameters in Upper West Branch of Priest River

Upper West Branch - Reference Reach Cross Sections						
X Section	Type	Wbf (ft)	Max Depth (ft)	Mean Depth (ft)	XS Area (sq ft)	W/D Ratio
Section 1	Riffle	46.15	3.83	2.91	134.2	15.87
Section 2	Pool Tail	26.43	4.43	2.87	75.95	9.20
Section 3	Pool tail	28.08	5.93	3.08	86.53	9.11
Section 4	Pool	23.23	4.9	3.29	76.49	7.05
Section 5	Riffle	21.28	2.76	2.28	48.55	9.33
Section 6	Pool tail	30.52	6.41	3.94	120.13	7.75
Section 7	Riffle	20.82	2.81	2.01	41.82	10.37
Section 8	Pool	34.05	5	3.12	106.16	10.92
Section 9	Riffle	21.62	2.08	1.69	36.49	12.81
Section 10	Riffle	31.04	2.7	1.75	54.33	17.73
Section 11	Pool	27.99	3.56	2.22	62.08	12.62
Section 12	Riffle	22.17	2.45	1.83	40.51	12.13
Average All		27.78	3.91	2.58	73.60	11.24
Average Riffles		27.18	2.77	2.08	59.32	13.04
Average Pools		28.38	5.04	3.09	87.89	9.44

Reference Reach Pebble Counts

Seven pebble counts were sampled on the Upper West Branch reference reach to document the bed substrate composition. Mean particle sizes (D50) ranged from 0.8 mm (medium sand) to 5.9 mm (very fine gravel). The 84th percentile (D84) of particle sizes ranged from 3 mm (very coarse sand) to 8.5 mm (fine gravel).

Table 5. Pebble count results for UWB.

Pebble Count Location	D50 (mm)	D50 Size Class	D84 (mm)	D84 Size Class
Station 1	4.5	Very fine gravel	7.5	Very fine gravel
Station 2	5.9	Very fine gravel	8.5	Fine gravel
Station 3	4	Very fine gravel	7.8	Very fine gravel
Station 5	0.8	Medium sand	3	Very coarse sand
Station 6	1.5	Coarse sand	3.8	Very coarse sand
Station 7	2.5	Very coarse sand	7.5	Very fine gravel

Additional Investigations

Field surveys provided valuable information as to existing channel, vegetation, and habitat conditions within the project area. Further investigations conducted following the field surveys include hydrology and the historic planform geometry of Goose Creek. These additional parameters are useful components for developing a restoration design. The following sections summarize the additional data compiled in these investigations.

Hydrology

Goose Creek is an ungaged creek with no available historic discharge data available. A water level recorder was placed in the creek near its mouth in 2009; however, these data were not available during the conceptual design phase. Developing estimates of Goose Creek's hydrology is an important component of the restoration design. Four methods of estimating various return intervals were analyzed to assist in developing a design discharge for Goose Creek.

Method 1 – Regional Regression

USGS regional regression equations provide estimates of various return intervals for ungaged streams (Berenbrock 2002; USGS Idaho StreamStats website). The variables for the regression equations for northern Idaho include the drainage area (sq miles), mean basin elevation (ft), and percentage of the watershed that is forested. Return interval results for Goose Creek at its mouth using the regression equations for Idaho are included in Table 6.

Table 6. Idaho regional regression return intervals for Goose Creek

Return Interval	Q (cfs)
1.5	134
2	162
2.33	175
5	237
10	304
25	367
50	423
100	485
200	556
500	637

Method 2 – WinXSPro Model on Goose Creek Cross Sections

The WinXSPro model estimates at-a-station discharge at various water surface elevations using a basic Manning's equation approach. Model inputs include cross section station and elevation points, channel slope, and Manning's n. The Manning's n value accounts for roughness and is based on the materials present in the channel (sand, gravel, cobbles, etc.). Model output includes a "bankfull" discharge where the channel has reached full capacity.

This method is most appropriate for estimating bankfull flows at reference riffles. Goose Creek did not exhibit true reference conditions within the project area due to anthropogenic alterations, channelization, dredging, downcutting, and floodplain discontinuity. Selected cross sections input into WinXSPro included riffles surveyed in Reach F near the mouth of Goose Creek, and deactivated channel segments surveyed in Reach E where bankfull indicators are well developed. Results of these calculations are provided in Table 7.

Table 7. Estimated bankfull flows using WinXSPro at surveyed cross sections in Goose Creek.

Cross Section input to WinXSPro	Bankfull Q (cfs)
XS F2	232
XS F4	263
XS Ea	173
XS Eb	109
XS Ec	117
XS Ed	94
Average	165 cfs

Method 3 – Estimates of Velocity using Hydraulic Equations

This method attempts to determine water velocities at a station using hydraulic calculations based on channel cross section dimensions, slope, and bed particle size to determine a value for Manning’s n. Values for wetted perimeter, hydraulic radius, and R/d84 were calculated for reference cross sections surveyed in Goose Creek. These parameters are used in three hydraulic calculations to estimate various Manning’s n values which allowed an estimation of velocity using Manning’s equation. With a velocity estimate, bankfull discharge was estimated as the product of velocity and cross sectional area. The resulting estimates of bankfull flow for Goose Creek are shown in Table 8. Results of each of these methods are shown in Table 9 through Table 11.

Table 8. Hydraulic variables for channel cross sections in Goose Creek.

XS	W _{bf} (ft)	XS Area (sq ft)	D ₈₄ (mm)	D ₈₄ (ft)	Slope (ft/ft)	Wetted Perimeter (ft)	Hydraulic Radius (ft)	R/D ₈₄ (ft)	Manning’s n using R/D ₈₄
F2	19.16	62.91	37	0.12	0.0011	25.73	2.45	20.14	0.030
F4	20.31	66.77	37	0.12	0.0011	26.89	2.48	20.46	0.030
Ea	26.48	56.59	5.5	0.02	0.0010	30.75	1.84	101.97	0.024
Eb	24.66	42.63	5.5	0.02	0.0010	28.12	1.52	84.02	0.024
Ec	24.05	44.13	5.5	0.02	0.0010	27.72	1.59	88.23	0.024
Ed	24.78	36.14	5.5	0.02	0.0010	27.70	1.30	72.31	0.025

$D_{b_{kf}}$ - Bankfull Mean Depth = $(A_{b_{kf}}/W_{b_{kf}})$ WP - Wetted Perimeter = $(2*D_{b_{kf}})+W_{b_{kf}}$
 $W_{b_{kf}}$ - Bankfull Width R - Hydraulic Radius = $A_{b_{kf}}/WP$ S - Slope

Table 9. Method #3a – Relative Roughness to Determine Manning’s n

Cross Section	Manning’s n using R/D84	Velocity (ft/sec)	XS Area (sq ft)	Qbf (cfs)
XS F2	0.030	2.99	62.91	188
XS F4	0.030	3.02	66.77	201
XS Ea	0.024	2.95	56.59	167
XS Eb	0.024	2.59	42.63	110
XS Ec	0.024	2.68	44.13	118
XS Ed	0.025	2.25	36.14	81
Average				144 cfs

Table 10. Method #3b – $u^* = 2.38 + \log(R/D84)$

Cross Section	$u^* = (gRS)^{0.5}$	Velocity (ft/sec)	XS Area (sq ft)	Qbf (cfs)
XS F2	0.2943	3.01	62.91	189
XS F4	0.2966	3.04	66.77	202
XS Ea	0.2434	3.46	56.59	195
XS Eb	0.2210	3.03	42.63	129
XS Ec	0.2264	3.13	44.13	138
XS Ed	0.2050	2.74	36.14	98
Average				159 cfs

Table 11. Method #3c – Jarrett’s Equation for estimating Manning’s n: $n = 0.39S^{0.38} R^{-0.16}$

Cross Section	Manning’s n Jarrett’s	Velocity (ft/sec)	XS Area (sq ft)	Qbf (cfs)
XS F2	0.0254	3.53	62.91	222
XS F4	0.0253	3.58	66.77	238
XS Ea	0.0256	2.76	56.59	156
XS Eb	0.0264	2.35	42.63	100
XS Ec	0.0262	2.45	44.13	108
XS Ed	0.0271	2.08	36.14	75
Average				150 cfs

The use of multiple methodologies for predicting return intervals and estimating bankfull flows provides a range of discharges that are likely to regularly occur in Goose Creek. The 2-year return interval is not necessarily a prediction of a bankfull flow event, but provides one tool for estimating regular return flows. Table 12 summarizes discharges calculated for Goose Creek using the various methodologies employed to develop a design discharge.

Table 12. Hydrology summary for Goose Creek design discharge

Method	Q (cfs)
USGS Regression Equations – 2 year return interval	162
WinXSPro Average bankfull discharge at surveyed riffles	165
Relative Roughness to determine Manning’s n	144
u/u* to determine Manning’s n	159
Jarrett’s Equation to determine Manning’s n	150

Historic Channel Planform

Typical planform characteristics of rivers include sinuosity, radius of curvature, belt width, and meander length. Each of these characteristics is important in designing a restored channel which will maintain stability and provide appropriate habitat features. Historic aerial photography provides a very useful tool in quantifying planform attributes of streams prior to significant human alterations. Aerial photographs of Big Meadows were taken in 1932, and provide excellent documentation of Goose Creek’s planform characteristics prior to channelization and dredging.

Sinuosity

Historic segments of Goose Creek were digitized to determine channel sinuosity at various locations within Big Meadows and to provide design guidance for the restored stream. The 1932 photography revealed reaches within Big Meadows where the channel lost definition, resulting in discontinuous channel digitization. Poor channel definition may be due to areas of the meadow that are particularly flat and contain a braided channel, areas where the channel has a very dense riparian corridor which overlays the channel, or where the reduction in image quality prevents obvious identification of the channel. Figure 27 illustrates historic and existing channel planform of Goose Creek through Big Meadows and includes calculated sinuosity for each digitized channel segment. Channel segments in this figure do not necessarily correspond to slope breaks in Figure 14 or reach breaks in Figure 5.

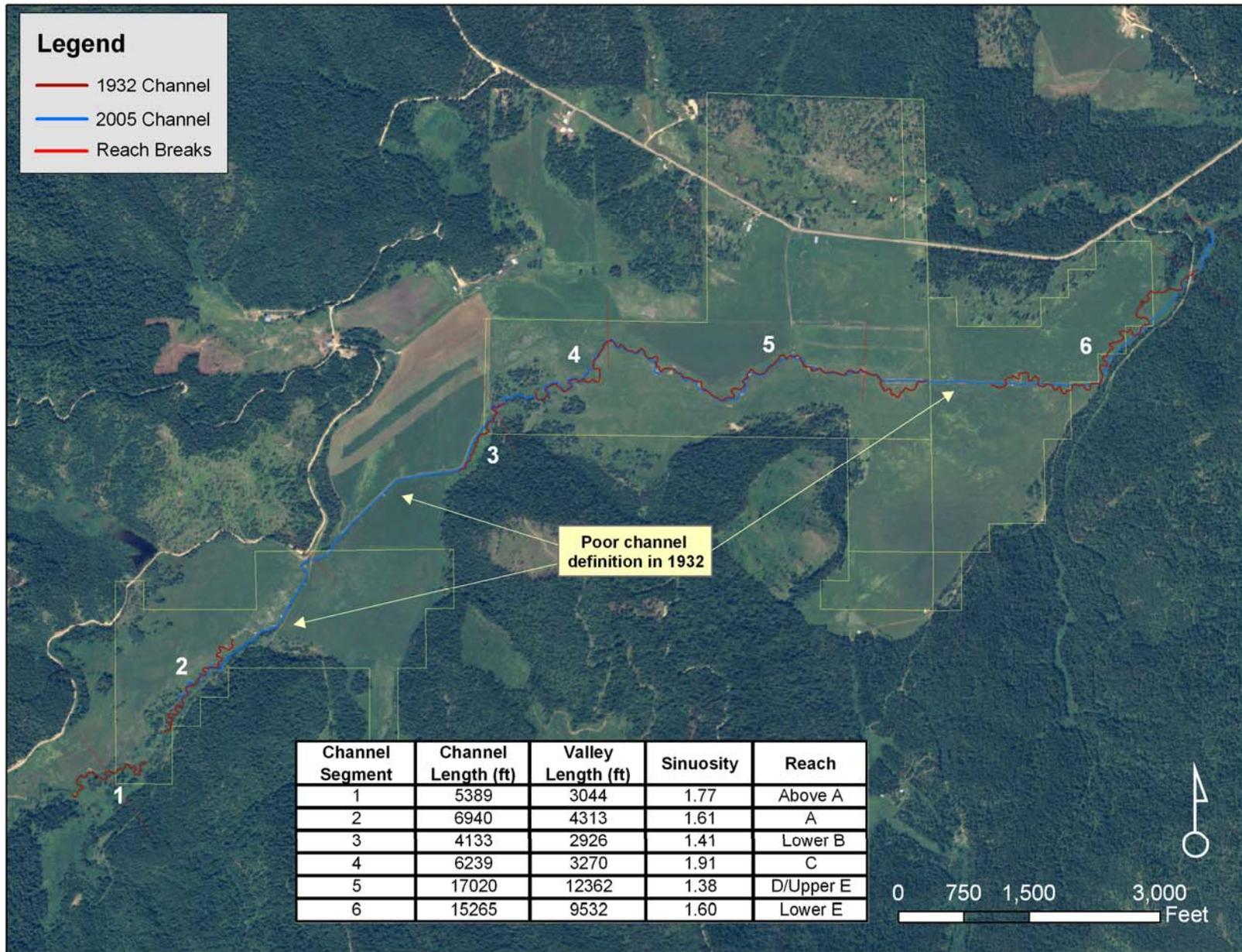


Figure 27. Historic and existing channel planforms and calculated sinuosity of Goose Creek in Big Meadows.

Belt Width, Meander Length, and Radius of Curvature

Each of these planform components was measured for each meander sequence within each of the 1932 channel segments illustrated in Figure 27. An example illustration of digitized meander lengths, belt widths, and radius of curvature from the 1932 aerial photos along lower Reach E is shown in Figure 28. Meander geometry results for each channel segment are included in Table 13.



Figure 28. Planform dimensions digitized from 1932 aerials.

Table 13. Planform geometry from historic Goose Creek channel.

Channel Segment	Reach	Belt Width (ft)			Meander Length (ft)			Radius of Curvature (ft)		
		Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
1	Above A	32	111	66	90	192	136	13	60	28
2	A	17	64	33	51	163	93	16	56	27
3	Lower B	19	121	56	94	249	146	19	84	42
4	C	15	112	55	67	233	139	14	102	35
5	D/Upper E	16	101	56	74	208	137	13	96	36
6	Lower E	39	101	69	71	201	126	20	56	31

Conceptual Design Criteria for Restoring Goose Creek and Big Meadows

Project Goals

The two goals of the Big Meadows restoration project are to 1) Restore aquatic, riparian, and wetland habitat within parcels owned by the Kalispel Tribe and neighboring landowners; and 2) Construct a fish passage barrier on Goose Creek to protect cutthroat trout populations from invasive brook trout. Specific criteria for meeting these goals include:

- Developing aquatic habitat features that are appropriate for the channel type and geomorphic setting of Goose Creek through Big Meadows;
- Developing various channel plan forms, profiles, and dimensions that provide vertical and lateral stability of the creek;
- Reestablishing connectivity between Goose Creek and its floodplain;
- Developing a riparian revegetation plan;
- Incorporating a structural passage barrier at least 4' high to prevent brook trout invasion at up to a 100 year flood event.

The existing condition of Goose Creek precludes attainment of the project goals. The channel bed has dropped in elevation due to mechanical alterations, channelization, and dredging, resulting in a lower groundwater table and largely non-functional floodplain. The ecological benefits of a riparian corridor have largely been lost where the channel has downcut. Achieving the project goals may be accomplished by relocating Goose Creek back to its historic elevation and dimensions. Historic aerial photography provides evidence of a gently meandering channel through much of Big Meadows. The flat character of the meadows likely provided the original, expansive floodplain for Goose Creek, and may be utilized to provide that function again if the channel is reconstructed. Excavating a new channel through the meadow which is designed to provide adequate capacity and maintenance of lateral and vertical stability throughout its hydrologic regime is a feasible restoration approach.

Design Elements

The information provided in previous sections of this report can be utilized to help define appropriate parameters for successful channel restoration design on Goose Creek. These parameters relate to channel planform, cross section, hydrology, and sediment transport conditions. By integrating these parameters with project goals and site topography, a conceptual design can be developed.

Channel Planform

The proposed planform design for Goose Creek includes parameters of sinuosity (ratio of channel length to valley distance), and bendway shape (meander length, radius of curvature, belt width). These parameters have been developed for Goose Creek based on measurements of historic conditions, measurements of reference conditions, an understanding of existing topography, and the integration of a fish passage barrier into the design.

The measured historic sinuosity for Goose Creek ranges from 1.38 to 1.91. This relatively high sinuosity defines a slope that reflects the total drop in elevation through the valley. In the restoration design, however, the inclusion of a 4-ft fish passage barrier will significantly reduce the available grade that can be used to lengthen the channel and increase sinuosity.

With a design sinuosity ranging from 1.2 to 1.7, there will be ample opportunity to incorporate complex planform elements into the restoration design. Above the fish passage barrier, sinuosity will range from 1.4 to 1.7. In this area, the channel will be constructed high in the stratigraphic column such that the bank toe materials will consist largely of cohesive silts, with potentially some non-cohesive sands exposed locally in the bank toe (See Section on Anticipated Channel Perimeter Materials). Where silts comprise the channel margin, the channel can likely accommodate the low radius of curvature (R_c) values that were measured on historic air photos. These values range from 13 to 102 feet on identifiable historic channel segments. Using an average cross section width (W) of 25 feet from the deactivated channel segment in Reach E, the resulting R_c/W values range from less than one to four. Typically, R_c/W values less than approximately 2 are prone to limited sediment transport conveyance, backwatering, infilling, and cutoff or avulsion (Lagasse, et al, 2004). To maintain effective sediment transport through the reach, it is anticipated that R_c/W values will range from approximately 2 to 4. These bends will be contained within a meander belt that approximates that of the historic channel, which is up to 120 feet in width.

Channel Slope

Slope is an important component of channel design, as the combination of channel slope and channel cross section defines conveyance capacity, sediment transport capacity, and erosive energy. Currently, channel bed slopes within the project reach range from 0.06% to 0.3%. All of these channel segments have been modified, and thus do not provide a pristine reference condition. The channel slope on the Upper West Branch, which has been identified as a potential reference reach, is 0.25%. In Reach F, which exhibits excellent habitat and sediment transport conditions, the channel slope is approximately 0.17%. Slope is a direct reflection of channel length, and as such, it is directly related to sinuosity. If sinuosity is used as a primary design element, the resulting slope must be at an acceptable condition for stream stability. For this design, target sinuosities result in proposed design slopes that range from 0.12 % to 0.16%, which is similar to that of Reach F. This slope range is within the range of existing conditions and close to that of Reach F. In combination with the proposed cross section, the proposed gradients should maintain effective sediment transport through the reach.

Design Discharge

In order to appropriately size the channel, it is critical that a design flow be developed that approximates the bankfull condition of a stable channel configuration. Based on a combination of methods, the design discharge developed for Goose Creek is 150-160 cfs. This estimate approximates both existing bankfull channel capacities, as well as results of regional regression analysis.

Channel Cross Section

As described above, cross section and slope are primary influences on the hydraulic conditions within a channel. Other factors such as bend radius of curvature and bed substrate also affect

these conditions, however to a lesser degree. To that end, cross section geometries have been developed to convey the design flow at an appropriate width to depth ratio. Conceptual cross sections have been developed for both pools and riffles.

On the deactivated channel segment in Reach E, the average width to depth ratio is 14.2. For existing conditions, average width to depth ratios are 14.9 for riffles and 11.5 for pools. W/D ratios in the Upper West Branch averaged 11.2. This range of W/D ratios will be used to develop a range of pool and riffle dimensions for the newly constructed channel. Final channel dimensions will fluctuate within each reach to account for design slopes and habitat features.

Sediment Transport

The geology of the upper watershed, coupled with the observed valley fill stratigraphy, indicates that gravel and finer sediment comprise the sediment load delivered to the project reach. Pit stratigraphy shows strong sorting between the channel (fine gravel and sand) and floodplain areas (silts). It is anticipated that the integration of historic channel configuration into restoration design will similarly sort sediment, effectively conveying the sandy bedload through the channel and allowing the deposition of fine silts on the adjacent floodplain. The application of a relatively low width to depth ratio in riffle cross sections will help facilitate the sediment transport conditions. Channels of relatively high sinuosity (>1.5) and low width to depth ratios (<12) tend to be highly effective at sand transport. It should be noted, however, that some sediment storage and bar formation in the constructed channel should be expected as the channel adjusts following construction in response to roughness changes provided by vegetation, and hydrologic conditions that ensue.

Floodplain Access

The establishment of a functional, broad floodplain adjacent to the Goose Creek channel is an important component of restoration design. Above the fish passage barrier, the channel will be raised and reconnected to its historic floodplain. Where necessary, floodplain dikes will be integrated into the design to prevent flooding in areas where it would conflict with existing land uses. Even with this limited access to the historic floodplain, however, overall floodplain extent will increase dramatically relative to existing conditions.

Downstream of the fish passage barrier, the channel will be too low to access its historic floodplain beyond bankfull conditions. In this area, the proposed cross section design includes the excavation of an inset floodplain surface that will range in width from approximately 70 to 90 feet. This inset floodplain will provide area that will dissipate flow energy beyond bankfull conditions, and also create additional opportunities with respect to riparian recovery in the reach.

Uncertainty

Some adjustment of the channel following construction should be expected and accommodated. Anticipated adjustments will include modifications in channel width due to lateral accretion on the channel margins, adjustments of pool depths in response to radius of curvature and flow conditions, and undercutting of the bank toe where non-cohesive sands are exposed. As the channel is constructed, it will be important to consider the need for local bank toe protection where the channel perimeter appears highly erosive. The allowance for some vegetative

recovery prior to the activation of reconstructed channels will significantly reduce the potential for short-term instability within the new channel.

Project Implementation

Relocating the channel to its historic elevation is possible by placing a plug across the existing channel that diverts flow into a newly constructed channel course. Using the meadow topography as a generalized elevation of the new floodplain, the new channel can be constructed at a proper sinuosity, gradient, and dimension to provide suitable riffle and pool habitat features. Following channel excavation, riparian revegetation and recovery will provide a suitable, well vegetated corridor along the new channel. Groundwater hydrology will be affected by the raised elevation of the new channel, and will likely return the project area into a wet meadow complex. Material generated by excavating the new channel can be used to fill the deactivated segments of Goose Creek. Placing a plug at the head of the new channel will result in a lengthy backwatered portion of Goose Creek upstream of the plug. This backwater feature will not result in flooding of the elevated meadow upstream of the reconstructed channel, because the existing channel is highly incised and able to contain additional water depths.

Placing a fish passage barrier within the project area is challenging due to the relatively flat gradient of Goose Creek and Big Meadows. An effective barrier to prevent brook trout movement upstream must be a minimum of four feet high and pass 100 year flood flows. Typically, fish passage barriers are installed in locations where a creek flows through a relatively confined valley and has sufficient gradient to provide the vertical drop necessary to install a drop structure without significantly altering sediment transport. The topography of Goose Creek and Big Meadows does not provide sufficient gradient or valley constrictions to install an effective barrier if the entire channel is relocated to a historic elevation. However, a barrier may be installed if the bed elevation of the channel below the barrier is at least four feet below the bed elevation above the barrier.

Following an analysis of various options for constructing a barrier, the most appropriate location for installing a passage barrier within Tribal property lies at the head of Reach E near the existing culvert and stream crossing. The culvert currently serves as a grade control structure and prevents the upstream migration of headcuts resulting from historic channelization and dredging activity below it. Downstream of the culvert, the channel is highly incised and the stream bed elevation lies 8.5 feet below the meadow. Sufficient channel cross section and meadow topography survey data have been collected to develop conceptual design elements of channel slope and floodway dimensions above and below a barrier if constructed at this location (See channel cross section E-1). Alternative locations for installing a barrier included at the mouth of Goose Creek, within Reach C on private lands, and upstream of Tribal lands. Each of these locations would require a check dam to act as a barrier and would result in a second backwatered reach of the Creek and a high probability of flooding issues. Subsequently, these alternative locations were determined to be inferior to placing a barrier near the existing culvert and excavating a lower floodplain elevation downstream of the structure.

Barrier installation may be accomplished at the proposed location by excavating a new, lower floodplain and channel approximately 6.5' below the existing meadow elevation downstream of the barrier. Currently, the bed of the Goose Creek at the head of reach E is approximately 8.5'

below the meadow; therefore, the newly built channel would be roughly two feet higher immediately below the barrier if installed in this location. Downstream of the barrier, the channel and inset floodplain may be excavated at a sufficient gradient to meet the existing channel on Tribal land near the east end of the meadow. Moreover, construction of a lower floodplain elevation below the barrier would alleviate flooding concerns in the eastern end of Big Meadows during high flow events. This portion of the meadow is extremely flat and would likely be inundated regularly if the reconstructed channel were designed to allow high flow events to escape the constructed channel boundaries.

The barrier must prevent fish passage at regular flooding events as well as large flood events (100-yr return interval) to meet the project goals. Given the flat nature of the meadow, this can be achieved by constructing a low berm across the valley perpendicular to the barrier which will contain the 100-year event while maintaining the passage barrier. Dimensions of the berm will be determined by conducting a flood study using various predictions of flood discharges. A second floodplain berm may be necessary to contain flood flows from reaching agricultural operations on the private parcel that lies between the two main Tribal parcels. Again, the dimensions of the berm will be determined by conducting a flood study and will be designed to withstand a specific flood event.

Project Phases

Due to the magnitude of the project area, the Goose Creek restoration plan has been broken into five phases, each of which can be accomplished in a calendar year. These proposed project phases do not necessarily correspond to the reach breaks defined in Figure 5, and were developed based on constructability. Each construction phase will need a final design completed in order to provide enough detail for a design/build approach. Each phase is described in more detail in the following sections.

Phase 1

This phase will include constructing a new floodplain and meandering channel through the eastern (downstream) portion of Big Meadows. The downstream extent of this project phase is defined by the tie-in point to the existing channel on Tribal land, while the upstream extent is immediately below the fish passage barrier. Construction of the channel below the barrier requires a stream bed elevation at least four feet below the bed above the barrier; therefore, a floodway will be excavated at a lower elevation to allow construction of a meandering channel within it. This phase includes constructing approximately 3,560 feet of floodway which with a top width ranging between 70 and 90 feet. Approximately 4,275 feet of new channel will be excavated within the floodway. Material excavated from the new floodway and channel will be used to fill the deactivated channel segment and construct a floodplain dike. Additional material will be stockpiled to use as fill in subsequent project phases.

A conceptual channel planform for Phase 1 is illustrated in Sheet 1. Planform sinuosity in the eastern extents of Big Meadows was historically 1.6 (Figure 27). Due to the incorporation of the fish passage barrier at the upper end of this phase dropping the channel elevation by four feet, the proposed channel sinuosity in Phase 1 is must be reduced to 1.2 to account for the reduction in gradient. Based on this planform configuration, the overall channel slope will be 0.12%. Four conceptual riffle cross sections downstream of the fish passage barrier are illustrated in Sheet 6. These cross section drawings illustrate the depth of excavation required to establish the new floodway and channel at four locations, including immediately above the barrier, immediately below the barrier, approximately half way between the barrier and the tie-in to the existing channel, and 400 feet upstream of the tie-in. These conceptual cross sections were used to develop material quantities required for excavation purposes.

Floodplain revegetation will include seeding bare areas of excavation and planting riparian shrubs throughout the corridor. Allowing the channel banks and floodplain to revegetate naturally for 1-2 growing seasons prior to activating the channel would reduce the need for using coir fabric or other bioengineering treatments to maintain stability and would greatly reduce project costs. Revegetated areas will be irrigated prior to activating the channel in order to maximize survival and growth rates. Weed management is highly recommended for all disturbed areas, including the new floodplain, floodplain dike, and any spoil piles of material stockpiled for use in subsequent phases.

Prior to initiating construction, a final design will be necessary to provide sufficient details for a design/build approach. Final designs necessary to initiate this phase will include:

- Flood Hazard Study (for entire project area)
- Wetland Delineation and Jurisdictional Determination (for entire project area)
- Final Channel Design (Phase 1 reach only)
- Floodplain Dike Design
- Fish Passage Barrier Design

The flood hazard study will include a determination of areas that are expected to become inundated (flooded) at various discharges in Goose Creek. This study will incorporate topographic data collected via LiDAR and hydrologic data discussed in this report to provide a map of anticipated flooded areas during out-of-bank flow events.

Filling the existing channel and associated wetland fringe will require a permit from the U.S. Army Corps of Engineers (ACOE) as mandated under Section 404 of the Clean Water Act. Under this regulatory framework, the existing channel margins of Goose Creek will likely be classified as emergent riparian wetlands, while the bed of the channel will be classified as a perennial waterway (Cowardin et al 1979). Each of these wetland types are considered jurisdictional by the ACOE and typically require mitigation if more than 0.1 acres are impacted as a result of a particular project. The Goose Creek and Big Meadows Restoration Project will cap the entire length of the existing channel (>12,000 feet of channel), and will result in filling well over the 0.1 acre threshold required for mitigation. Mitigation of the impacted wetlands may potentially be accomplished in-kind by constructing the new channel and riparian corridor, which will add over 4,000 feet of additional channel, and elevate the water table to establish a wetland buffer along the channel. The ACOE will require a wetland delineation of the project area prior to formally issuing a jurisdictional determination (JD) of wetlands and waterways. The wetland delineation must include surveying and mapping jurisdictional wetlands within the vicinity of the project based on wetland hydrology, vegetation, and soils characteristics. Results of the delineation will allow a quantification of existing jurisdictional wetlands and provide a baseline for quantifying proposed impacts in these areas.

The channel design will include finalizing the channel planform, profile, and cross section dimensions, volume calculations, revegetation plans, irrigation measures, erosion control, and equipment access and staging areas. Final plans will be used as construction documents during the implementation phase and may also be useful in obtaining additional regulatory permits.

The floodplain dike will be designed following the flood hazard study to determine how the dike will affect valley flooding during various discharges. The dike will be designed to maintain structural integrity and barrier function during flood flows. A geotechnical investigation of existing soil properties as well as proposed dike materials will be necessary to properly engineer the floodplain dike.

The fish passage barrier will need finalized structural designs and specifications in order to obtain construction bids. The barrier will be designed to maintain a 4' vertical drop and integrate into the floodplain dike. The barrier will also be designed to integrate a railroad car bridge to

maintain a stream crossing at the proposed site. Final designs of the barrier will incorporate Tribal objectives and biological passage requirements for all anticipated fish species.

Phase 2

Phase 2 will include constructing the fish passage barrier and extending the new channel upstream an additional 3,170 feet (Sheet 2). The channel in this phase will be excavated to dimensions that allow the meadow to act as a floodplain and will take advantage of existing swales within the meadow to align the new channel. Sheet 6 illustrates proposed cross sections for riffles and pools upstream of the barrier. The new channel segment may be activated via a bypass channel from Goose Creek at the upstream extent of the phase. Material excavated to create the new channel will be stockpiled to fill the deactivated channel segment in subsequent phases.

Historic planform sinuosity in this reach of Big Meadows was 1.4, which will remain the target sinuosity for Phase 2. This target sinuosity will result in an overall channel gradient of 0.16%. Historic belt width, meander length, and radius of curvature will be used to develop the geometric template of the restored channel.

A floodplain dike will be constructed to maintain the fish passage barrier at high flows. The foundation and core of the dike should be constructed with suitable materials such as clay or gravel to prevent breaching at high flows. The clay layer could be capped with topsoil for revegetation purposes. A geotechnical analysis of existing soil conditions, permeability, and potential borrow sources is highly recommended during final engineering designs.

The fish passage barrier will be installed to provide a 4' drop in elevation in the channel bed. Sheets 7 and 8 illustrate two alternatives for constructing an open channel barrier constructed of concrete. The barrier will include wing walls which will tie into the floodplain dike and a concrete apron to prevent fish jumping immediately below the barrier. Option 1 (Sheet 7) includes incorporation of a railroad car bridge immediately downstream of the barrier, and utilizes the walls of the barrier structure as bridge abutments. Option 2 (Sheet 8) incorporates the rail car bridge on the upstream side of the barrier, and would tie into the floodplain dike. The bridge could be structurally supported by the walls of the barrier, by fill material used to construct the dike, or both. Option 2 would compliment an access road that lies on top of the dike, whereas Option 1 would compliment an access road below the dike. Final designs will need to incorporate specifications for fish passage and structural components of the barrier in order to obtain sufficient construction bids.

Phase 2 revegetation will include installing riparian shrubs along the riparian corridor. This could be accomplished by transplanting woody species from within the active channel, transplanting woody shrubs grown on site, or installing containerized plants. Revegetated areas will be irrigated prior to activating the channel in order to maximize survival and growth rates. Weed management is recommended for all disturbed areas, including spoil piles of material stockpiled for future phases.

This phase will also include activating the new channel and backfilling the existing channel through Phase 1. Stockpiled material excavated during Phase 1 will be used to completely backfill the deactivated channel. The reclaimed channel will be revegetated with seed mix and treated for weeds.

A final channel design will include finalizing the channel planform, profile, and cross section dimensions, volume calculations, revegetation plans, irrigation measures, erosion control, and equipment access and staging areas. Final plans will be used as construction documents during the implementation phase.

Phase 3

Phase 3 extends the new channel construction upstream an additional 4,535 feet (Sheet 3). As in phase 2, channel construction will utilize the meadow as a new floodplain elevation and construct a meandering channel across it. The upstream extent of this phase is at an existing equipment and livestock crossing at the eastern edge of the meadow.

Historic planform sinuosity in this reach ranged from 1.4 in Reach B to 1.9 in Reach C. A target planform sinuosity of 1.4 downstream of the channel crossing will conform to the design sinuosity for Phase 2. Channel gradient in this portion of the new channel will be 0.16%. Upstream of the channel crossing, the target sinuosity will be reduced to 1.3 with an overall channel gradient of 0.15%.

If necessary, a floodplain dike will be constructed along the western side of the new channel between the upstream end of Phase 3 and the channel crossing. This dike will prevent excessive flooding of agricultural operations on private land to the north of the new channel. The dimensions and length of the dike will be determined by results of the flood study.

Revegetation of Phase 3 will include installing woody shrubs along the riparian corridor. Woody shrubs are available to transplant from the existing channel, plants grown on-site, or from nursery stock. Revegetated areas will be irrigated prior to activating the channel in order to maximize survival and growth rates. All disturbed areas will be reseeded and managed for weeds.

This phase will also include activating the new channel and backfilling the existing channel through Phase 2. Stockpiled material excavated during Phases 1 and 2 will be used to completely backfill the deactivated channel. The reclaimed channel will be revegetated with seed mix and treated for weeds.

The channel design will include finalizing the channel planform, profile, and cross section dimensions, volume calculations, revegetation plans, irrigation measures, erosion control, and equipment access and staging areas. Final plans will be used as construction documents during the implementation phase.

Phase 4

Phase 4 of the project includes extending the relocated channel segment 4,195 feet upstream to meet the existing channel above an access road near survey cross section A2. This channel segment will be activated by placing a plug in the existing channel just downstream of the head of the new channel. A new channel crossing will be constructed at the head of the creek and could be either a large culvert or bridge. Material excavated to create the new channel will be stockpiled to fill the deactivated channel in the final phase.

No historic planform geometry is available for this portion of Big Meadows. In order to maintain a consistent gradient with downstream phases, the target planform sinuosity of this reach is 1.7, establishing an overall channel gradient of 0.16%.

Revegetation efforts would include installing woody species along the riparian corridor of the new channel. Woody species transplants are available from the existing channel, may be grown on-site, or purchased from a nursery.

Phase 4 will include activating the new channel segment constructed during Phase 3. Stockpiled material excavated during Phases 1 and 3 will be used to completely backfill the deactivated channel segment. The reclaimed channel will be revegetated with seed mix and treated for weeds.

A new stream crossing will be necessary to provide private landowner access to parcels to the south of Big Meadows. This crossing could consist of a bridge or culverts to allow vehicle passage across the channel.

The channel design will include finalizing the channel planform, profile, and cross section dimensions, volume calculations, revegetation plans, irrigation measures, erosion control, and equipment access and staging areas. Final plans will be used as construction documents during the implementation phase. In addition to the final channel designs completed for Phases 1-3, this phase will require designing a new channel crossing at the head of the relocated reach.

Phase 5

The final phase of the project includes activating the newly constructed channel segment in Phase 4 and reclaiming the deactivated channel segment. Material stockpiled during Phase 4 will be used to fill the deactivated channel. Reclamation of the deactivated channel will include reseeding and treating for weeds.

Activating New Channel Segments

Each of the newly constructed channel segments may be activated by placing a plug in the existing channel to check water into the new channel. A short bypass channel will be necessary to activate Phases 1 and 2, as their upstream endpoints do not terminate at the existing channel. It will be advantageous to wait 1-2 growing seasons following the excavation of each channel segment before activating the channel to allow time for revegetation efforts to take hold. This approach would highly benefit from irrigation of the revegetated riparian corridor for the

duration of time between plant installation and channel activation. Irrigation is recommended because the water table will remain well below the proper, restored elevation until the channel segment is activated. The phases described above include activating new channel segments 1 year following construction; however, this plan could easily be amended to allow a 2 year growth period prior to channel activation.

It is also possible to construct all phases of the new channel prior to activating any channel segments. This would allow the maximum time allotment for revegetation of the first phase. In this case, the fifth phase will include activating the entire channel and reclaiming all of the existing channel in one year.

If the newly constructed channel segments are allowed to revegetate for 1-2 years following the initial construction phase, it will be necessary to provide some form of irrigation along the channel to maintain the riparian and wetland corridor. Although the existing channel is well below the anticipated elevation of the restored channel, it is expected the new channel will intercept localized sources of groundwater at some points of the growing season. Placing temporary check structures such as hay bales in the channel will check the water up and assist in irrigating plants along the channel fringe. If the Tribe maintains sufficient water rights on Goose Creek, temporary diversion structures could be placed to provide flood irrigation along the new channel.

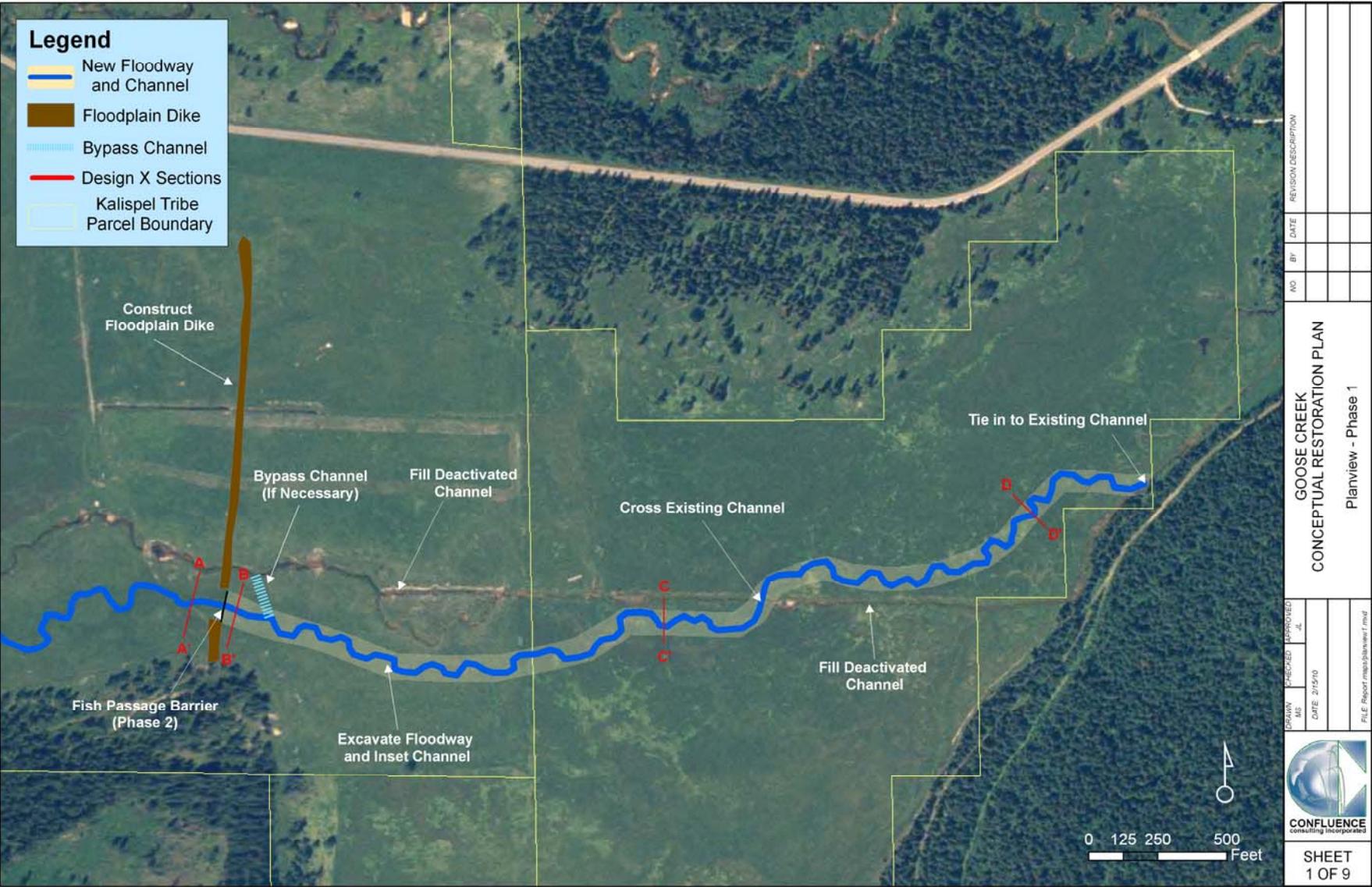
Anticipated Material Volumes

Table 14 provides preliminary cut and fill volumes estimated for each phase as described above. Cut volumes include in-place material necessary for excavation from the floodway and channel in Phase 1 and for the channel in Phases 2-4. Fill volumes were estimated using the average area of surveyed cross sections in the existing channel and multiplying along the length of channel to be filled. These volume estimates are preliminary and should be further investigated in final designs.

Table 14. Conceptual volume estimates, Phase 1-4.

Phase	Cut (cy) (IN PLACE)	Fill (cy)	Net
1	28,275	9,735	18,540
2	6,250	15,110	-8,860
3	8,940	16,310	-7,370
4	8,270	7,020	1,250
Total	51,735	48,175	3,560

These preliminary estimates reveal a net gain of ~3,500 cubic yards of material will be generated by excavating the new channel and floodplain. This material may be utilized to build the floodplain dike(s) and spread across upland areas and reseeded. The excess quantity of material generated from Phase 1 will need to be stockpiled along the existing channel for use in reclaiming it in subsequent phases.

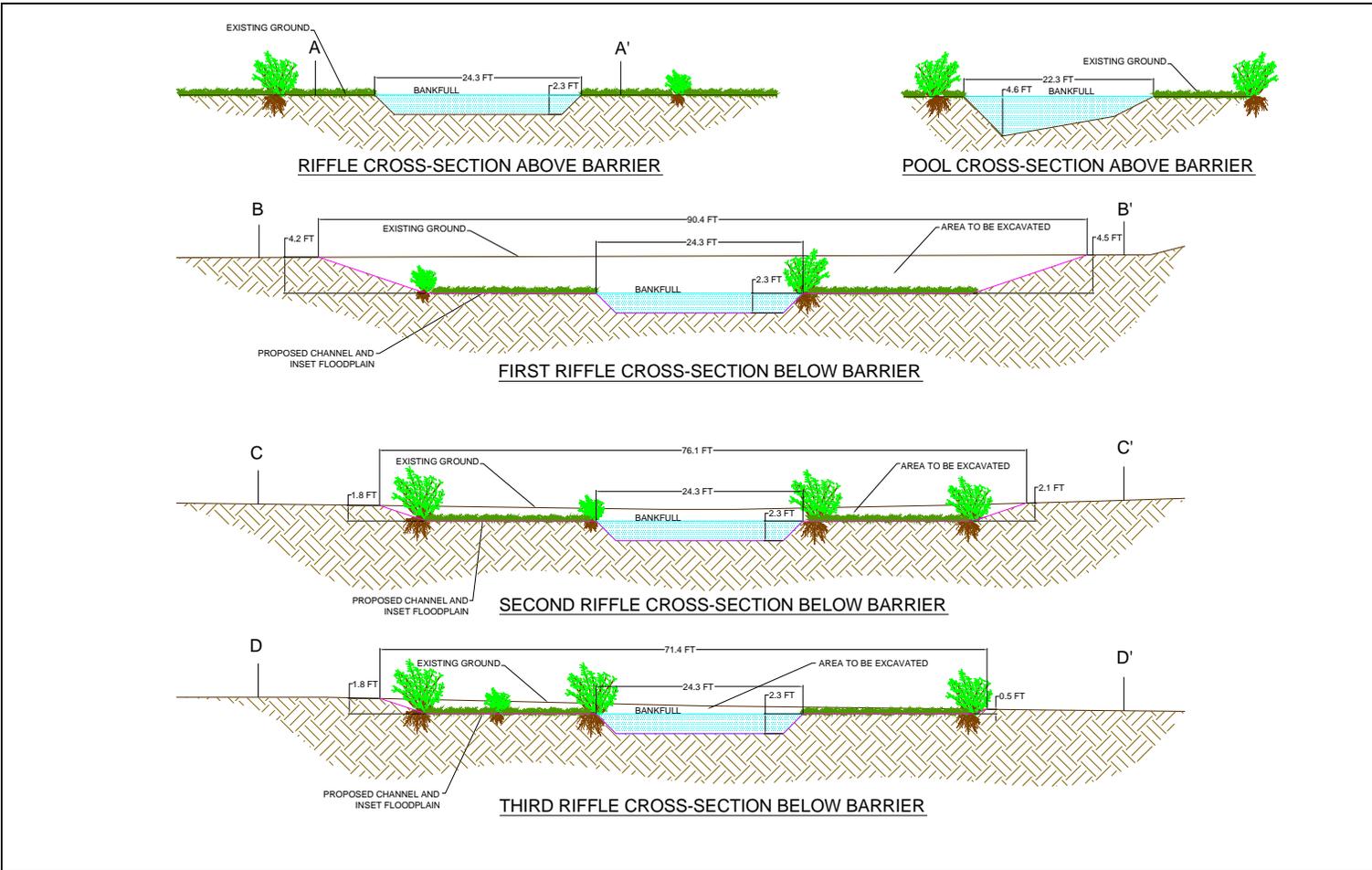








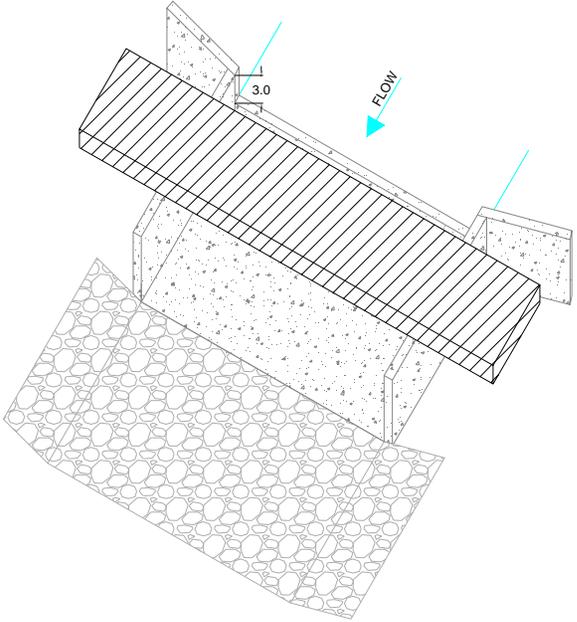
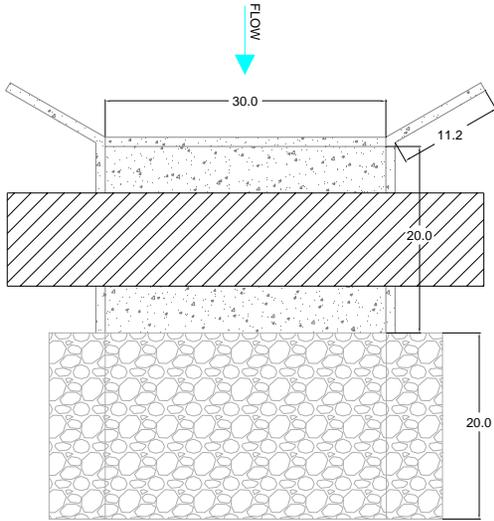
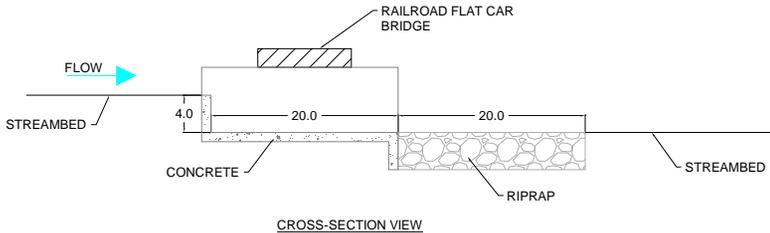




Goose Creek Conceptual Cross-Section Design

Prepared for:
 Kalispel Tribe

Sheet 6 of 8		
Date: 02/16/2010		
Issued For: <i>Conceptual Design</i>		
Drawn	Checked	Approved
RLB	MDS	
<small>Drawing: proposed.dwg</small>		



PLAN VIEW

ISOMETRIC VIEW



PO Box 1133
 Bozeman, MT 59771
 406-585-9500

Goose Creek Conceptual Fish Barrier Design Road and Bridge on DS Side of Berm

Prepared for:
 Kalispel Tribe

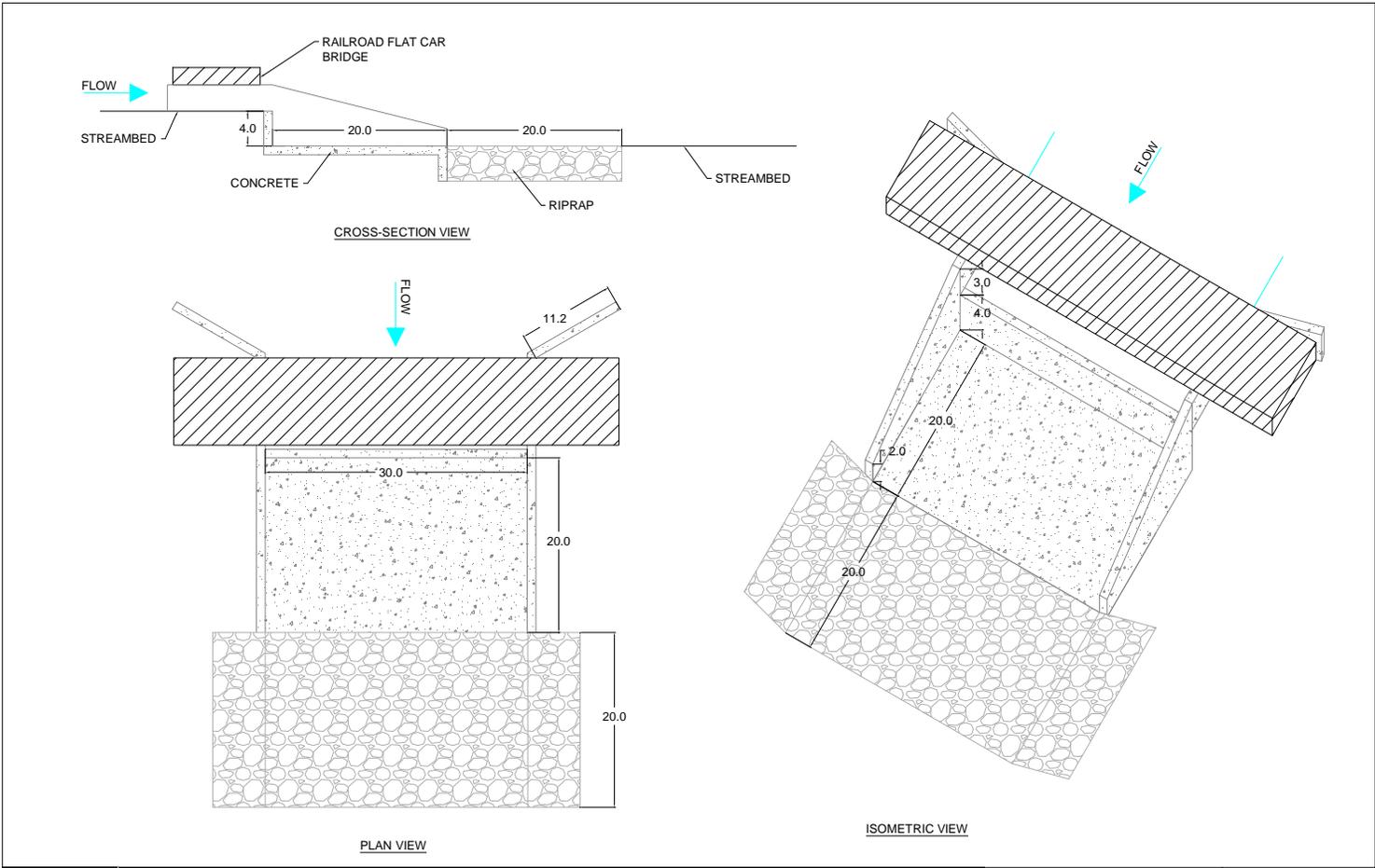
Sheet 7 of 8

Date: 04/16/2010

Issued For:
 Conceptual Design

Drawn	Checked	Approved
RLB	MDS	

Drawing: fish_barrier.dwg



Goose Creek Conceptual Fish Barrier Design Road and Bridge on Top of Berm

Prepared for:
 Kalispel Tribe

Sheet 8 of 8		
Date: 02/16/2010		
Issued For:		
<i>Conceptual Design</i>		
Drawn	Checked	Approved
RLB	MDS	
<small>Drawing: fish_barrier.dwg</small>		

Anticipated Channel Perimeter Materials and Implications for Channel Construction

The reconfiguration of Goose Creek will include vertical shifting of the restored channel relative to the current channel. This change in channel bed elevation may result in the exposure of different boundary materials in the constructed channel relative to those that currently comprise the channel margin. In order to assess this potential change, the conceptual design for Goose Creek at the pit locations was assigned bed elevations for both pool and riffle cross sections, and these elevations are compared to the logged pit stratigraphy (Figure 29 and Table 15).

In the uppermost part of the valley, the restored channel will be impounded at Soil Pit 6, such that the perimeter materials will not change. Downstream at Soil Pit 5, the channel perimeter at riffle cross sections will consist of silts, however the pools will likely extend down into non-cohesive sands. In this area, there is good potential for bank undercutting on the sand horizon, which could provide excellent habitat elements. Alternatively, excess undercutting on the sand horizon could result in localized upper bank collapse. Establishing a channel fringe with dense, wetland and riparian vegetation will be the key to maintaining lateral stability within this area. Field surveys identified no significant borrow areas for wetland sod to transplant along the stream banks. As a result, it would be advantageous to allow 1-2 growing seasons following channel construction to allow wetland vegetation to establish along the immediate bank line. This technique will reduce the potential for block failure and bank undercutting on the sand layer exhibited in Soil Pit 5.

At the locations of Soil Pits 4, 3, and 2, the proposed channel is anticipated to be fully bound by cohesive silts, which will provide significant bank stability that will allow for complex planform elements, and maintenance of relatively low width to depth ratios once the banks are well vegetated. Planform stability will rely on wetland and woody species colonization along the banks. No significant wetland sod borrow sources were identified in the vicinity of the project reach; therefore it is recommended to refrain from activating these channel segments for 1-2 years following excavation. This timeframe will allow revegetation efforts to mature and wetland vegetation to establish along the channel fringe.

At Soil Pit 1, the channel will be held within a deeper, compound cross section that contains an inset floodplain margin. As a result, the deeper cross section will extend down through the sands and into peat for both riffles and pools. Peat is similarly exposed in the bed of the existing channel to the north (Figure 30). Although bank failure is common in that channelized segment, the role of peat in that instability is unclear. This layer will not provide immediate bank and bed stability, although it may provide a rich source of seeds and organic matter. This layer may provide a very suitable medium for revegetation of the floodplain and stream banks. As stated earlier, it would be advantageous to refrain from activating this channel segment immediately following channel construction, and wait 1-2 growing seasons for revegetation efforts to mature.

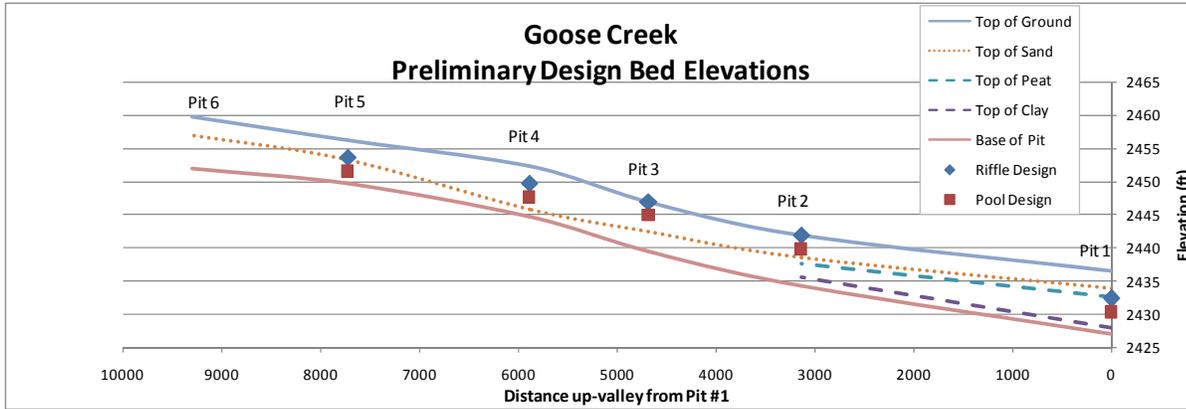


Figure 29. Valley fill stratigraphy and proposed riffle/bed elevations.

Table 15. Anticipated bed materials for pool and riffle cross sections at soil pit locations.

<i>Soil Pit Reference ID</i>	<i>Anticipated Riffle Bank Toe Material</i>	<i>Anticipated Riffle Bed Material</i>	<i>Anticipated Pool Bank Toe Material</i>	<i>Anticipated Pool Bed Material</i>
Soil Pit 1	Sand	Peat	Peat	Peat
Soil Pit 2	Silts	Silts	Silts	Silts
Soil Pit 3	Silts	Silts	Silts	Silts
Soil Pit 4	Silts	Silts	Silts	Silts
Soil Pit 5	Silts	Silts	Non-cohesive sands	Non-cohesive sands
Soil Pit 6	N/A (Backwatered)	N/A (Backwatered)	N/A (Backwatered)	N/A (Backwatered)



Figure 30. Peat exposures in bed of lower Goose Creek.

Conceptual Project Costs

The following section provides total estimated project costs for design and construction for each phase as proposed in this conceptual design report (Table 16). Some components of each phase may be moved to other phases if necessary. For example, construction of the floodplain dike proposed in Phase 2 could be moved to Phase 1. Likewise, if an additional growing season is added to newly constructed stream segments, activation of that segment could be pushed back to a subsequent phase.

Project final design costs for each phase are included in Table 17. Anticipated final designs for Phase 1 are considerably higher due to several additional components necessary to construct the first two phases of the project. Each phase includes a 3% increase per year for cost escalation (inflation). Given the recent turmoil of the construction industry, there is considerable uncertainty in labor, materials, and equipment costs over the next five years. In order to plan for this uncertainty as well as any unforeseen circumstances, a 20% contingency has been added to the overall project cost.

Table 16. Projected Design and Construction Costs for Goose Creek Restoration Project.

Phase 1	Qty	Unit	Price/Unit	Cost	
Phase 1 Final Design	1	LS	\$ 72,280	\$ 72,280	See Detail for Phase 1 Design
Equipment Mobilization	1	LS	\$ 5,000	\$ 5,000	
Construct Channel and Floodway	4272	FT	\$ 65	\$ 277,680	
Revegetate New Channel/Floodplain	6.13	AC	\$ 10,000	\$ 61,295	Plant seed, plugs, shrubs
Flood Irrigation	1	LS	\$ 7,000	\$ 7,000	Install diversions, straw bale dams
Install Phase 1 Sediment Control	3560	FT	\$ 4	\$ 14,240	Silt fence along stream
Weed Control	1	LS	\$ 10,000	\$ 10,000	Initial weed control for entire project area
Subtotal				\$ 447,495	
Construction Oversight (10% of Construction Costs)				\$ 37,521	
Phase 1 Cost				\$ 485,016	
Phase 2	Qty	Unit	Price/Unit	Cost	
Phase 2 Final Design	1	LS	\$ 14,490	\$ 14,490	See Detail for Phase 2 Design
Equipment Mobilization	1	LS	\$ 5,000	\$ 5,000	
Construct Channel	3170	FT	\$ 20	\$ 63,400	
Revegetate New Channel/Floodplain	2.18	AC	\$ 10,000	\$ 21,832	Plant seed, plugs, shrubs
Flood Irrigation	1	LS	\$ 7,000	\$ 7,000	Install diversions, straw bale dams
Construct Berm	4038	CY	\$ 15	\$ 60,570	
Construct Barrier	1	LS	\$ 200,000	\$ 200,000	Concrete dam
Install Phase 2 Sediment Control	2642	FT	\$ 4	\$ 10,567	
Remove Phase 1 Sediment Control/Flood Irrigation	3560	FT	\$ 1	\$ 3,560	
Backfill Phase 1 Existing Channel	9733	CY	\$ 1.50	\$ 14,600	
Reseed Phase 1 Backfill, Spoil Areas	6.54	AC	\$ 2,295	\$ 15,005	Reseed channel fill, beneath spoil piles: seed = 18 lbs/acre @ \$125/lb, seeding = \$25/acre chisel plow + \$20/acre drill seeding
Weed Control	1	LS	\$ 5,000	\$ 5,000	Re-spray weeds as needed for entire project area
Subtotal				\$ 421,023	
Price Escalation 3%				\$ 12,631	
Construction Oversight (10% of Construction Costs)				\$ 41,916	
Phase 2 Cost				\$ 475,570	
Phase 3	Qty	Unit	Price/Unit	Cost	
Phase 3 Final Design	1	LS	\$ 15,510	\$ 15,510	See Detail for Phase 3 Design
Equipment Mobilization	1	LS	\$ 5,000	\$ 5,000	
Construct Channel	4535	FT	\$ 20	\$ 90,700	
Revegetate New Channel/Floodplain	3.12	AC	\$ 10,000	\$ 31,233	Plant seed, plugs, shrubs
Flood Irrigation	1	LS	\$ 7,000	\$ 7,000	Install diversions, straw bale dams
Install Phase 3 Sediment Control	3779	FT	\$ 4	\$ 15,117	
Remove Phase 2 Sediment Control/Flood Irrigation	2642	FT	\$ 1	\$ 2,642	
Backfill Phase 2 Existing Channel	15108	CY	\$ 1.50	\$ 22,662	
Reseed Phase 2 Backfill, Spoil Areas	4.85	AC	\$ 2,295	\$ 11,134	Reseed channel fill, beneath spoil piles: seed = 18 lbs/acre @ \$125/lb, seeding = \$25/acre chisel plow + \$20/acre drill seeding
Weed Control	1	LS	\$ 2,500	\$ 2,500	Spot-spray weeds as needed for entire project area
Subtotal				\$ 203,497	
Price Escalation 3%				\$ 12,393	
Construction Oversight (10% of Construction Costs)				\$ 20,038	
Phase 3 Cost				\$ 235,928	
Phase 4	Qty	Unit	Price/Unit	Cost	
Phase 4/5 Final Design	1	LS	\$ 18,970	\$ 18,970	See Detail for Phase 4/5 Design
Equipment Mobilization	1	LS	\$ 5,000	\$ 5,000	
Construct Channel	5195	FT	\$ 20	\$ 103,900	
Revegetate New Channel/Floodplain	3.58	AC	\$ 10,000	\$ 35,778	Plant seed, plugs, shrubs
Construct New Channel Crossing (bridge)	1.00	LS	\$ 16,000	\$ 16,000	Install bridge
Flood Irrigation	1	LS	\$ 7,000	\$ 7,000	Install diversions, straw bale dams
Install Phase 4 Sediment Control	4329	FT	\$ 4	\$ 17,317	
Remove Phase 3 Sediment Control/Flood Irrigation	3779	FT	\$ 1	\$ 3,779	
Backfill Phase 3 Existing Channel	16309	CY	\$ 1.50	\$ 24,464	
Reseed Phase 3 Backfill, Spoil Areas	6.94	AC	\$ 2,295	\$ 15,929	Reseed channel fill, beneath spoil piles: seed = 18 lbs/acre @ \$125/lb, seeding = \$25/acre chisel plow + \$20/acre drill seeding
Weed Control	1	LS	\$ 2,500	\$ 2,500	Spot-spray weeds as needed for entire project area
Subtotal				\$ 250,636	
Price Escalation 3%				\$ 23,241	
Construction Oversight (10% of Construction Costs)				\$ 25,491	
Phase 4 Cost				\$ 299,368	
Phase 5	Qty	Unit	Price/Unit	Cost	
Mobilization	1	LS	\$ 5,000	\$ 5,000	
Remove Phase 4 Sediment Control/Flood Irrigation	4329	FT	\$ 1	\$ 4,329	
Backfill Phase 4 Existing Channel	7021	CY	\$ 1.50	\$ 10,532	
Reseed Phase 4 Backfill, Spoil Areas	7.95	AC	\$ 2,295	\$ 18,247	Reseed channel fill, beneath spoil piles: seed = 18 lbs/acre @ \$125/lb, seeding = \$25/acre chisel plow + \$20/acre drill seeding
Weed Control	1	LS	\$ 2,500	\$ 2,500	Spot-spray weeds as needed for entire project area
Subtotal				\$ 40,608	
Price Escalation 3%				\$ 5,097	
Construction Oversight (10% of Construction Costs)				\$ 4,570	
Phase 5 Cost				\$ 50,275	
Subtotal All Phases				\$ 1,546,157	
Contingency 20%				\$ 309,231	
TOTAL COST				\$ 1,855,388	

Table 17. (series) Phase 1-4 Final Design Cost Estimates

**Final Designs - Goose Creek Restoration Project
 Phase 1**

Task No.	Task Description	Total
1	Flood Study	\$15,045
1.1	Cross Section Surveys	\$4,900
1.2	Hydraulic Modeling	\$7,650
1.3	Maps and Reporting	\$2,495
2	Wetland Delineation and Reporting	\$8,050
2.1	Wetland Delineation	\$4,650
2.2	Survey Wetland Boundary	\$840
2.3	Write Report of Findings and Submit to ACOE	\$2,560
3	Final Channel Design	\$18,080
3.1	Final Volume Calculations	\$680
3.2	Equipment staging, material placement	\$340
3.3	Final Revegetation Plan	\$7,520
3.4	Final Channel/Floodway Drawings and Specifications	\$7,500
3.5	Final Irrigation Plan	\$1,360
3.6	Final Sediment Control Plan	\$680
4	Floodplain Dike Design	\$21,335
4.1	Geotechnical Soil Survey and Analysis	\$16,650
4.2	Floodplain Dike Designs and Specifications	\$4,685
5	Fish Passage Barrier Design	\$6,750
5.1	Structural Design	\$1,290
5.2	Hydraulics	\$1,360
5.3	Final Design and Specifications	\$4,100
6	Project Management	\$3,020
6.1	Contracting, Budget Management	\$1,345
6.2	Communications, planning, logistics	\$1,675

Total Cost \$72,280

Final Designs - Goose Creek Restoration Project

Phase 2

Task No.	Task Description	Total
1	Final Channel Design	\$12,840
1.1	Final Volume Calculations	\$680
1.2	Equipment staging, material placement	\$340
1.3	Final Revegetation Plan	\$3,420
1.4	Final Channel/Floodway Drawings and Specifications	\$6,360
1.5	Final Irrigation Plan	\$1,360
1.6	Final Sediment Control Plan	\$680
2	Project Management	\$1,650
2.1	Contracting, Budget Management	\$570
2.2	Communications, planning, logistics	\$1,080
Total Cost		\$14,490

Final Designs - Goose Creek Restoration Project

Phase 3

Task No.	Task Description	Total
1	Final Channel Design	\$13,860
1.1	Final Volume Calculations	\$680
1.2	Equipment staging, material placement	\$340
1.3	Final Revegetation Plan	\$3,420
1.4	Final Channel/Floodway Drawings and Specifications	\$6,360
1.5	Final Irrigation Plan	\$1,360
1.6	Final Sediment Control Plan	\$680
1.7	Final Stream Crossing Design	\$1,020
2	Project Management	\$1,650
2.1	Contracting, Budget Management	\$570
2.2	Communications, planning, logistics	\$1,080
Total Cost		\$15,510

Final Designs - Goose Creek Restoration Project
Phase 4/5

Task No.	Task Description	Total
1	Final Channel Design	\$17,320
1.1	Final Volume Calculations	\$680
1.2	Equipment staging, material placement	\$340
1.3	Final Revegetation Plan	\$1,820
1.4	Final Channel/Floodway Drawings and Specifications	\$6,360
1.5	Final Irrigation Plan	\$1,360
1.6	Final Sediment Control Plan	\$680
1.7	Final Stream Crossing Design	\$1,020
1.8	Bridge/Culvert Crossing Design	\$5,060
2	Project Management	\$1,650
2.1	Contracting, Budget Management	\$570
2.2	Communications, planning, logistics	\$1,080
Total Cost		\$18,970

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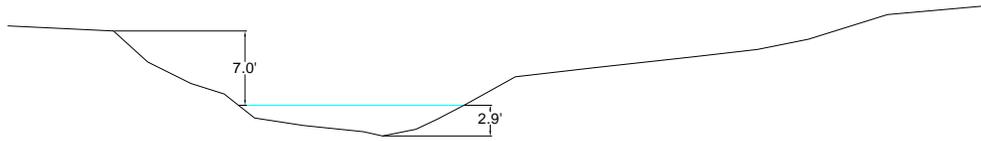
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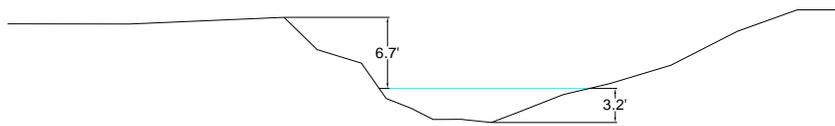
Appendix A

Plots of Surveyed Cross Sections in Goose Creek, 2009

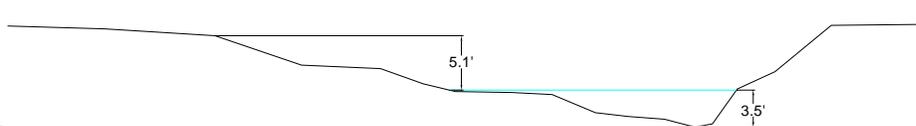
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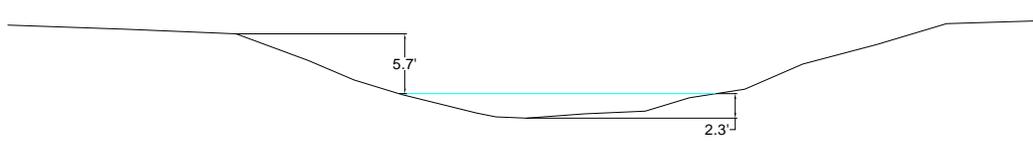
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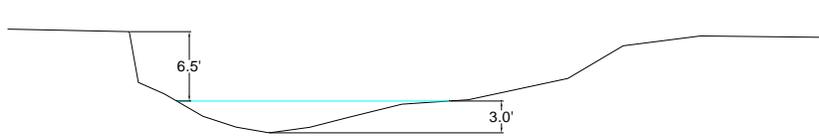
A3



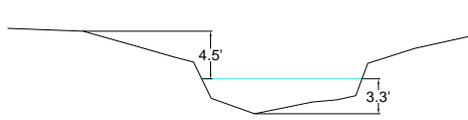
A4



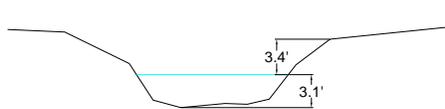
B1



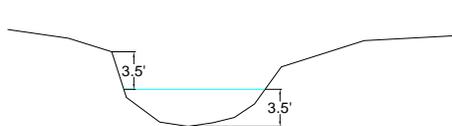
B2



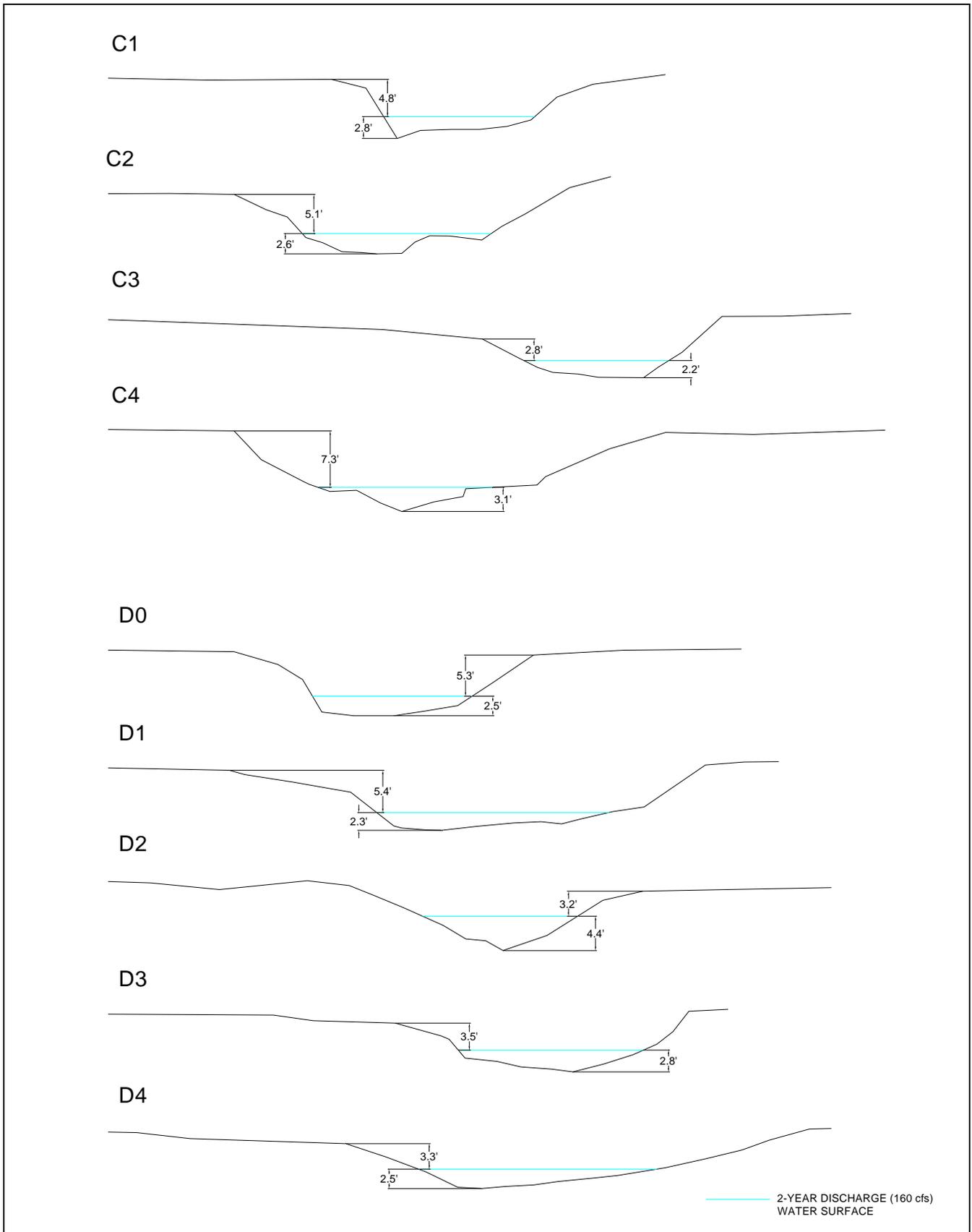
B3

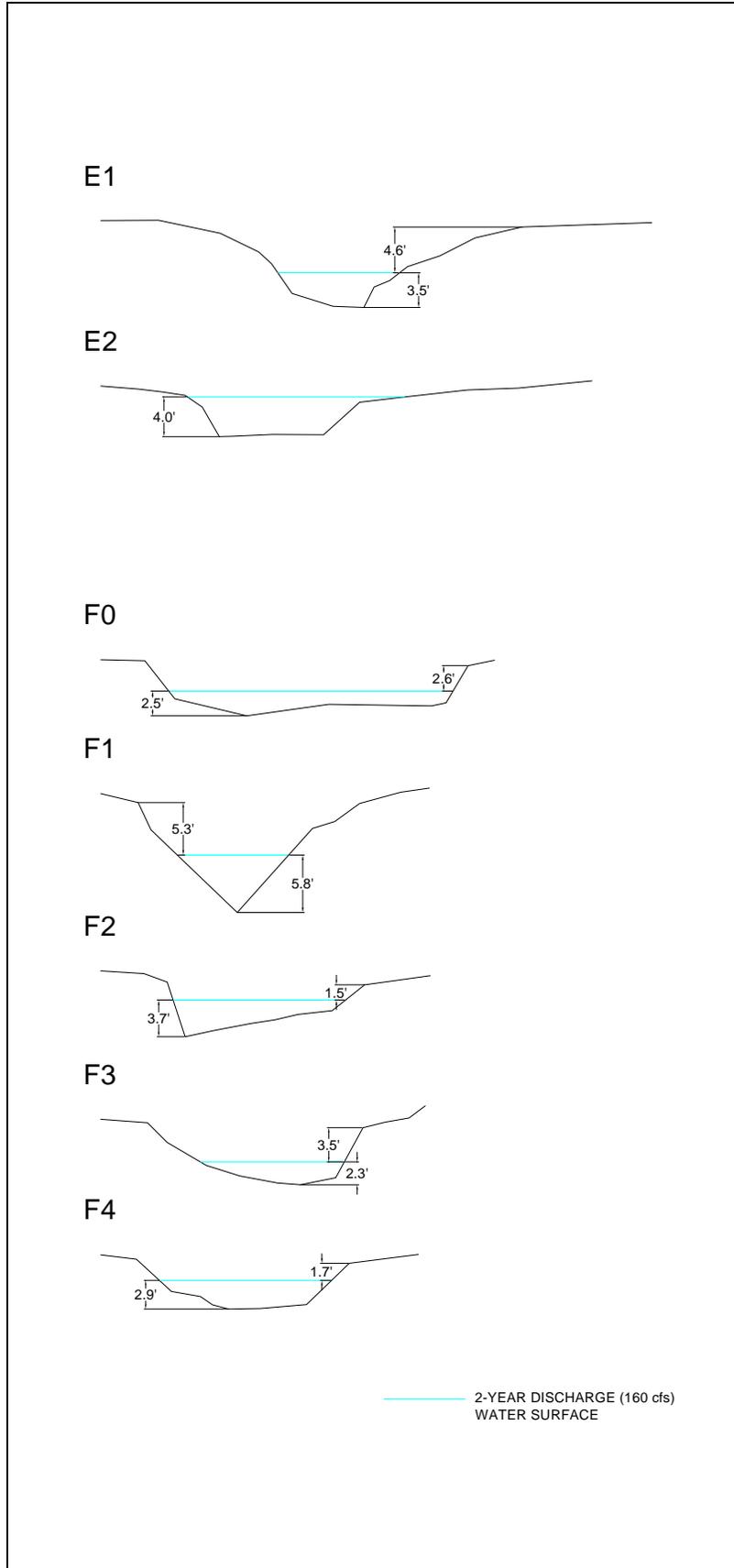


B4



— 2-YEAR DISCHARGE (160 cfs)
WATER SURFACE



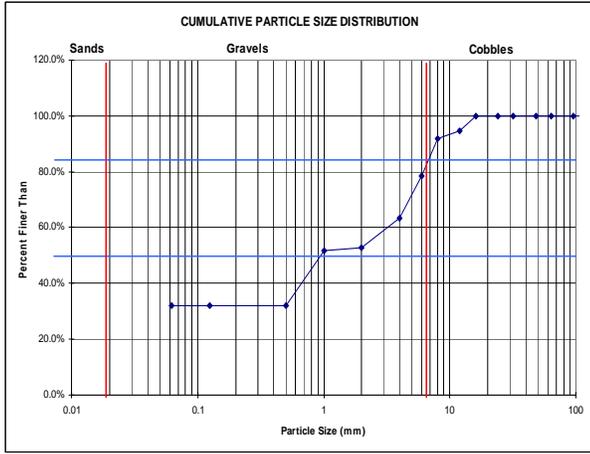


Appendix B

Pebble Count Results for Goose Creek, 2009

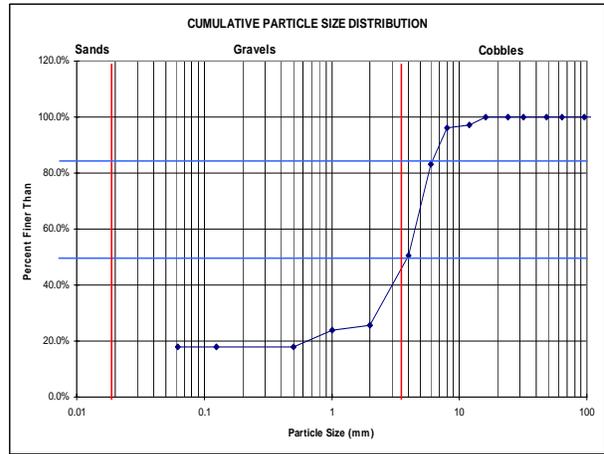
XS: A2
 Reach: Pool

D₅₀: 0.9mm
D₈₄: 6.8mm



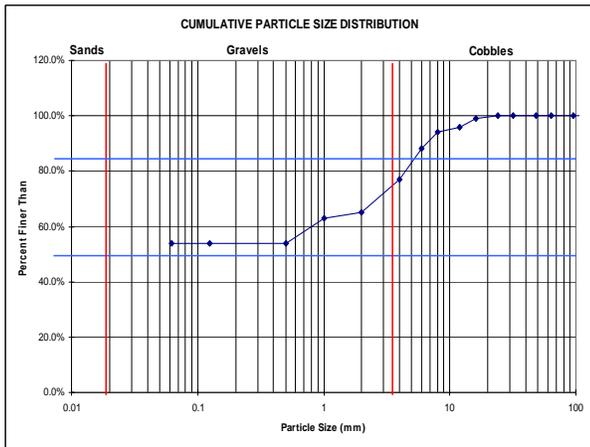
XS: A4
 Reach: Riffle

D₅₀: 3.8mm
D₈₄: 6.1mm



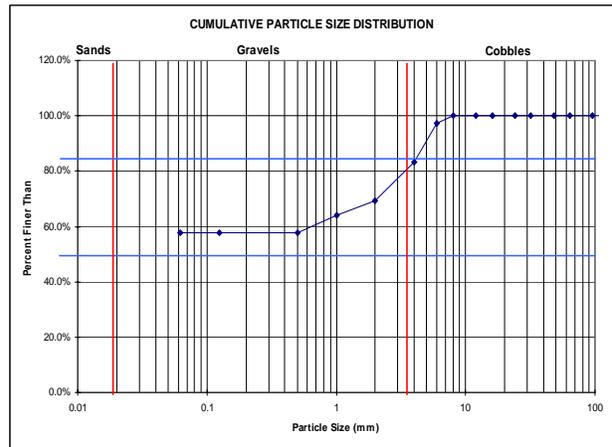
XS: B3
 Reach: Riffle

D₅₀: <.062mm
D₈₄: 5.5mm



XS: B4
 Reach: Pool

D₅₀: <.062mm
D₈₄: 4.2mm



XS: C2
 Reach: Riffle

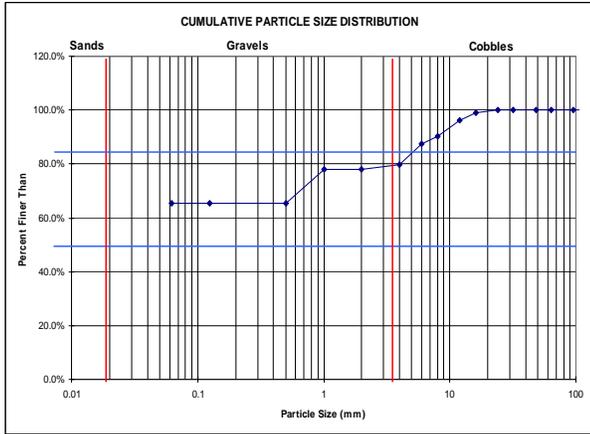
D₅₀: <.062mm
D₈₄: 5.0mm



XS: C4
 Reach: Pool

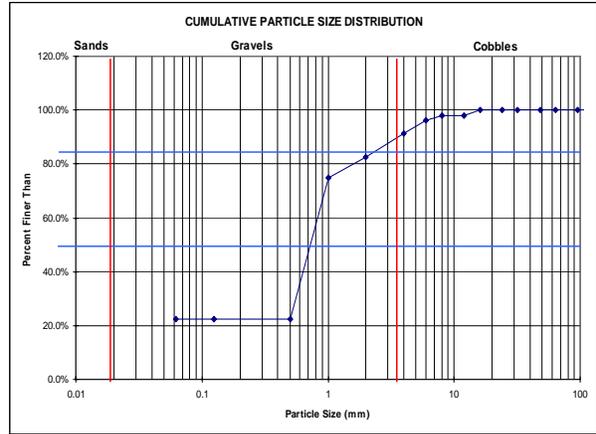
D₅₀: 0.7mm
D₈₄: 2.33 mm





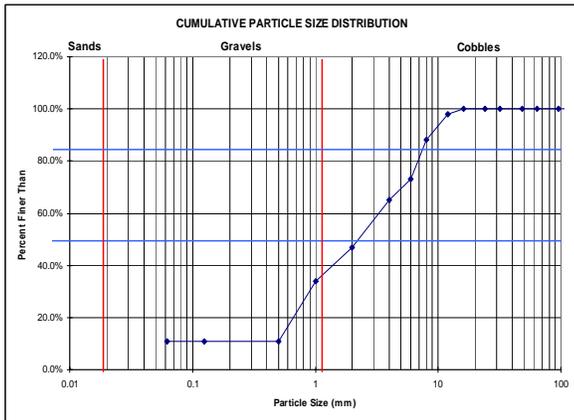
XS: D1
Reach: Pool

D₅₀: 2.33mm
D₈₄: 7.0mm



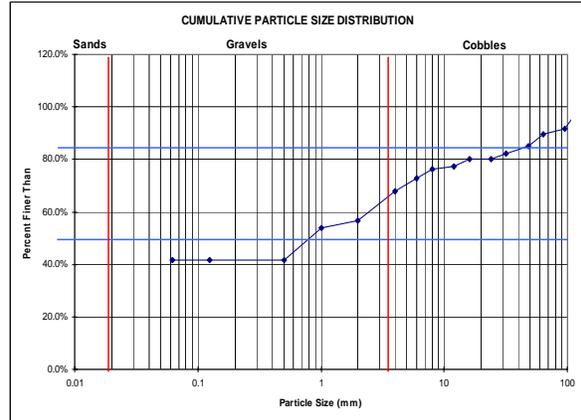
XS: D2
Reach: Pool

D₅₀: 0.8mm
D₈₄: 45.0mm



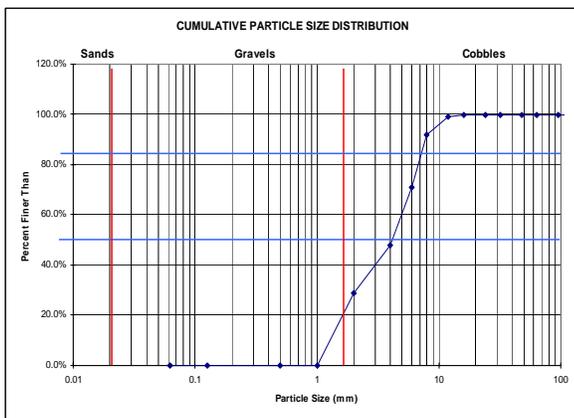
XS: D3
Reach: Riffle

D₅₀: 4.33mm
D₈₄: 7.5mm



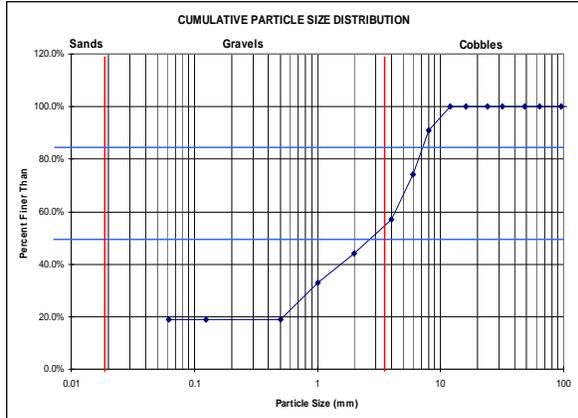
XS: D4
Reach: Riffle

D₅₀: 2.66mm
D₈₄: 7.0mm



XS: E1

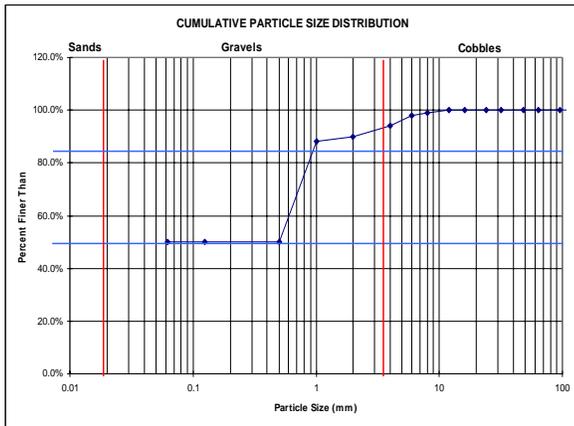
D₅₀: 0.5mm



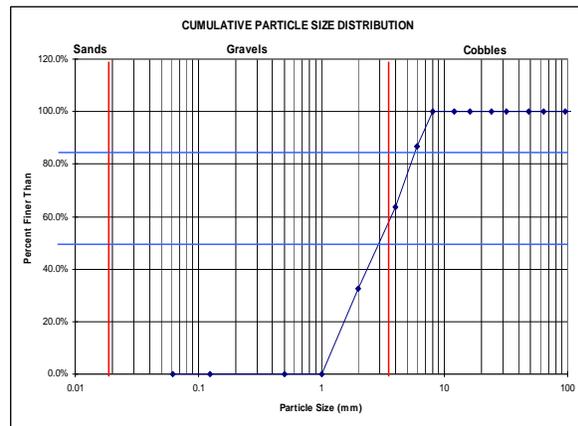
XS: E2

D₅₀: 3.0mm

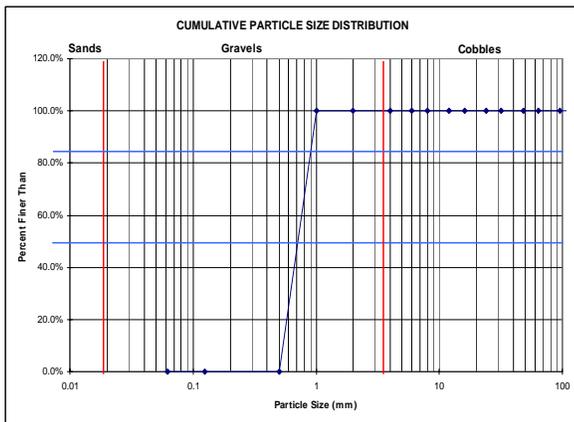
Reach: **D₈₄: 0.9mm**



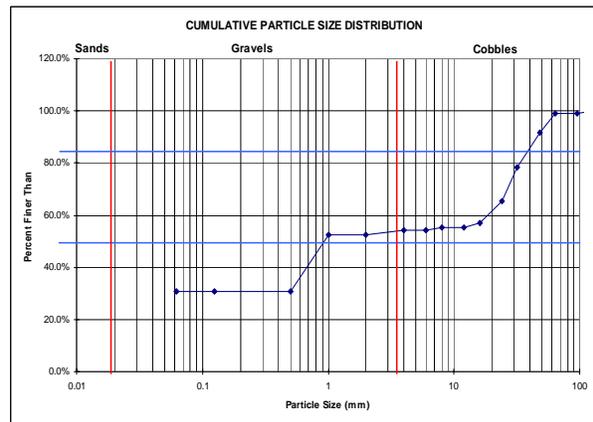
Reach: Pool **D₈₄: 5.5mm**



XS: F3 **D₅₀: 0.7mm**
Reach: Pool **D₈₄: 0.9mm**



XS: F4 **D₅₀: 0.9mm**
Reach: Riffle **D₈₄: 3.7mm**



Appendix C

Soil Pits Logs, Big Meadows, 2009

Test Pit Log

Goose Creek Test Pit Logs			
Pit Number: <u>1</u>		Location: N: <u>5366224</u>	
Date: <u>9/15/09</u>		E: <u>0501359</u>	
Logger: <u>Karin Boyd</u>		Page <u>1</u> of <u>1</u>	
Depth (ft)	Stratigraphy (Drawing)	Description	Comments
0.0		DARK BROWN, MASSIVE SILTS/SANDS	
0.2			
0.4			
0.6			
0.8			
1.0			
1.2			
1.4			
1.6			
1.8			
2.0			
2.2			
2.4			
2.6			
2.7			
2.8		LIGHT BROWN SILT TO SAND - DISTINCT CHANNELS	
3.0			
3.2			
3.4			
3.6			
3.8		COARSE channel deposits SAND TO FINE GRAVEL	
4.0			
4.2		PEAT	
4.4			
4.6			
4.8			
5.0			
5.2			
5.4			
5.6			
5.8			
6.0			
6.2			
6.4			
6.6			
6.8			
7.0			
7.2			
7.4			
7.6			
7.8			
8.0			
8.2			
8.4			
8.6			
8.8			
9.0		BLUE/GRAY CLAY	
9.2			
9.4			
9.6			
9.8			
10.0			

P2241 →
 P2242 →

P2240 →

P2239 - General Pit
 P2240 - lowestmost clay
 P2241 - Massive Peat
 P2242 " "

Test Pit Log

Goose Creek Test Pit Logs

Pit Number: ② Location: N: 5366212
 Date: 9/15/09 E: 0500572
 Logger: Karin Boyd Page 1 of 1

Depth (ft)	Stratigraphy (Drawing)	Description	Comments
0.0		TAN BLOCKY TOPSOIL	0-0.7
0.2		ROOT DENSITY	POOR STRUCTURE LIKELY DISTURBED
0.4		~25% ₂₀	
0.6			
0.8		LIGHT BROWN SILTY SILT	LOOKS STRUCTURED UNDISTURBED
1.0			
1.2		BLACK MASSIVE SOIL HORIZON	1.0-1.9 UNDISTURBED SOILS
1.4		ROOT DENSITY	
1.6		~10% ₂₀	
1.8			
2.0		LIGHT BROWN SILT/CLAY	1.9-2.8: FINE GRAINED, STRUCTURED
2.2		ROOT DENSITY ~10% ₂₀	OVERBANK (SLACKWATER DEPOSIT)
2.4			
2.6			
2.8			
3.0		FINE SANDS SILTY CLAY INTERBEDS	2.8-3.4: INTERBEDDED FS SAND TO CLAY BIOTITE-RICH
3.2			
3.4			
3.6		COARSE QUARTZITIC SAND TO FINE GRAVEL CHANNELS	3.4-4.3: SAND CHANNEL 10' WIDE 2.5' DEEP
3.8			SAMPLE PIT #2
4.0			
4.2			
4.4			
4.6		PEAT - ORGANIC-RICH, STICKS CLAY MATRIX	4.3-6.3 PEAT - BEAVER DAM DEPOSITS?
4.8		IRREGULAR UPPER CONTACT	
5.0			
5.2			
5.4			
5.6			
5.8			
6.0			
6.2			
6.4		Ogl clay w/ MINOR COARSE SAND LENSES	6.3-7.3: Ogl clay w/ MINOR GRAY SAND LENSES
6.6		HIGHLY SATURATED / UNSTABLE	
6.8			
7.0			
7.2			
7.4			
7.6		MASSIVE SATURATED GRAY SAND	7.3-7.6: MASSIVE SATURATED GRAY GRANULIC SAND
7.8		GRANULIC (GRUSS TO FINE GRAVEL)	SATURATED => COLLAPSING
8.0			P2247
8.2			
8.4			
8.6			
8.8			
9.0			
9.2			
9.4			
9.6			
9.8			
10.0			

P2244 →

H₂O 7.3
 P2245 →

T.D. = 7.6'

P2244 Sand channel

P2246 PIT FROM SOUTH

Test Pit Log

Goose Creek Test Pit Logs

Pit Number: 3 Location: N: 5366165
 Date: 9/14/09 E: 0500027
 Logger: KARL BOYD Page 1 of 1

Depth (ft)	Stratigraphy (Drawing)	Description	Comments
0.0		MASSIVE BLOCKY TOPSOIL	0-1.6: Non-DESCRIPTIVE BLOCKY MASSIVE TAN SILTY LAYER w/ ROOT DENSITY 5-20% NATURAL OVBANK DEPOSITS TOPSOIL
0.2			
0.4			
0.6			
0.8			
1.0			
1.2		THINLY BEDDED WHITE ASH LAYER ROOT DENSITY <5%	1.6-2.2: WHITE-LIGHT GRAY ASH/TOFF MAZAMA ASH 6600-7000 bp?
2.0			
2.2		MASSIVE SILT (FINE SAND-MODERATELY COHESIVE)	2.2-4.6 OVBANK SAND/SILT
2.4			
2.6			
2.8			
3.0			
3.2			
3.4			
3.6			
3.8			
4.0			
4.2		SAND TO MEDIUM GRAVEL. SATURATED/ UNCONSOLIDATED/ COMPRESSING	4.6-7.5 COARSE SATURATED
4.4			
4.6			
4.8			
5.0			
5.2			
5.4			
5.6			
5.8			
6.0			
6.2		SAND TO MEDIUM GRAVEL. SATURATED/ UNCONSOLIDATED/ COMPRESSING	4.6-7.5 COARSE SATURATED
6.4			
6.6			
6.8			
7.0			
7.2			
7.4			
7.6			
7.8			
8.0			
8.2			
8.4			
8.6			
8.8			
9.0			
9.2			
9.4			
9.6			
9.8			
10.0			

2250 →

7.5'

T.D. 7.5'

P2248
 P2249
 P2250
 P2251
 P2252

Test Pit Log

Goose Creek Test Pit Logs

Pit Number: (4) Location: N: 5 3660 26
 Date: 9/14/09 E: 0499762
 Logger: K Boyd Page 1 of 1

Depth (ft)	Stratigraphy (Drawing)	Description	Comments
0.0		BLOCKY, NON-STRUCTURED SILTY SOIL	0-1.4: TOPSOIL - REWORKED?
0.2			
0.4			
0.6		DISTINCT SAND LAYERS	
0.8			
1.0		ROOTING DENSITY ~20%	
1.2			
1.4			
1.6		WHITE ASH ~0.5' THICK	1.4-2.0: WHITE THINLY-BEDDED TUFF/MOZAMA ASH?
1.8		THIN BEDS EVIDENT	
2.0			
2.2			
2.4		MASSIVE SILTS FINE SAND	2.0-4.4: COHESIVE SILTS - MASSIVE SLACKWATER FLOODPLAIN
2.6			
2.8		ROOT DENSITY ~5%	
3.0			
3.2			
3.4		DARK BROWN	
3.6			
3.8			
4.0			
4.2			
4.4			
4.6		INTERBEDDED SILTS / FINE SAND	4.4-5.2: THINLY-BEDDED FLOOD DEPOSITS < 1/4" BEDDING NON-COHESIVE / ERODIBLE
4.8			
5.0			
5.2			
5.4			
5.6		MASSIVE BROWN SILT	5.2-6.4: RESISTANT / COHESIVE MASSIVE SILT
5.8			
6.0			
6.2			
6.4			
6.6		SATURATED GRANITIC SAND / WOODY DEBRIS	6.4-7.5: MASSIVE, WET GRANITIC SANDS WITH STICKS TO 6" DIAMETER STUMPS AND WOOD. COARSE SAND TO FINE GRAVEL. FINER THAN PIT #3
6.8			
7.0			
7.2			
7.4			
7.6			
7.8			
8.0			
8.2			
8.4			
8.6			
8.8			
9.0			
9.2			
9.4			
9.6			
9.8			
10.0			

P2254 →

P2255 →
P2256

7.5' T.D.
W.S.L.

P2253
P2254
P2255
P2256

Test Pit Log

Goose Creek Test Pit Logs			
Pit Number: <u>5</u>		Location: N: <u>536584</u>	
Date: <u>9/14/09</u>		E: <u>0499306</u>	
Logger: <u>KARIN BOUD</u>		Page <u>1</u> of <u>1</u>	
Depth (ft)	Stratigraphy (Drawing)	Description	Comments
0.0		MASSIVE SILT	0-1.8:
0.2			INFILL -
0.4			STRUCTURELESS
0.6			
0.8			
1.0			
1.2			
1.4			
1.6			
1.8		BROWN THINLY-LAMINATED CLAYS W/ SOME SILT	1.8-2.4:
2.0			INTERBEDDED ASH/SILT
2.2			MOZAMA'S
2.4			
2.6		INTERBEDDED SILT/SAND	2.4-2.8
2.8			
3.0		SAND TO FINE GRAVEL PT BAR DEPOSIT IN OLD SWALE	2.8-3.8
3.2			2.8-3.8: CLEAN COARSE SAND / FINE GRAVEL -
3.4			LENS THICKENS NORTHWARD
3.6			TO 4' THICK
3.8			PT BAR DEPOSIT
4.0			
4.2			
4.4			
4.6		MASSIVE SILT/CLAY DARK BROWN W/ HI CONC. WOODY DEBR.	BEAVER DAM / BACKWATER / SLOUGH DEPOSITS
4.8			
5.0			
5.2			
5.4			
5.6			
5.8			
6.0			
6.2			
6.4			
6.6			
6.8			
7.0			
7.2			
7.4			
7.6			
7.8			
8.0			
8.2			
8.4			
8.6			
8.8			
9.0			
9.2			
9.4			
9.6			
9.8			
10.0			

P2258 →
P2259

TD 6.5

P2257 P2258 P2259
P2260

Test Pit Log

Goose Creek Test Pit Logs			
Pit Number: <u>6</u>		Location: N: <u>5365399</u>	
Date: <u>9/14/09</u>		E: <u>0499014</u>	
Logger: <u>KARL BOYD</u>		Page <u>1</u> of <u>1</u>	
Depth (ft)	Stratigraphy (Drawing)	Description	Comments
0.0		MASSIVE SILTS / FINE SAND W/ MINIMAL INTACT STRUCTURE. NO SOIL HORIZON BOUNDARIES. ROOT DENSITY 5-10%	0-1.8': Disturbed SOIL / TILLED + LEVELED
0.2			
0.4			
0.6			
0.8			
1.0			
1.2			
1.4			
1.6			
1.8			
2.0		PREDOMINANTLY SILT WITH FINE SAND INTERBEDS	1.8-2.8
2.2			INTERBEDDED SILT / SAND
2.4		OVERBANK DEPOSITS	UNCONFORMABLE LOWER CONTACT
2.6			
2.8		FINING UPWARD CLEAN GRANITIC SAND UP TO 6MM. DISTINCT SMALL CHANNELS	2.8-4.6
3.0			GRANITIC SAND CHANNEL SEQUENCE - FLUVIAL -
3.2			
3.4			
3.6			
3.8			
4.0			
4.2			
4.4			
4.6			
4.8		INTERBEDDED BLACK ORGANIC-RICH SILTS WITH TAN GRANITIC SAND. LARGE WOOD FRAGMENTS COMMON IN DARK LAYERS	4.6-6.0
5.0			BACKWATERED OVERBANK DEPOSITION WITH SHEETFLOW SANDS INTERBEDS
5.2			
5.4			
5.6		MASSIVE SATURATED GRAY SANDS WITH LARGE STICK FRAGMENTS TO 2" DIAMETER	SHEETFLOW + CHANNELIZED SAND WITH HI WOODY DEBRIS LOAD - BEAVER COMPLEX?
5.8			
6.0			
6.2			
6.4			
6.6			
6.8			
7.0			
7.2			
7.4			
7.6			
7.8			
8.0			
8.2			
8.4			
8.6			
8.8			
9.0			
9.2			
9.4			
9.6			
9.8			
10.0			

▽
7.7' T.D

- PZZ61
- PZZ62
- PZZ63
- PZZ64
- PZZ65
- PZZ66