Aquatic Habitat Survey
&
Habitat Enhancement Plan
for Bear Creek
Bear Creek Regional Park
El Paso County Parks Department
Colorado Springs, El Paso County
Colorado

Prepared by

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In July 2006, FIN-UP Habitat Consultants, Inc. was contracted by MFG, Inc. to conduct an aquatic habitat analysis and habitat enhancement strategy for a segment of Bear Creek between 8th Street and 21st Street within Bear Creek Regional Park. An aquatic assessment was conducted within the project area during the 2nd and 3rd week of September, 2006, and the results of this work are summarized below.

Bear Creek is a small, headwater tributary of Fountain Creek, located on the east slope of Pikes Peak, in EI Paso County Colorado. The stream begins as a series of small tributaries in Jones Park, a high mountain meadow located approximately five miles southwest of the City of Colorado Springs. From the headwaters in Jones Park, Bear Creek descends steeply through a rocky canyon1/2 mile before another steep, narrow and rocky section is encountered. Downstream of this second area of falls, the stream maintains a relatively constant gradient, until it exits the canyon near the Gold Camp Road in Colorado Springs. Downstream of the Gold Camp Road, the stream flows through Bear Creek Regional Park, crossing under 21st Street and 8th Street south of the former gold mill at Gold Hill Mesa. The stream eventually flows into Fountain Creek near the Martin Drake Power Plant.

The geology of the headwaters of Bear Creek is composed of weathered, decomposing Pikes Peak granite. A popular one-way dirt road, the High Drive, joins the stream at a point close to the Forest Service Boundary and confines the stream channel through the lower portion of the canyon. Two very popular trails are accessed from the High Drive. A multiple-use trail (FS Trail #667), known locally as the Buckhorn Trail, begins at the small saddle near Mays Peak, and follows a ridge crest west to Jones Park. This trail receives considerable motorcycle and mountain bicycle traffic, and is severely eroded along most of it's length. The Buckhorn Trail joins Bear Creek immediately upstream of the bedrock falls, located downstream of Jones Park. The Bear Creek Canyon Trail, begins at the point where the High Drive joins Bear Creek. This trail follows the creek for approximately 1/4 mile before climbing the south slope of the canyon. The trail again joins the creek at the bedrock falls mentioned above, and continues a few hundred feet further to the junction with the Buckhorn Trail. Studies conducted by the US Forest Service in the headwaters of the watershed in the mid 1990's indicate that High Drive and the two trail systems may be significant contributors of sediment to Bear Creek.

Downstream of Gold Camp Road, the stream enters a region of sedimentary geology consisting of several types of sandstone, limestone and clay. Stream gradient is much lower, and deposition of decomposed granite particles from the headwaters is evident throughout the lower portion of the watershed. Although the stream is protected from encroachment from stream-side development, it is still subject to urban storm water run-off from storm drains located throughout Bear Creek Regional Park. The stream channel exhibits vertical instability and head-cutting along several segments within the park. Downstream of the Penrose Equestrian Center, the stream is severely entrenched, flowing through a ravine that has degraded to bed-rock parent material. This ravine is approximately thirty feet deep, with extremely unstable banks subject to frequent toe slope failure and mass wasting into the channel.

A diversion structure is maintained by Colorado Springs Utilities on Bear Creek, immediately upstream of the Gold Camp Road. Downstream of this structure, flows in Bear Creek are periodically severely limited. Natural accretion of flow from the adjacent water table and occasional springs do prevent the stream from going completely dry. The diversion structure is a physical barrier to migration of fish through the watershed. A large raw water pipeline flows under the creek approximately 1500 feet downstream of 21st Street. Colorado Springs Utilities has expressed an interest in establishing another diversion structure at this site to capture additional water from the creek.

The headwaters of Bear Creek, upstream of the CSU diversion structure, support a population of the rare Greenback Cutthroat (*Oncorhynchus clarki stomias*). A possible explanation for this population may be that the Bear Creek drainage is one of the few streams on Pikes Peak that does not have some type of water impoundment or reservoir near its source. Historically, rainbow, brown, and brook trout were stocked in these impoundments for recreational use, and the south slope reservoirs of Pikes Peak are good examples of this. Downstream of the diversion structure, brook trout (*Salvelinus fontinalis*) and brown trout (*Salmo trutta*) are present.

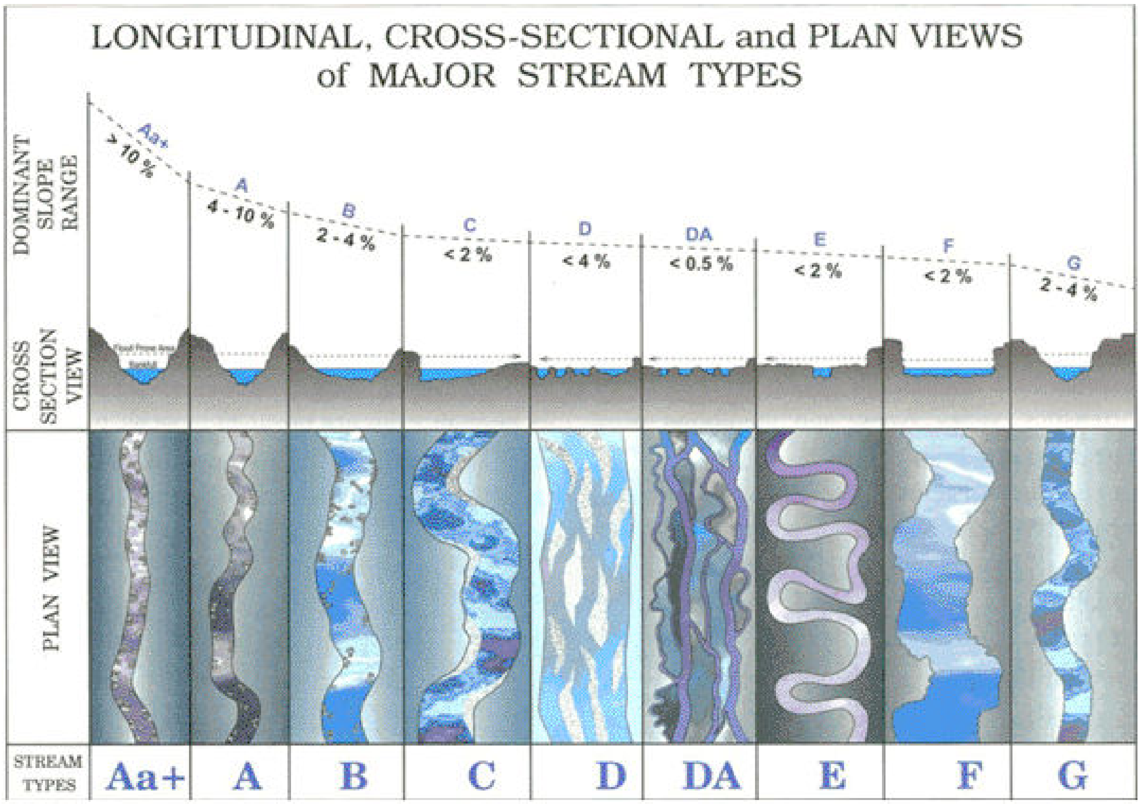
An automated stream gauge is maintained by the USGS and CSU on Bear Creek. The location of this gauge is at Latitude 38°49'21", Longitude 104°53'17", in NE¼NE¼ sec.21, T.14 S., R.67 W., El Paso County, Hydrologic Unit 11020003, on left bank 30 ft east of 26th Street, 0.6 mi southwest of Bear Creek Nature Center, 3.4 mi upstream from the confluence with Fountain Creek. The drainage area upstream of the gauge is 6.89 mi^2. Flow records available indicate a bank full stage of approximately 40 cfs at the gauge. The highest peak flow on record at the gauge is 185 cfs, and occurred during the April 1999 flood.

Assessment Methods and Protocols

For the purposes of this assessment, the stream was delineated into distinct reaches, or segments, based on valley type, channel morphology, perennial vs. intermittent flows, and administrative or physical boundaries. Reaches are numbered consecutively, beginning at the furthermost downstream ranch boundary, and continuing upstream to the headwaters.

Rosgen Stream Classification System:

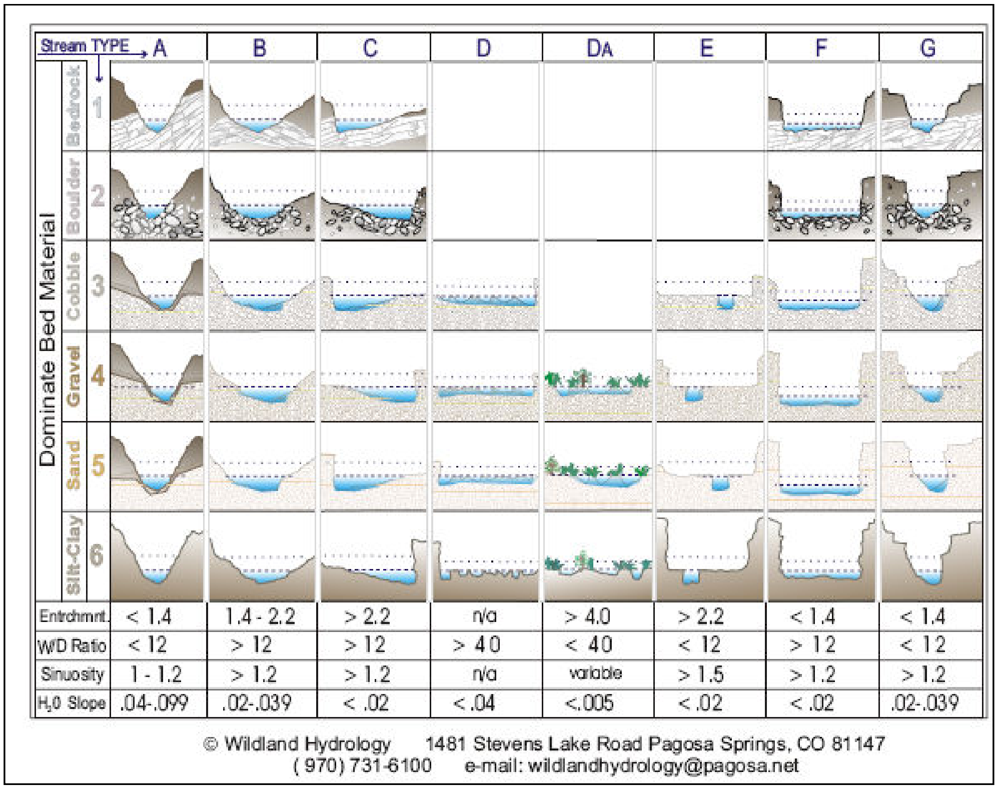
Stream reaches were classified using the Rosgen Stream Classification System (D.L. Rosgen, CATENA, 1994). The Rosgen classification system groups streams by similar channel geomorphology, gradient, sinuosity and function. The classification system is stratified into three progressive levels, based on channel form, dominant substrate, and gradient. A graphic depiction of the Level 1 classification is shown in the drawing on the next page.



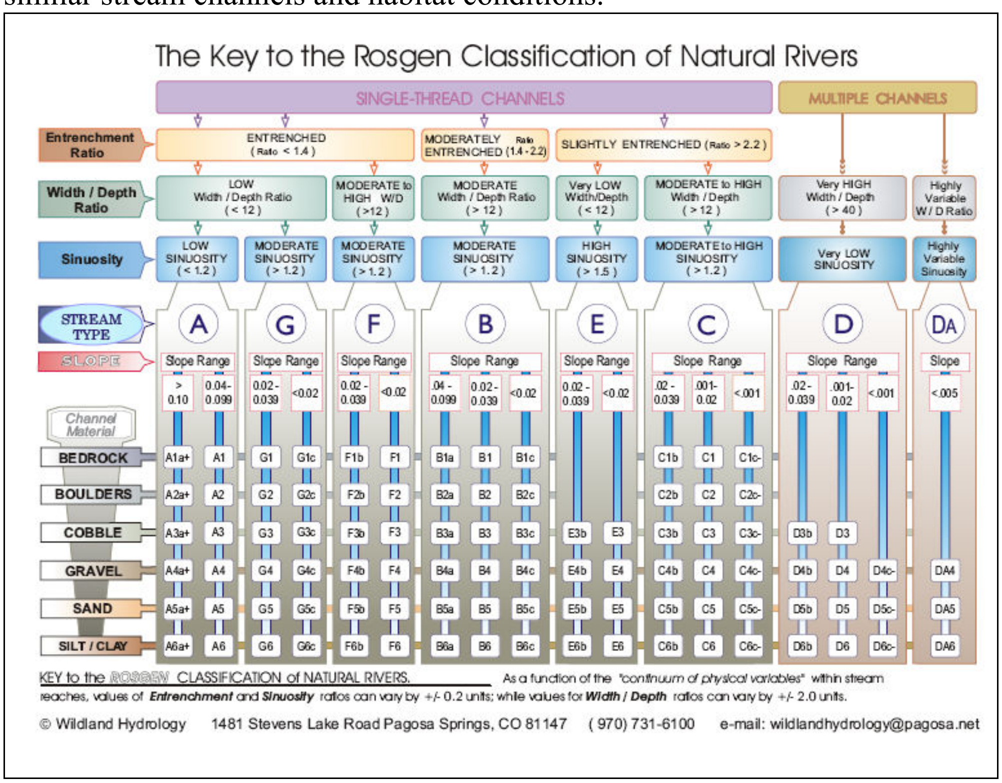
Rosgen, David L. "A classification of natural rivers." Catena 22 (1994): 179. www.wildlandhydrology.com

Generally, A type channels are typically found near the headwaters of mountain streams. Lower gradient B channels are characteristic of streams flowing though alluvial plains and broad mountain valleys below the headwaters. C and E channels tend to be found in lower elevation reaches with broad floodplains and low gradients. Each of these channel type supports different assemblages of aquatic habitats, and each can be important in providing habitat complexity for trout. F and G channels are typically found in areas that have been subjected to some disturbance, such as a flood or significant down-cutting of the stream channel. Frequently, in recovering F type channels, a new C channel will begin to form in the flat bottom of the F channel, establishing a new floodplain at a lower elevation.

The Level 2 classification stratifies dominant substrate composition, and ranges from 1, bedrock or native bed material, to 6, which represents fine particles of less than 1/4" diameter. A diagram of the Level 2 classification is shown on the following page. Level 3 of the Rosgen system includes more detailed gradient and sinuosity values. For example, a Rosgen A3a channel would be a steep (<10%), deeply entrenched, and confined channel that exhibits low width/depth ratios and low sinuosity. Channel materials are typically unconsolidated, non-cohesive materials, dominated by cobbles, but also containing some boulders, gravel and sand. The A3a type is generally found in landforms associated with slump/earth-flow and debris torrent erosional processes, and would likely exhibit fluvial entrainments, mass wasting of steep adjacent slopes and debris scour. A detailed diagram of the Level 3 Rosgen classification system is show in the drawing on the next page.

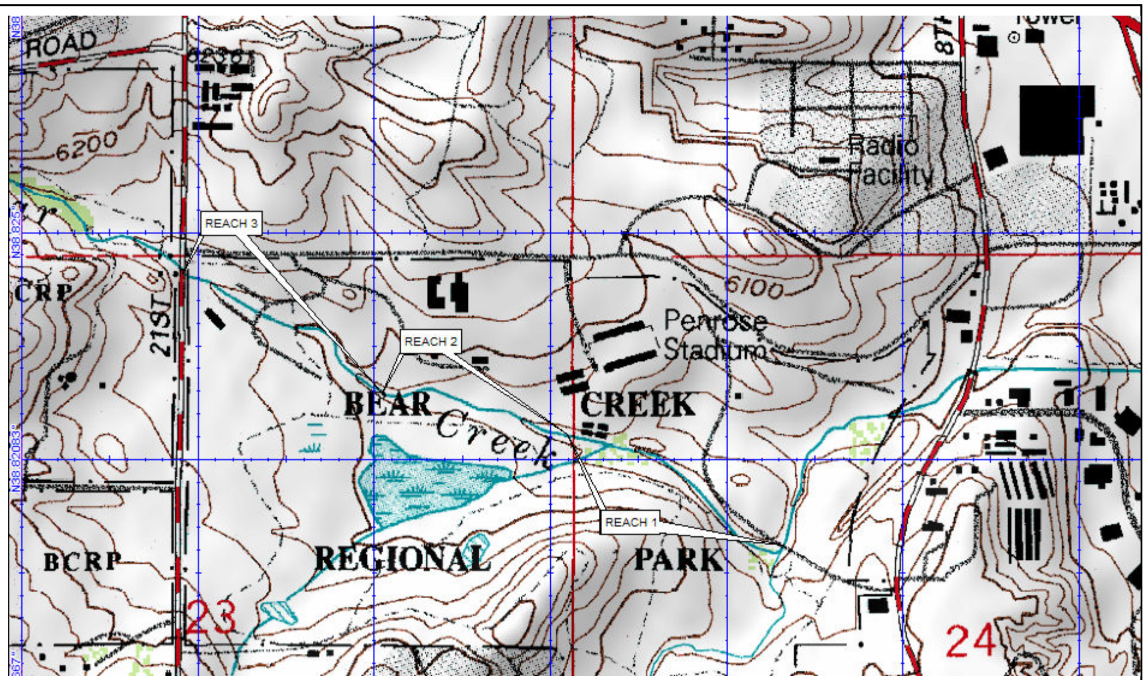


The Rosgen classification system has been widely adopted by water professionals throughout the west, and is a useful tool for evaluation and comparative analysis of similar stream channels and habitat conditions.



Aquatic and Riparian Habitat Assessment Protocols:
Each reach was assessed separately, in order to characterize existing habitat conditions and evaluate current management and restoration potential. Stream reaches were analyzed using a basin-wide stream habitat survey protocol developed by the US Forest Service and Colorado Division of Wildlife for smaller streams in the Rocky Mountain Region (Winters and Gallagher, 1997). This protocol is a modified basin-scale aquatic habitat inventory based on the Hankin & Reeves survey method. All meso-habitat types within a delineated reach are measured for multiple attributes, include physical dimension, morphic form, bank condition and composition, substrate class, and cover for salmonids. The advantage of the Winters protocol is that it is a repeatable method, and therefore can be used to quantify changes in habitat resulting from management, habitat enhancement, or natural events. The Winters Protocol may be found in the appendix.

Aquatic Habitat Survey Results:
Three reaches were delineated within the project area on Bear Creek (Map 1 and Photo 1). Reach 1 begins at the confluence of a small intermittent tributary of Bear Creek immediately south of Penrose Equestrian Center, and continues approximately 2,000 feet upstream to a horse trail crossing the stream near the western boundary of the Penrose Equestrian Center. Reach 2 begins immediately upstream of the horse trail crossing, and continues 1,800 feet upstream to the point where the Colorado Springs Utilities raw-water pipeline crosses the stream. Reach 3 begins at the pipeline crossing, and continues upstream to the 21st Street Bridge. A rapid assessment of channel morphology and aquatic habitat was undertaken on all three reaches, and a detailed stream habitat inventory was conducted in September 2006 on Reach 2 and 3 of Bear Creek within the project area. Discharge was measured during the survey at a point approximately in the middle of the project area using a Marsh-McBirney Flow-Mate 2000 flow meter, and was calculated to be 1.4 cubic feet per second.



Map 1: Location of stream reaches on Bear Creek - Bear Creek Regional Park, El Paso County, CO.

Photo 1: Arial Photo of the Project area, showing foot bridges, roads, and the Reach delineations.

Reach 1:

Reach 1 of Bear Creek is severely entrenched, flowing through a ravine that has degraded to bed-rock parent material (Photo 2). This ravine is approximately thirty feet deep in places, with extremely unstable banks subject to frequent toe slope failure and mass wasting into the channel. Aquatic habitat in most of the reach is extremely limited, and no fish were observed except in the upper most portion of the reach, where the entrenchment is not as severe. The geomorphic channel type was determined to be a Rosgen G4 channel in the lower section of the reach, with several segments of G1 where the channel has down-cut to bedrock. The upper-most limit of Reach 1 begins to exhibit characteristics of a B3 channel, with a identifiable floodplain and adjacent riparian zone. "B" channels tend to be somewhat less sinuous and slightly entrenched, and tend to exhibit a higher ratio of riffles to pool habitat. Most of Reach 1 on Bear Creek appears to have been physically altered by the construction of the Penrose Equestrian Center, which is located on the north bank of the stream throughout the reach. Most likely, the stream was straightened and relocated in order to accommodate the parking lots and barns for the center. Due


Photo 2: Ravine and Mass Waste Slope on Bear Creek

to the extremely degraded condition of the stream and difficulty of equipment access for restoration, a detailed habitat survey was not conducted in this reach.

Reach 2:

Reach 2 is characterized by a relatively narrow valley bottom and riparian corridor, with a slightly sinuous, low gradient stream channel classified as a Rosgen B3. There is some evidence of recent down-cutting due to flooding, and short segment of the reach exhibits characteristics of a G4 channel in the upper portion of the reach. The riparian zone in the reach exhibits good vigor, and is composed of willow, sedge, alder, and some cottonwood. There appears to be adequate regeneration of plant species and the riparian zone is considered to be in properly functioning condition.


Photo 3: Plunge Pool 12 on Reach 2 - Bear Creek. Note sediment in storage in the channel upstream of the pool.

Initial reconnaissance indicated that Reach 2 exhibited a greater potential for a quality fishery than the segment downstream, and appeared to be a good representation of habitat conditions within B channels along Bear Creek in the lower portion of the watershed. Several fish were observed throughout the reach, and most likely were brook trout. Habitat in the reach may also support other native species of minnows and dace.

There were 48 individual meso-habitats measured in the reach (15 pools, 23 riffles and 10 glides), along a length of 1,330 feet of river, and comprising a total wetted area of 8,938ft^2. The total area of the reach consisted of 64% riffles and 20% pools, with the remaining 16% consisting of glide/run habitat (Chart 1). The average wetted width of the stream was 6.7 feet throughout the reach. Approximately 70% of left bank, and 74% of the right bank were found to be vegetated and stable, consisting mostly of sand and gravel sized fragments. There were 321 feet of actively eroding stream banks contributing sediment directly into the river. This accounted for slightly more than 12% of the total length of banks in the study reach.

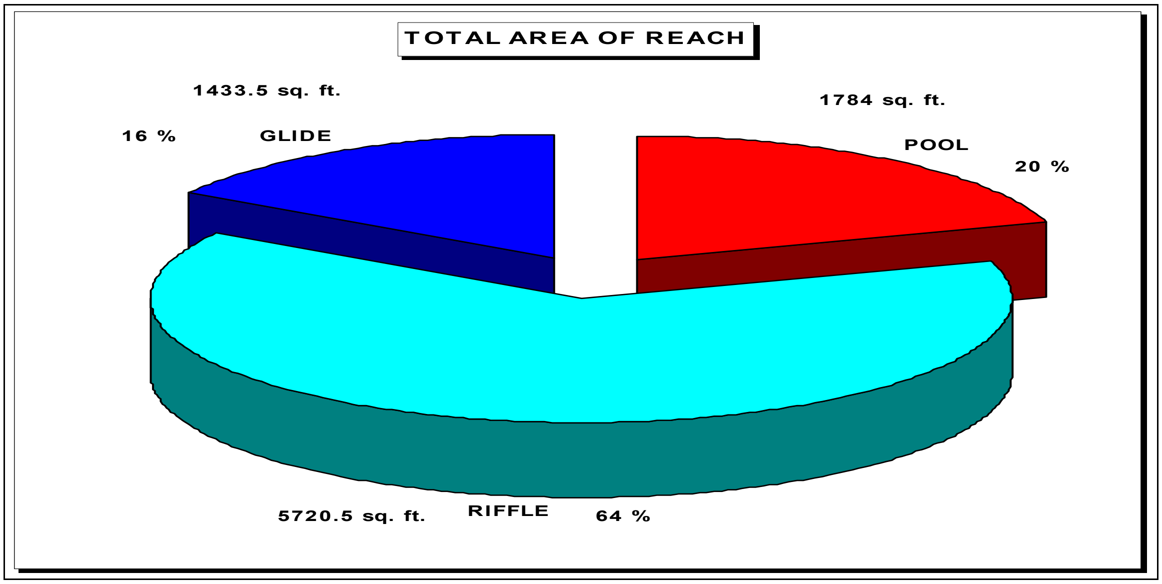


Chart 2 - Distribution of Pool, Riffle and Glide habitats in Reach 2 of Bear Creek.

Low gradient cobble riffles were the most common habitat type in terms of numbers and area, accounting for 36% of the total reach area (Chart 2). Low gradient riffles can provide good spawning habitat, but are somewhat limited in terms of cover from high flows and predators. Low gradient gravel riffles and sand riffles were also common in the reach, each amounting to 12% of the wetted area of this segment. Gravel riffles exhibit similar characteristics to cobble riffles, and may provide excellent spawning habitats if not impacted by excessive sediment loads. Sand riffles typically provide little useful habitat, and may become barriers to fish passage at extremely low flow. A few higher gradient, pocket water dominated riffle types were observed near the upstream boundary of the reach. Overall, very little cover for trout was observed in the riffles, amounting to less than 0.1% (8 ft^2) of the total wetted area of these habitat types. The average width of all the riffles observed in the reach was 6.5 feet.

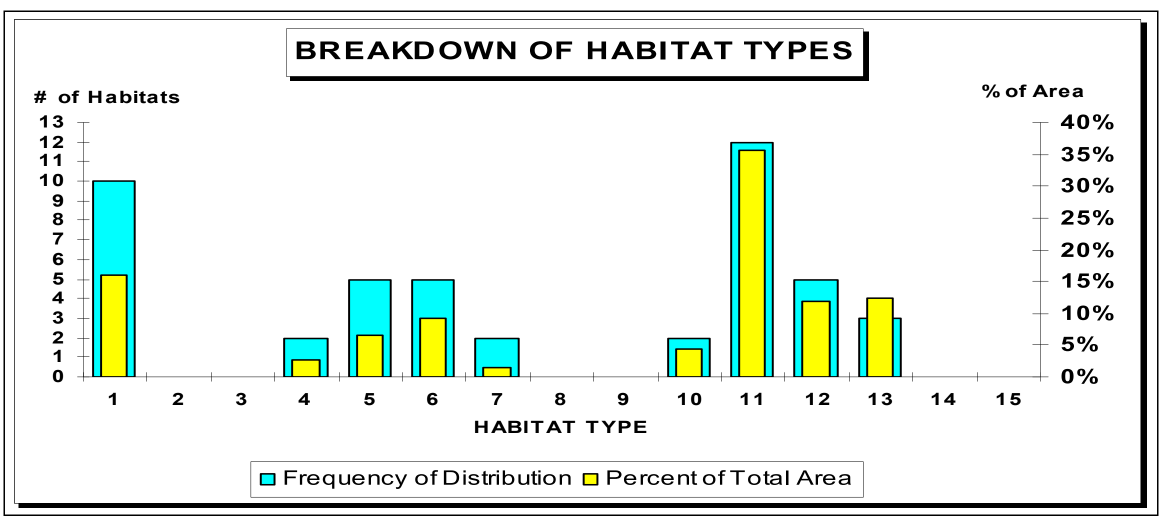


Chart 2 - Distribution of Habitat Unit Types (HUT's) as a percentage of # of habitats and as a percentage of wetted perimeter of Reach 2.

All types of pools were observed in the reach, with lateral scour pools (type 6) being the most abundant (Chart 3). This pool type forms along the outside bank of stream meander bends, as well as by deflections due to bedrock, boulder, and root wad obstructions along the banks. Lateral scour pools were found to be present in 9% of the total area of the reach. Plunge pools were the next most dominant pool type, accounting for 7% of the wetted perimeter of the reach. Plunge pools were typically associated with drops over large wood that had fallen into the stream channel. Two trench pools were observed in the reach, and were associated with root-wad restrictions in the channel creating scour along the stream bottom. All of the pools exhibited some degree of in-filling of sediment, mostly consisting of smaller particles of decomposed granite. Due to this in-filling of fines, the average pool depth in Reach 2 was less than 1 foot. Residual pool depth is estimated to be the amount of water that would be retained in a pool under greatly reduced flows in the stream and is useful in determining the over-wintering capacity of a stream ecosystem. Residual pool depth (RPD) in Reach 2was found to range from 0.6 to 2.2 feet, with an average of 1.3 feet throughout the reach. RPD was considered adequate to provide for over-wintering of salmonids and other native species in this reach. Cover for trout accounted for slightly less than 25% of the total wetted area of the pools, which is fairly good for a stream of this size. The average wetted width of all pool types found within the reach was 7 feet.

Glide habitat more extensive in the reach that would be expected for a B channel. Most of the glide habitats observed appeared to be former pools that had been completely in-filled with sediment. Ten glide habitats were observed along 214 ft of the river, and tended to be associated with anthropogenic impacts such as bridges, fords, and other "construction" activities along the stream. Cover for trout was extremely limited in these habitats, which tend to provide little protection from flows or predators. The average width of these glide habitats was 6.6 feet.

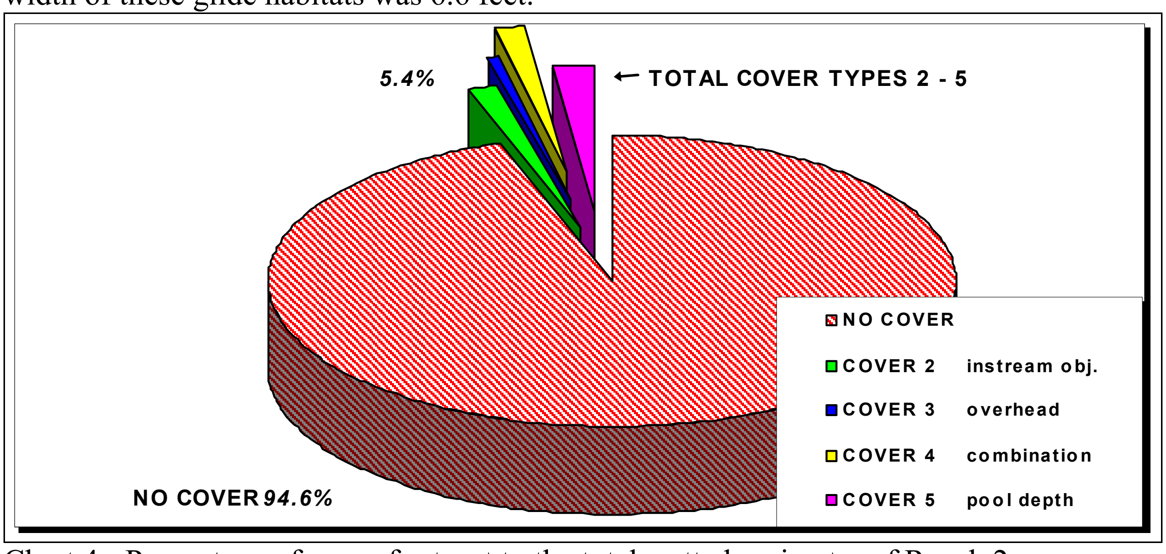


Chart 4 - Percentage of cover for trout to the total wetted perimeter of Reach 2.

Cover for adult trout accounted for approximately 5% of the reach, which is relatively poor for a river the size of Bear Creek (Chart 4). Available cover appears to be a limiting factor in the fishery, particularly in the riffle habitats. Pool cover (Cover Type 5 -

>1.5'deep) was the dominant type observed in the reach, and was typically associated with the lateral scour pools. Pool cover is another important indicator for determining the available over-wintering capacity of the stream reach, and appeared to adequately support the wintertime habitat requirements of trout in this reach. Instream object cover (Cover Type 2 - >1' deep) was the next most abundant form, and was found in both pool and riffle habitats. Instream object cover was abundant in the pool habitats, but was somewhat limited in the riffles. Combination cover was present in several of the large lateral scour pools, and was formed primarily by undercut banks and submerged rock ledges. Overhead cover was the least abundant cover type. Overhead cover appeared to be limited not by lack of adjacent riparian vegetation, but due to a lack of velocity shelters in the channel.

Stream banks were generally in good condition in this reach. Deeply rooted, streamside riparian vegetation is a critical component in maintaining the integrity of stream banks during runoff and other high flow events, and in this study reach, this vegetation component appears to be in reasonably sound condition. Seventy percent of the left bank and 74% of the right bank were found to be vegetated and stable and 4% of the left banks and 2% of the right banks of the habitat units were found to be stable and unvegetated (Chart 5). Bank rock content consisted mostly of sand and smaller fragments (Type 8), with small accretions of larger materials (Chart 6). Bank rock content is a good indicator as to the armored condition of the banks, and in this case the undisturbed, vegetated banks appear to be adequate to resist higher flows. The general reach substrate was determined using an ocular estimate of each habitat unit. Stream substrate in Reach 2 was estimated to consist of approximately 73% sand and other fine materials, 15% gravel, 9% cobble, and 3% boulder. Twenty-seven pieces of large wood (>4" diameter and > 3' long) were found in the reach. Large wood is an important habitat forming component for rivers in the Rocky Mountains, and provides cover and complexity to the aquatic ecosystem.

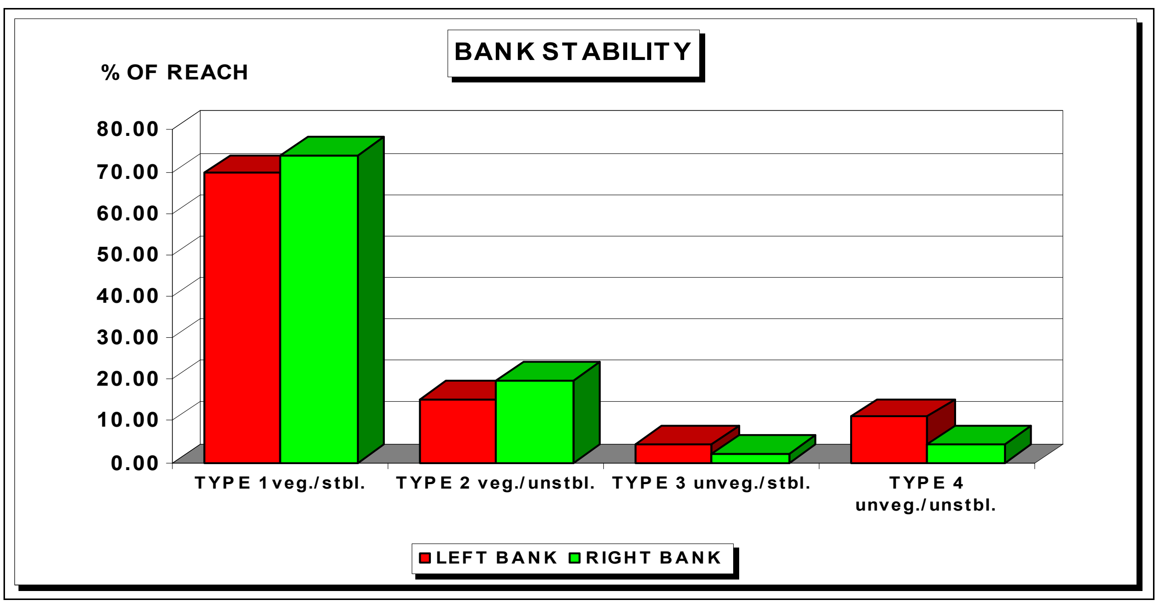


Chart 5 - Percentage of stable banks to unstable banks in Reach 2

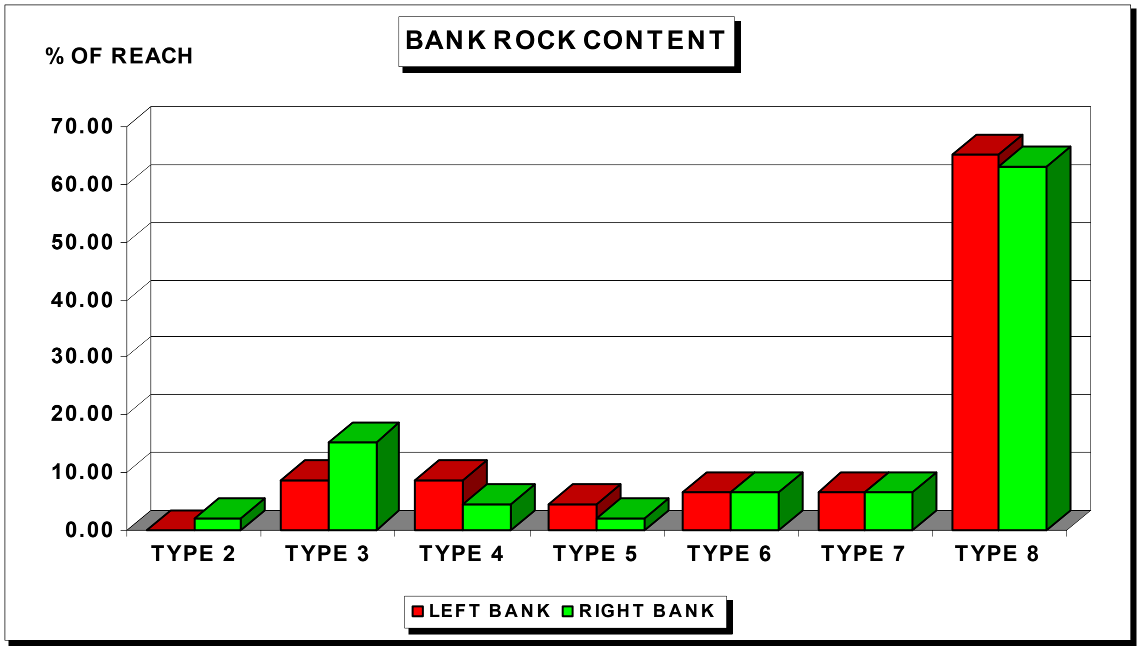


Chart 6 - Percentage of bank rock content sizes in Reach 2.

Reach 2 represented the best aquatic habitat conditions within the project area, however, the condition of the reach was still generally fair to poor. While riparian and stream bank conditions were relatively stable, effects from degraded areas upstream have resulted in poor pool depths, lack of cover, and in-filling of habitat by excessive sediment. Many of these limiting factors could be addressed through channel and habitat enhancement techniques to improve scour and create complexity. However, due to the planned installation of a new diversion structure near the upstream boundary of the reach, and the expected effects of water depletion on the reach, habitat enhancement is not recommended at this time.

Reach3:

Reach 3 is geomorphicly similar to Reach 2, being characterized by a relatively narrow valley bottom and riparian corridor, with a slightly sinuous, low gradient stream channel classified as a Rosgen B3. There is considerably more evidence of recent down-cutting due to flooding in this reach, and the upper half of the reach exhibits characteristics of a G4 channel. Although the stream appears to no longer be connected to the floodplain in the upper portion of the reach, the riparian zone still exhibits good vigor, and is composed of willow, sedge, alder, and some cottonwood. There appears to still be some regeneration of plant species and the riparian zone is appears to be in properly functioning condition.

Initial reconnaissance indicated that Reach 3 exhibited poorer quality habitat and greater channel instability than the segment downstream. Indeed, no pools were observed within a 530 foot long segment of the upper portion of the reach. Several active head-cuts were identified in the channel within Reach 3, and sedimentation from these erosion sources, as well as from sources upstream, are negatively impacting aquatic habitat within the reach and Reach 2 downstream.

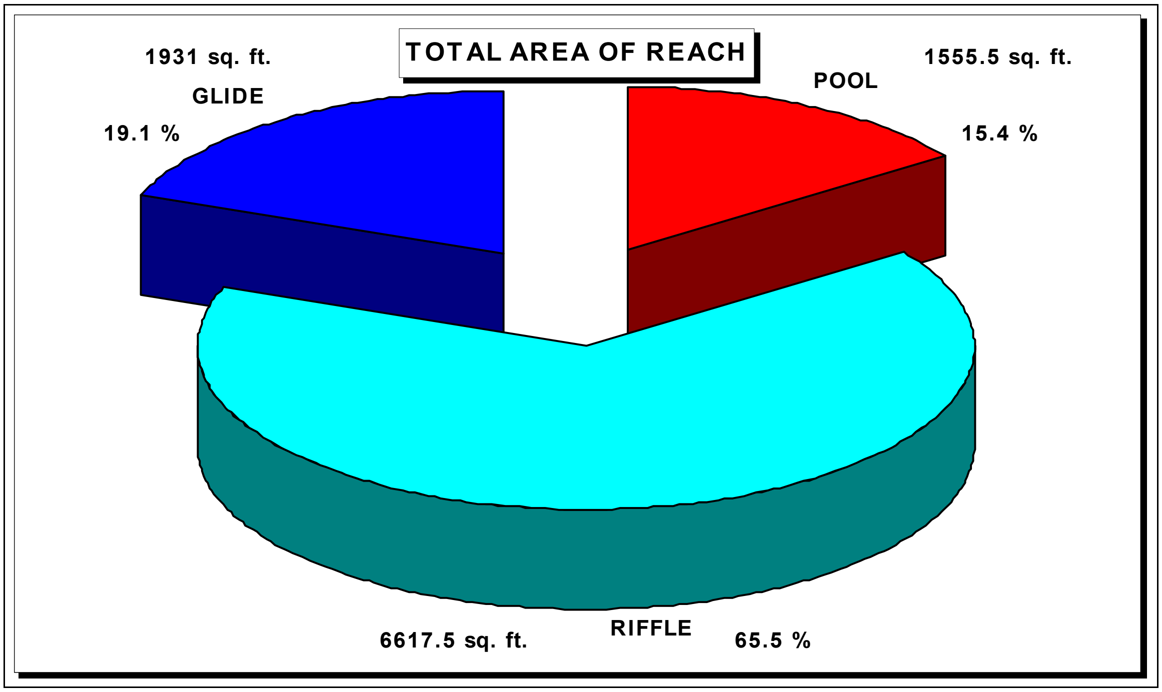


Chart 7 - Distribution of Pool, Riffle and Glide habitats in Reach 3 of Bear Creek.

There were 44 individual meso-habitats measured in the reach (11 pools, 22 riffles and 11 glides), along a length of 1,455 feet of river, and comprising a total wetted area of 10,104ft^2. The total area of the reach consisted of 66% riffles and 19% glides, with the remaining 15% consisting of pool habitat (Chart 7). The average wetted width of the stream was 7.1 feet throughout the reach. Approximately 62% of the stream banks were found to be stable, consisting mostly of sand and gravel sized fragments. There were 774 feet of actively eroding stream banks contributing sediment directly into the river. This accounted for slightly more than 27% of the total length of banks in the study reach.

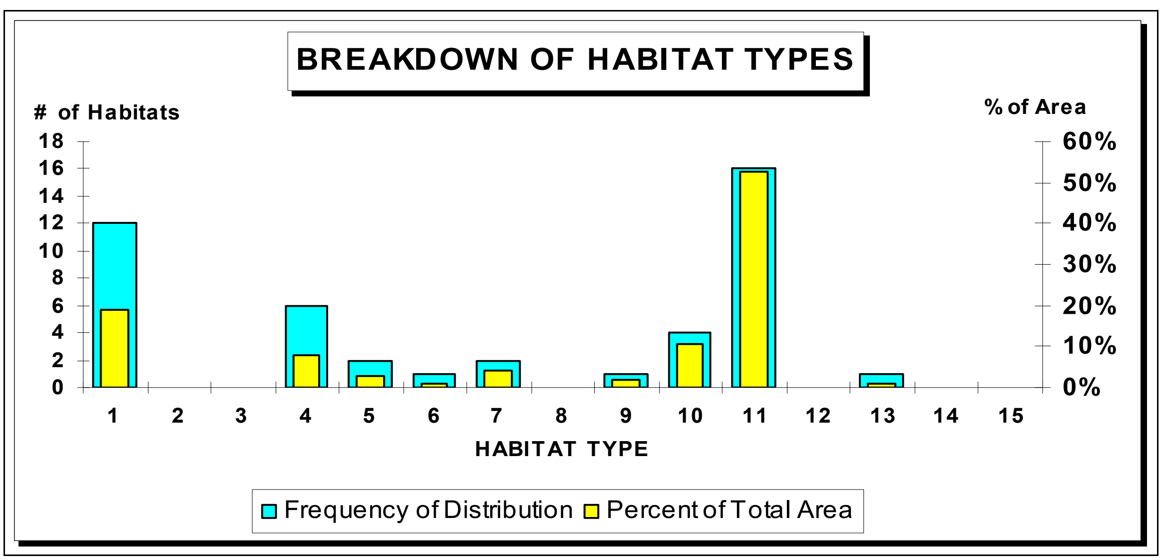


Chart 8 - Distribution of Meso-Habitat Types as a percentage of # of habitats and as a percentage of wetted perimeter of Reach 3 on Bear Creek.

Low gradient cobble riffles were the most common habitat type in terms of numbers and area, accounting for 52% of the total reach area (Chart 8). Low gradient riffles can provide good spawning habitat, but are somewhat limited in terms of cover from high flows and predators. A few higher gradient, pocket water dominated riffle types were observed in the reach. Overall, very little cover for trout was observed in the riffles, amounting to less than 0.5% (30 ft^2) of the total wetted area of these habitat types. The average width of all the riffles observed in the reach was 7.1 feet.

Pool habitat is very limited in the reach, with trench pools being the most abundant (Chart 8). This pool type forms due to root-wad and other restrictions in the channel creating scour along the stream bottom. Lateral scour pools were found, as well as plunge pools and debris dam pools. All of the pools exhibited some degree of in-filling of sediment, mostly consisting of smaller particles of decomposed granite. Due to this in-filling of fines, the average pool depth in Reach 3 was barely more than 1/2 foot. Residual pool depth (RPD) in Reach 3 was found to range from 0.6 to 1.5 feet, with an average of 0.9 feet throughout the reach. Only three pools exhibited RPD of greater than 1 foot. RPD in the reach is relatively poor, and likely does not provide adequate over-wintering habitat for salmonids and other native species in this reach. Cover for trout accounted for slightly less than 12% of the total wetted area of the pools, which is quite poor for a stream of this size. The average wetted width of all pool types found within the reach was 7.4 feet.

Glide habitat is considerably more extensive in the reach than should be expected for a B channel. Most of the glide habitats observed appeared to be former pools that had been completely in-filled with sediment. The eleven glide habitats observed comprised 282 ft of the length of the river, and tended to be associated with channel disturbances such as head-cuts, bridges and culverts (Photo 4). Cover for trout was extremely limited in these habitats, which tend to provide little protection from flows or predators. The average width of these glide habitats was 6.8 feet.

Photo 4: Poor glide habitat below Footbridge 4 in Bear Creek Reach 3. Note the entrenchment of the channel throughout this area.

Cover for adult trout accounted for approximately 2.8% of the reach, considerably less than in Reach 2(Chart 10). Available cover appears to be a limiting factor in the fishery, and will be addressed in the Habitat Enhancement Plan. Instream object cover (Cover Type 2 - >1' deep) was the dominant type observed in the reach, and was typically associated with the pool habitats. Overhead cover was the next most abundant form, and was found in both pool and riffle habitats. Pool cover (Cover Type 5 - >1.5'deep) was very limited in the reach, and comprised only 2% of the wetted area of the pools. Pool cover is an important indicator for determining the available over-wintering capacity of the stream reach, and appeared to be severely limited in this reach. Combination cover was present in three of the pools, and was formed primarily by undercut banks. Instream and overhead cover could be enhanced in the riffle habitats by adding structure and velocity shelters along the stream banks with strategically placed boulders and large wood. Additionally, pool cover may be increased by improving scour in existing pools as well as creating new pool habitats.

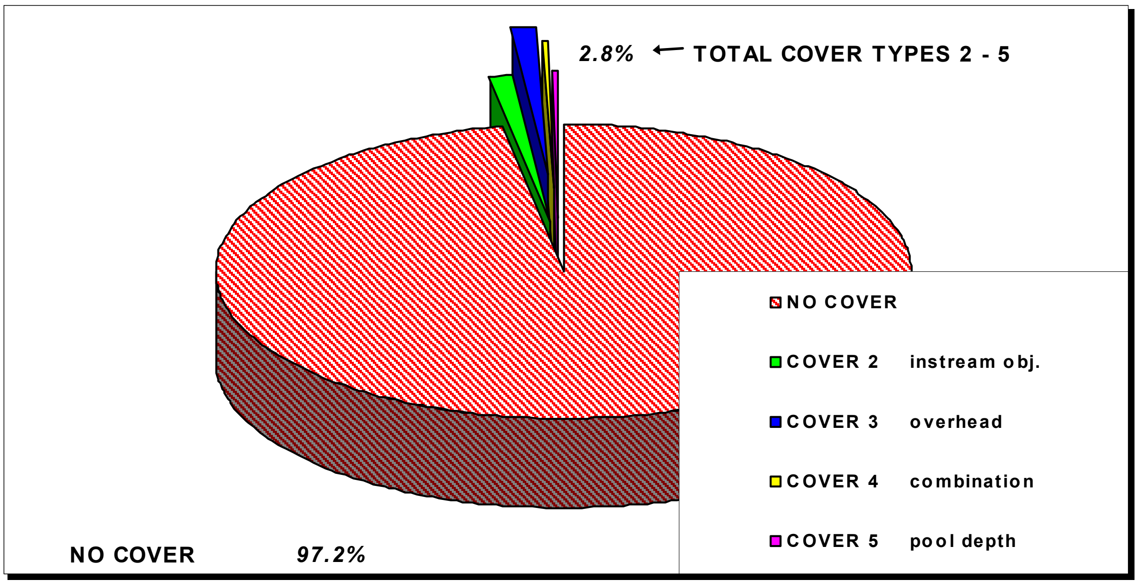


Chart 10 - Percentage of cover for trout to the total wetted perimeter Reach 3 on Bear Creek.

Stream bank stability was generally poor, primarily due to the active head cuts in the reach. In the segments of the reach not affected by head-cutting, the stream banks were generally in good condition. Deeply rooted, streamside riparian vegetation is a critical component in maintaining the integrity of stream banks during runoff and other high flow events. Sixty percent of the left bank and 62% of the right bank were found to be vegetated and stable and 2% of the left banks of the meso-habitat units were found to be stable and unvegetated (Chart 11). Bank rock content consisted mostly of sand and smaller fragments (Type 8), with small accretions of larger material (Chart 12). The general reach substrate was calculated using a Z-Walk pebble Count (Bevenger, 1997) and the results are shown in Table 1. A bimodal distribution of smaller particles (fines) and larger cobble and boulder is readily apparent in the pebble count data (Chart 13), and suggests that sediment yield in the stream exceeds the capacity of the stream to move the material. Large wood (>4" diameter and > 3' long) is somewhat scarce in the reach, with only nine pieces being observed. Large wood is an important habitat forming component for rivers in the Rocky Mountains, and provides cover and complexity to the aquatic ecosystem.

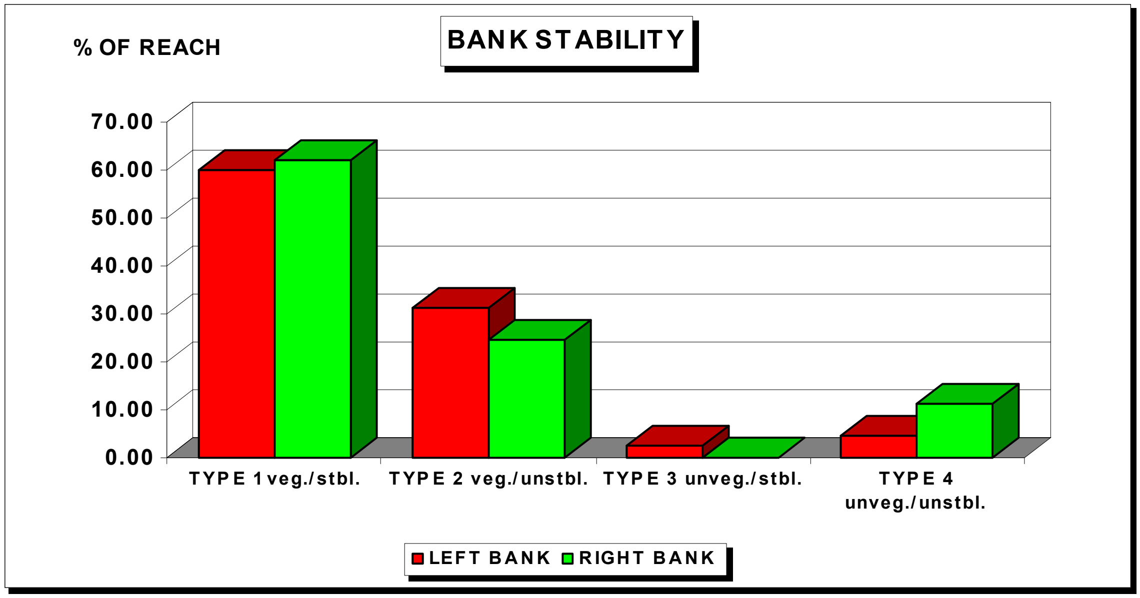


Chart 11 - Percentage of stable banks to unstable banks in Reach 3 on Bear Creek.

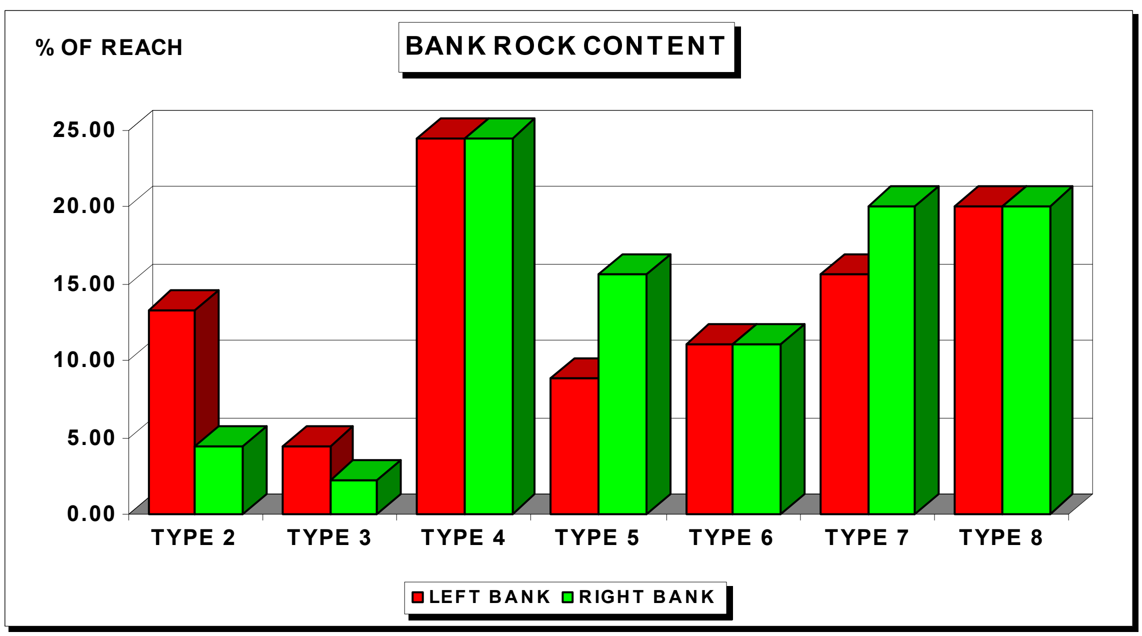


Chart 12 - Percentage of bank rock content sizes in Reach 3 on Bear Creek.

Aquatic habitat conditions throughout Reach 3 were generally very poor. Limiting factors to the fishery appear to be excessive sedimentation due to head-cutting and sediment from upstream areas, a severe lack of pool habitat, and limited in-channel object cover in the low gradient riffles. Several problem areas were identified during the course of the inventory that should be addressed in order to alleviate potential worsening problems and loss of habitat, as well as to help the river achieve its full potential as a cold water fishery.

Z-Walk		Class	Dot & Dash Count	Total	% of	Cumulative
Metric - mm	Inches	Name	: . = 3, : : = 9	Number	Total	%
.125-.25		Fine			0.0%	0.0%
.25-.50		Medium		2	1.33%	1.33%
.50-1.0		Coarse		10	6.67%	8.00%
1.0-2.0		Very Coarse		6	4.00%	12.00%
2.0-4.0		Very Fine		29	19.33%	31.33%
4.0-8.0		Fine		18	12.00%	43.33%
8.0-16	.08-.6	Medium		12	8.00%	51.33%
16-32	.6-1.3	Coarse		10	6.67%	58.00%
32-64	1.3-2.5	Very Coarse		8	5.33%	63.33%
64-128	2.5-5.0	Small		8	5.33%	68.67%
128-256	5-10	Large		17	11.33%	80.00%
256-512	10-20	Small		15	10.00%	90.00%
512-1024	20-40	Medium		11	7.33%	97.33%
1024-2048	40-80	Large		4	2.67%	100.0%
2048-4096	80-160	Very Large			0.0%	100.0%

Table 1 - Results of the Z-Walk Pebble Count, showing distributions of substrate size classes in Reach 3 on Bear Creek.

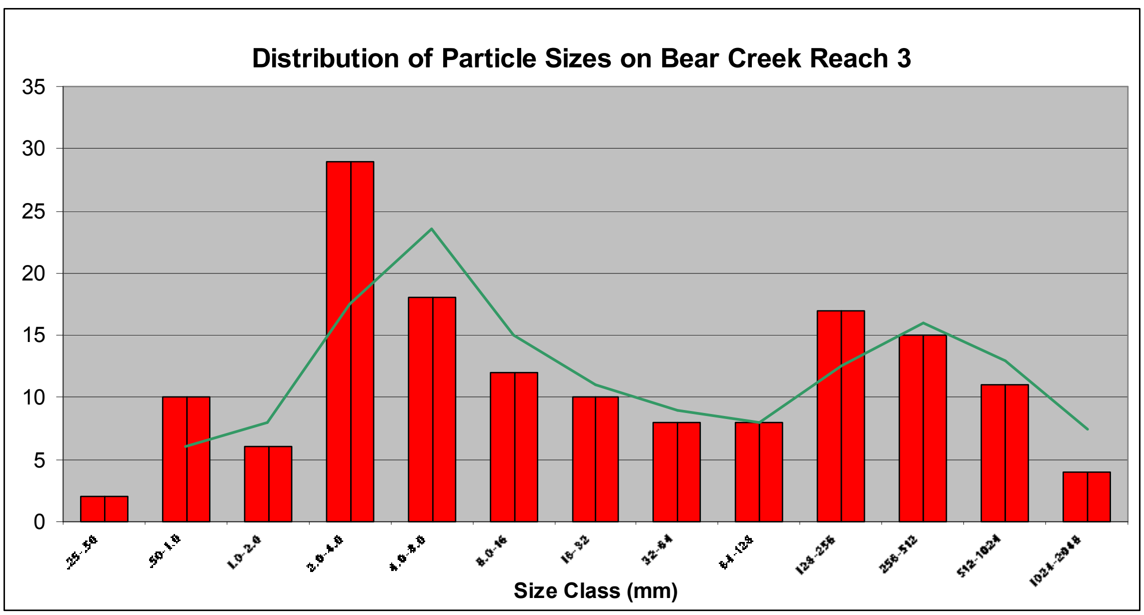


Chart 13 - Distribution of particle size classes showing a bi-modal distribution of sand and larger cobbles and boulder in Reach 3 on Bear Creek.

Aquatic Habitat Enhancement Plan for Bear Creek - Reach 3.

Currently, the greatest threat to aquatic habitat in reach 3 is the down-cutting of the stream channel near the downstream boundary of the reach and upstream of the culverts at Riffle 15. Active head-cuts are currently located near the transition from Riffle 7 and Glide 3, and immediately downstream of Glide 10 (Photos 5 & 6). Below these head-cuts, the channel has down-cut at least three feet, effectively abandoning the adjacent flood-plain and riparian zone (Longitudinal Profile in the Appendix). Left untreated, these head-cuts will continue to migrate upstream until a bedrock control or other hardened point in the channel is reached. Stream banks below the head-cuts are very unstable, with root-systems of adjacent alder and cottonwood exposed. These banks are subject to extreme shear stress during peak flows, and may collapse, resulting in the loss of important and esthetic tree cover and riparian vegetation along the banks. Continued down-cutting will also result in filling of pools downstream with sediment and further loss of critical deep water habitats. This inventory identified stream banks along Reach 3 that are already showing signs of bank failure. Stabilization of vertical channel profile and protection of stream banks downstream of the head-cuts may be enhanced through the strategic placement of rock vanes and full-channel cross-vane structures in the reach, as well as toe slope stabilization using boulder and large wood along the banks below the head-cuts.

Photo 5: Head-cut downstream of Glide 2

Photo 6: Head-cut downstream of Glide 10

Additionally, several of the pools and most of the glide habitats, particularly in the downstream half of the reach, may benefit from installation of cross-vanes and minor excavation of some of the stored sediments in these channels. Cross vanes will help to further stabilize the vertical profile of the channel in the reach, and enhance scour in the pools to maintain adequate depth. In-channel object and overhead cover in the low gradient riffle habitats may be enhanced through the selective placement of bank-side boulders and large wood. The following section will address these priorities, and give specific recommendations and treatments to enhance aquatic habitat conditions throughout the reach.

Arial photographs showing the locations of the proposed enhancements can be found in the Appendix

Priority 1: Stabilization of Active Head-Cuts in Reach 3.

As stated earlier, there are two active head-cuts that need to be stabilized as soon as possible. The river will continue to down-cut upstream of these head-cuts as it adjusts to the new channel slope. The downstream head-cut can be repaired by installing a full-channel rock cross vane near the upstream boundary of Riffle 7 (X-Vane 3 on the Project Map in the Appendix). The upstream head-cut may be controlled by installing another full channel rock cross vane immediately downstream of Glide 10 (X-Vane 11) These vanes should be constructed to an elevation of the bank full stage of the old abandoned channel (Photo 7). These vanes should be constructed of large boulders (3/4 yd^3) fit tightly together, with smaller boulders and cobble in-fill, with adequate footer boulders and geo-textile filter cloth between the footers and the upper row of rock. Conceptual drawings and photos of actual cross-vanes may be found in the Appendix.

Photo 7: Example of a cross vane structure constructed to stabilize the vertical profile of the river channel. Fountain Creek below the 21st Street Bridge. Colorado Springs, El Paso County, CO

Preliminary estimates are that this work would take approximately 1 to 2 days to complete, and would require the use of a 12,000lb excavator with a hydraulic thumb, and a front end loader. Approximately 30 yd^3 of large rock will likely need to be imported into the site in order to complete the work.

Priority 2: Bank and Channel Enhancements to Protect from Flood Flows and Improve Habitat Conditions

The following work is recommended to stabilize the damaged stream banks below the head-cuts in Reach 3, improve pool habitat and complexity, and increase in-channel object and overhead cover in the low gradient riffle habitats. Additional habitat enhancements will include cross vane structures to improve pool scour, toe slope stabilization of vertical banks (Photos 8 & 9) and re-vegetation with native riparian

Photo 8: Unstable bank on Cucharas Creek before toe-slope stabilization. Huerfano County, CO.

Photo 9: The same bank on Cucharas Creek one year after toe-slope logs were installed in Oct. 2005

species, and construction of pocket water habitats in a few of the steeper riffle meso-habitats. Conceptual drawings and photos of actual cross-vanes may be found in the Appendix. Each enhancement is listed in order of progression from the downstream boundary of the reach, not necessarily in order of priority. The following habitat and channel stability enhancements are recommended, but are not as critical a priority as the work previously listed.

1. Construct a cross-vane (X-Vane 1) at the upstream boundary of Glide 1. Excavate Glide 1 down to the buried cobble substrate (approximately 1.5 ft).
2. Construct a cross-vane (X-Vane 2) at the upstream boundary of Glide 2. Excavate Glide 2 down to the buried cobble substrate (approximately 1.5 - 2 ft).
3. Remove two boulders and some cobble armoring the bottom of Pool 3 to allow for enhanced scour.
4. Install toe slope stabilization logs and boulders along 302 feet of stream banks (both sides of the channel) below the downstream head-cut. Re-vegetate stream banks above toe-slope structures using native riparian vegetation transplanted from adjacent areas. This toe slope stabilization begins at Riffle 6, and includes Pool 4, Riffle 7, and Glide 3. See Appendix for conceptual drawings and photographs of similar structures.
5. Construct a cross-vane (X-Vane 4) between Riffle 8 and Glide 4 to create a type 7 dam pool. There is heavy recreation use in this area, and the public has attempted to "create" this habitat by stacking cobbles in the stream. This structure will provide a deep water habitat (1.25 - 1.75ft) while also providing additional vertical stability in the channel.
6. Minor excavation of sediment in Pool 8. Remove approximately 1ft of sediment from bottom of the pool.
7. Adjust boulders and install additional boulder to create micro vortex pocket water habitats in Riffle 13
8. The culverts forming Pool 10 most likely are barriers to migration of fish and other aquatic organisms. Remove armor from the pools downstream of the culverts to create enough depth so that trout may be able to pass into the culvert and maintain necessary burst speed to pass the 40 foot length. A pool depth of approximately 1 -1.5 feet may be necessary. Footer the culverts with boulders in order to prevent undercutting of these structures.
9. Construct a cross-vane (X-Vane 5) between Riffle 15 and Glide 5 to create a type 7 dam pool. This structure is immediately upstream of the road accessing the Park Headquarters building and may be an appropriate site for interpretation of the project for the public. This structure will provide a deep water habitat (1.25 - 1.75ft) while also providing additional vertical stability in the channel.
10. Install toe slope stabilization logs and boulders along 240 feet of stream banks (both sides of the channel) between Riffle 16 and Glide 7. Re-vegetate stream banks above toe-slope structures using native riparian

vegetation transplanted from adjacent areas. This toe slope stabilization includes Riffle 17, and Glide 6.

11. Construct a cross-vane (X-Vane 7) at the upstream boundary of Glide 7 to enhance scour and stabilize the vertical channel profile.
12. Construct a cross-vane (X-Vane 8) at the upstream boundary of Riffle 18 to stabilize the vertical channel profile.
13. Construct a cross-vane (X-Vane 9) at the upstream boundary of Glide 8 to enhance scour and stabilize the vertical channel profile.
14. Install toe slope stabilization logs and boulders along 168 feet of stream banks (both sides of the channel) between Glide 9 and Glide 10. Re-vegetate stream banks above toe-slope structures using native riparian vegetation transplanted from adjacent areas. This toe slope stabilization includes Riffle 20
15. Adjust boulders and install additional boulder to create micro vortex pocket water habitats in Riffle 21
16. Remove concrete and other materials from a failing retaining wall that is collapsing into the channel within Pool 11.

Preliminary estimates are that this work would take approximately 5 to 7 days to complete, and would require the use of a 12,000lb excavator with a hydraulic thumb, and a front end loader. Approximately 120 yd^3 of large rock will likely need to be imported into the site in order to complete the work. Additionally, approximately 25 - 30 cottonwood or other trees, averaging 12"-18" DBH, will need to be secured to complete the toe-slope stabilization work.

Goals and Objectives of Habitat Restoration in Reach 3

- Treat two active head-cuts in the reach through installation of cross vanes to stabilize the vertical profile of the stream and control further down-cutting of the channel.

- Increase pool habitat by 80% in the reach by converting sediment filled glide habitats back to self scouring pool habitat through the use of cross vanes and other structure. This work will reduce habitat limited glides in the reach by 64%.

- Increase average pool depth by 32%. Increase deep water pool cover in the pool meso habitats by 100% (35 square feet) by excavating fines from existing pools and conversion of glides back to pools.

- Increase riffle pocket water cover by 100% through installation of 6 mircro-vortex structures in the higher gradient riffle habitats.

- Stabilize 710 feet of actively eroding stream bank within the reach using log and rock toe slope stabilization techniques and riparian benching. Reduce unstable banks in the reach to less than 15% of the total bank length of the channel.

Glossary of Terms:

Benthic Zone - The benthic zone is the lowest level of a body of water. It is inhabited mostly by organisms that tolerate cool temperatures and low oxygen levels, called benthos or benthic organisms.

Cascade - A meso-habitat type. Cascades are the steepest riffle habitat types, in terms of gradient, in streams. These riffles consist of alternating small waterfalls and shallow pools. These habitats may appear to have the characteristics of a Step-pool system. Cascades are characterized by swift current flows and often have exposed rocks and boulders above the water surface, which creates considerable turbulence and surface agitation. The substrate normally found in cascades is bedrock or accumulations of boulders.

Cover - Locations where fish prefer to rest, hide and feed are called cover. Cover serves to visually isolate fish, which increases the number of territories in the same space. Additionally, cover can create areas of reduced velocities providing critical resting and feeding stations for fish. The amount of cover available in a stream can influence the production of a number of fish and invertebrate species.

Cross-Vane - A structure spanning the entire width of the channel, constructed of large boulders and/or large wood, that provides vertical stability, increased scour, increased stage upstream, and reduced stream power. This structure type is commonly used as a diversion structure for irrigation ditches, as well as for treating active down cutting and head cuts in the stream channel.

Embeddedness - The degree to which the interstitial spaces between larger substrate particles are filled with finer sediments. Embeddedness tends to armor the substrate, thus limiting available habitat for benthic dwelling macroinvertebrates and spawning habitat for salmonids.

Glide - A meso-habitat type. Glides are those portions of streams which have relatively wide uniform bottoms, low to moderate velocity flows, lack pronounced turbulence, and have substrates usually consisting of either cobble, gravel or sand. Glides are usually described as stream habitat with characteristics intermediate between those of pools and riffles. These habitats are commonly found in the transition between a pool and the head of a riffle, however they are occasionally found in low gradient stream reaches with stable banks and no major flow obstructions.

Green Line - A narrow band of riparian plant species immediately adjacent to the stream bank in deeply entrenched streams. These are typically streams that have no identifiable flood plains.

Head-Cut - An area of active down-cutting in the channel where a river or stream is eroding down to a new, lower flood plain.

Intermittent - An intermittent stream is one that only flows for part of the year.

Lotic - Of, relating to, or living in moving water such as streams and rivers.

Meso-Habitat - A channel scale habitat form. Typically a pool, riffle, rapid, cascade or glide habitat. A meso-habitat occupies the entire width of the stream channel, and with few exceptions (most notably plunge pools in high gradient step-pool systems) is at least as long as the channel is wide.

Micro-Habitat - Micro habitats are small, site specific habitats within a meso-habitat form, and may include spawning redds, in-stream or overhead cover, and velocity shelters.

Micro-Vortex - A small rock cluster structure that replicates pocket water habitat in riffles, rapids and cascades.

Over-Wintering Habitat - Areas of a stream or water body exhibiting depths that may sustain a population through the winter months.

Perennial - A perennial stream is one that flows year round.

Pocket Water - A micro-habitat type. Pocket water habitats are typically found in higher gradient riffles, rapids, and cascades with large cobble, boulder, and large woody debris. These pocket water habitats provide small areas for velocity shelter and cover within these fast-water habitat forms.

Pool - A meso-habitat type. Pools are channel segments exhibiting areas of scour and deposition where the water is deeper and slower moving.

Primary Producers - Primary producers are those organisms in an ecosystem that produce biomass from inorganic compounds. In almost all cases these are photosynthetically active organisms.

Rapid - A meso-habitat type. Rapids are riffles associated with high gradients (greater than 4%) with swiftly flowing (greater than 1.5 ft/sec), moderately deep, and highly turbulent waters. These riffles are generally associated with boulder substrates, which protrude through the surface of the water.

Residual Pool Depth (RPD) - Residual pool depth is estimated as the depth of water which would be retained in a pool under highly reduced flows or the stoppage of flows in the stream. This area of pools would be utilized by fish in low flow conditions. Residual pools would also provide habitat for overwintering of fish when ice buildup restricts movement in riffles or glides between pools. Residual pool depth is calculated by locating and measuring the greatest depth of the pool at the riffle crest (deepest point of the downstream boundary cross-section of the pool), and subtracting this value from the greatest measured depth of the pool habitat. The difference in these measurements is described as the RPD. RPD may be difficult to determine in some habitats, particularly dam pools with woody debris structural associations. In many of these habitat units, the RPD may actually be a very low value or zero due to water flowing through these debris dams.

Riffle - A meso-habitat type. Riffles are those areas of the stream in which turbulence in the water column is the major identifying characteristic, as a result of relatively high gradients. These units contain moderately deep to shallow, swift flowing water, and are characterized by boulder or cobble substrates. Riffles are very important for macroinvertebrate production, due to the availability of light and oxygen, and the corresponding vegetative growth on the bottom substrate. The quality of riffles, including low sediment deposition and resulting embeddedness can have a direct impact on fish populations. The cleaner and healthier the vegetative growth and benthic macroinvertebrate community, the more food there is for the fish population.

Salmonids - Salmonidae is a family of ray-finned fish, the only family of order Salmoniformes. It includes the well-known salmons and trouts; the Atlantic salmons and trouts of genus Salmo give the family and order their names.

Subfamily - Salmoninae
Brachymystax - lenoks
Oncorhynchus - Pacific salmon and trout
Salmo - Atlantic salmon and trout
Salvelinus - Char and trout (Brook trout, Lake trout)

Substrate - Stream substrate (sediment) is the material that rests at the bottom of a stream.

Thermal Refugia - Micro habitats found in streams and lakes that provide thermal protection for cold water species such as trout. These may include shaded areas, cool water springs, and deep water habitats.

Toe-Slope - The foot, or bottom, of the sloping bank of a stream. This is the area of the highest sheer stress and erosion potential on a stream bank, and is typically the point of failure leading to mass wasting and collapse.

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Ariel Photography used with permission: Data from Google Earth and USGS/Microsoft TerraServer. Topographical maps created using USGS and Delorme TOPO 6.0

APPENDIX

Project Area Map - Including locations of proposed treatments

Longitudinal Profiles of Reach 3

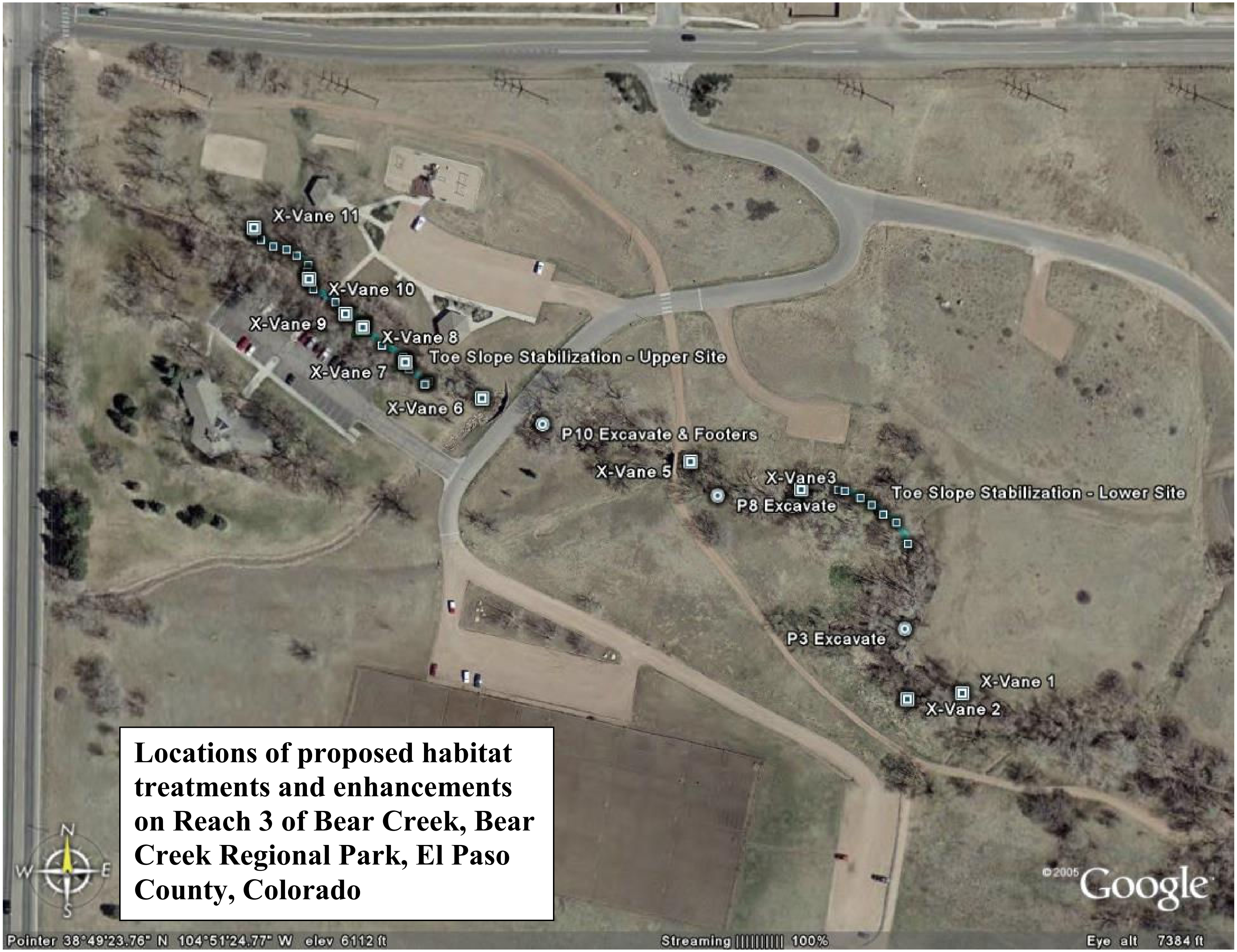
Cross - Sections

Proposed Treatments Designs and Conceptual Drawings

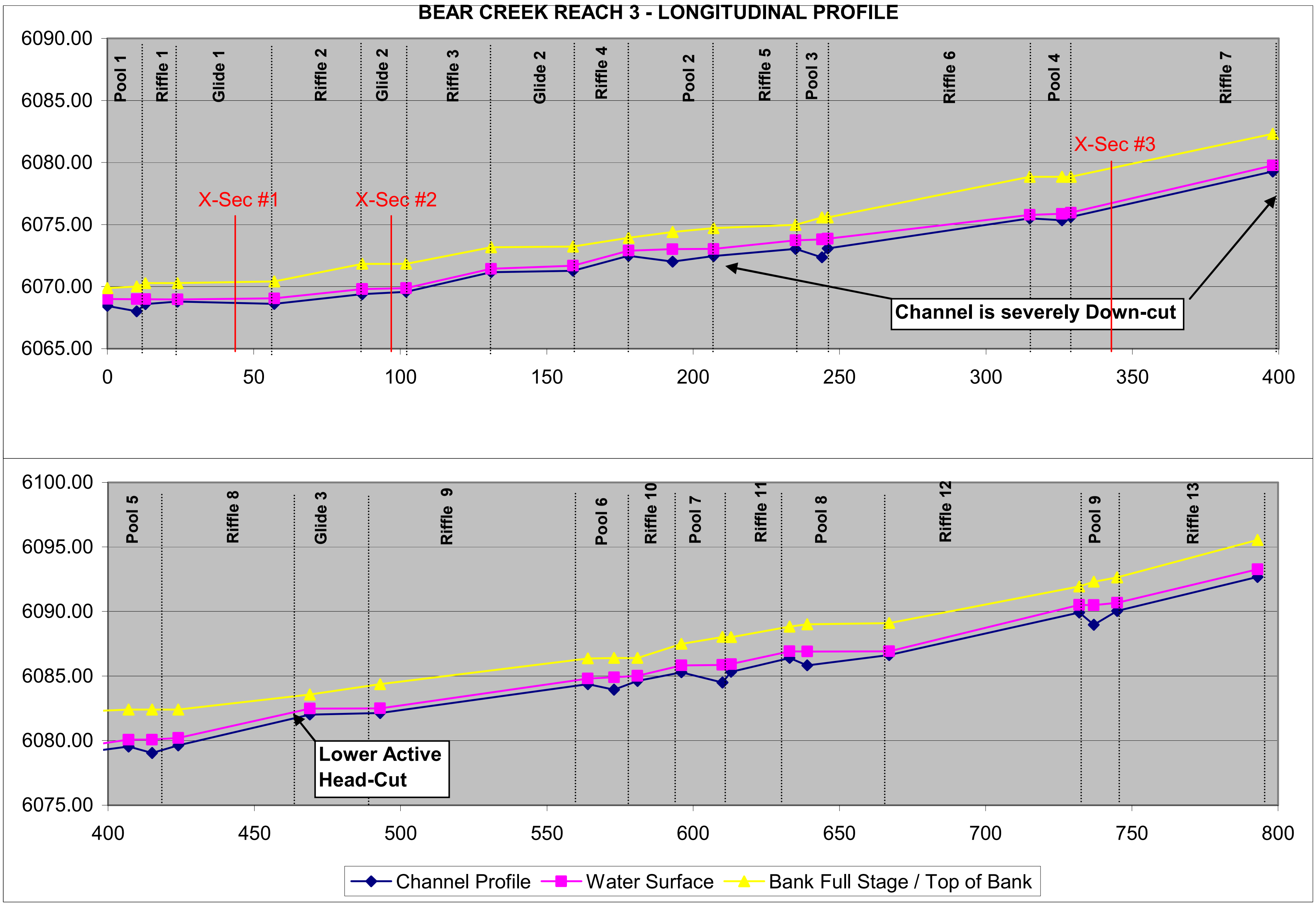
Photographs of Proposed Treatment Types

Stream Inventory BWSHI Data Sheets and Summaries

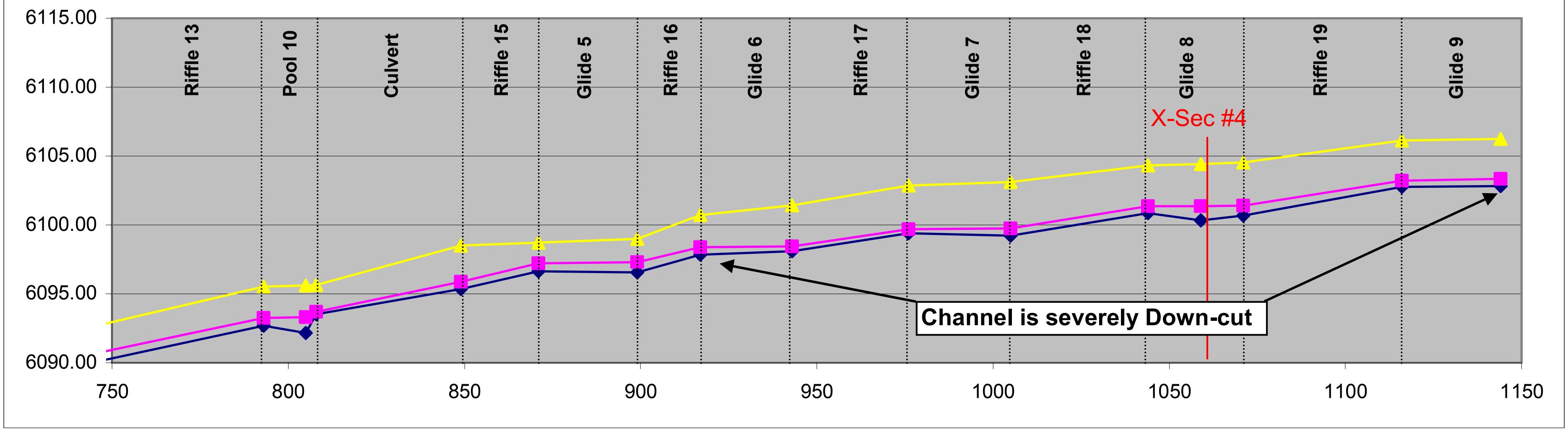
Winters / Gallagher Basinwide Stream Habitat Survey Protocol Documentation

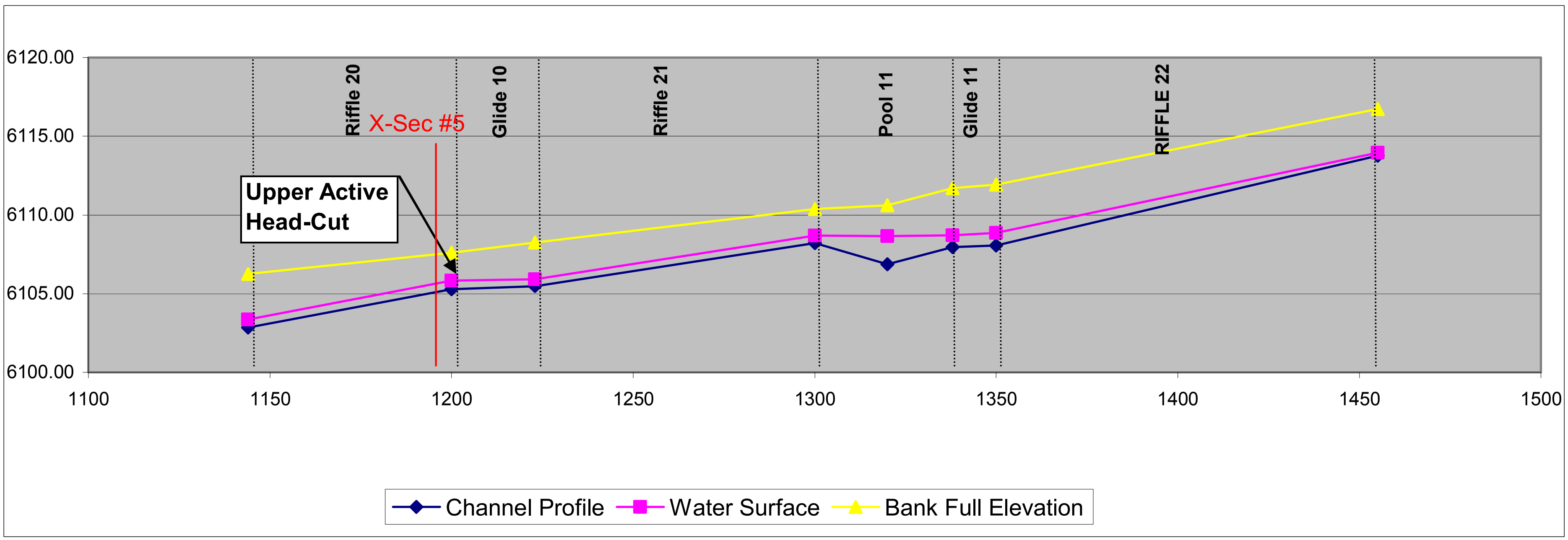


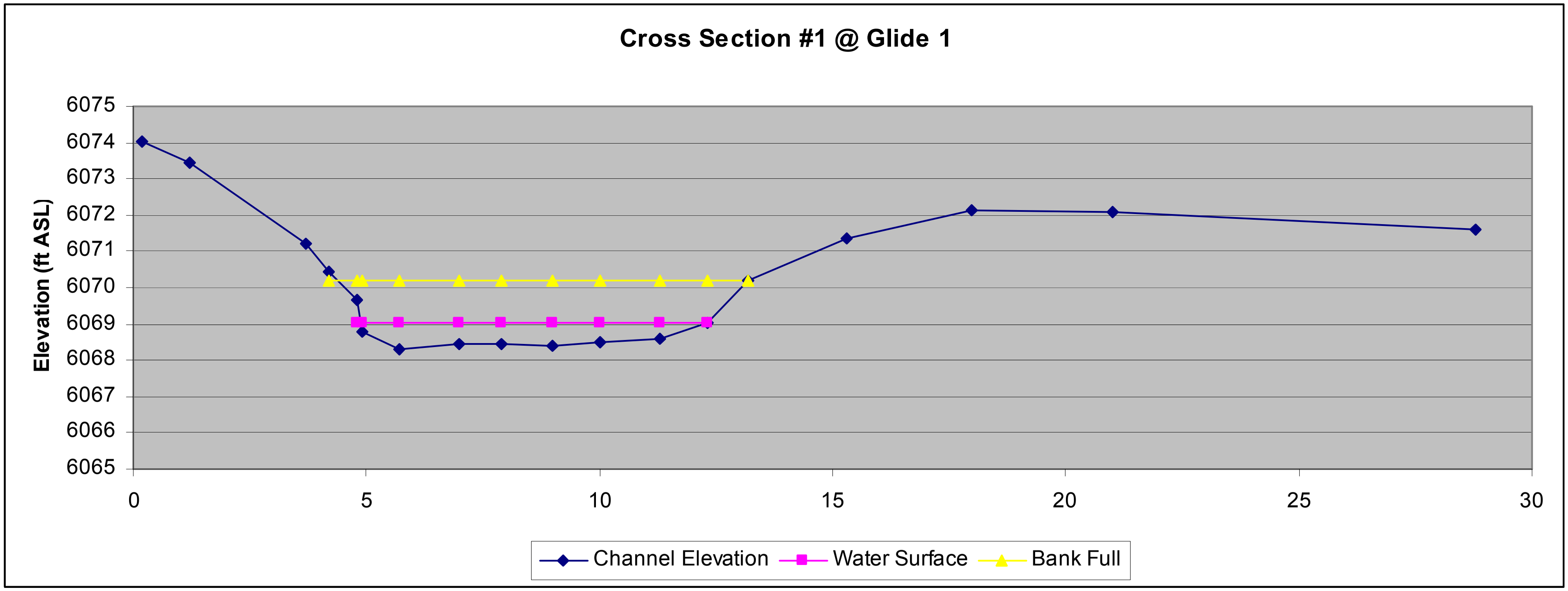
Locations of proposed habitat treatments and enhancements on Reach 3 of Bear Creek, Bear Creek Regional Park, El Paso County, Colorado

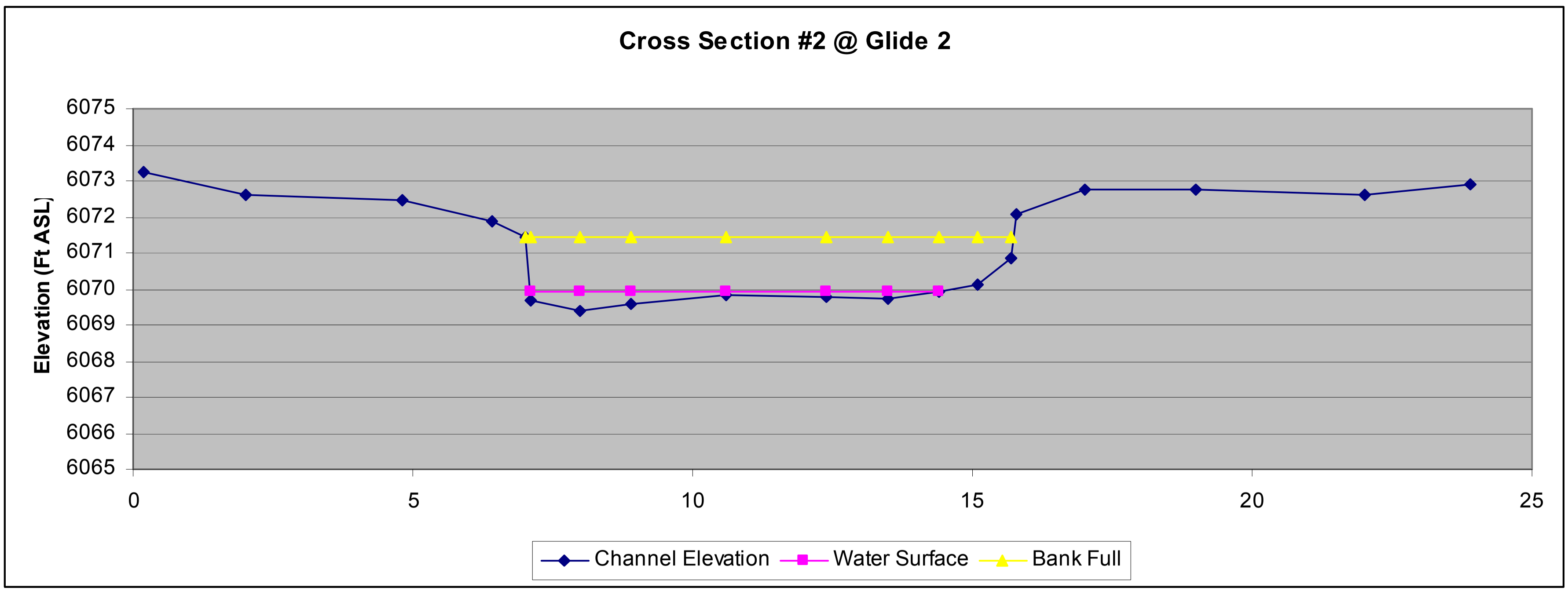

BEAR CREEK REACH 3 - LONGITUDINAL PROFILE
Pool 1
Riffle 1
Glide 1
Riffle 2
Glide 2
Riffle 3
Glide 2
Riffle 4
Pool 2
Riffle 5
Pool 3
Riffle 6
Pool 4
Riffle 7
X-Sec #1
X-Sec #2
X-Sec #3
Channel is severely Down-cut
Pool 5
Riffle 8
Glide 3
Riffle 9
Pool 6
Riffle 10
Pool 7
Riffle 11
Pool 8
Riffle 12
Pool 9
Riffle 13
Lower Active Head-Cut
Channel Profile
Water Surface
Bank Full Stage / Top of Bank

BEAR CREEK REACH 3 - LONGITUDINAL PROFILE

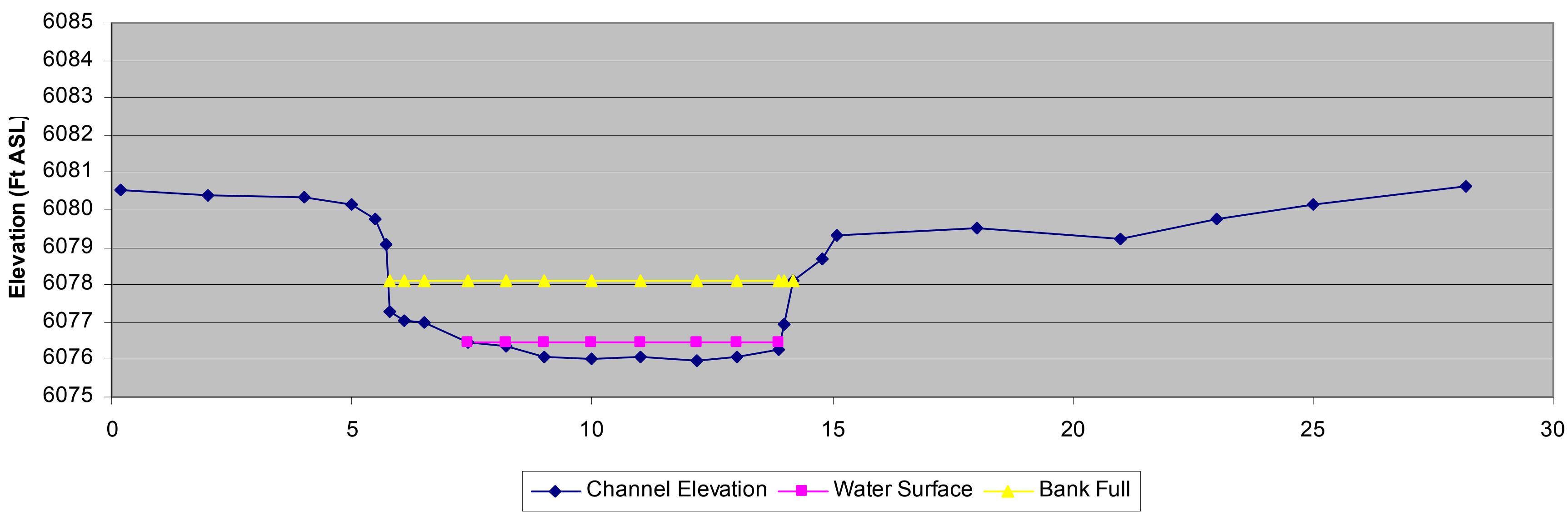




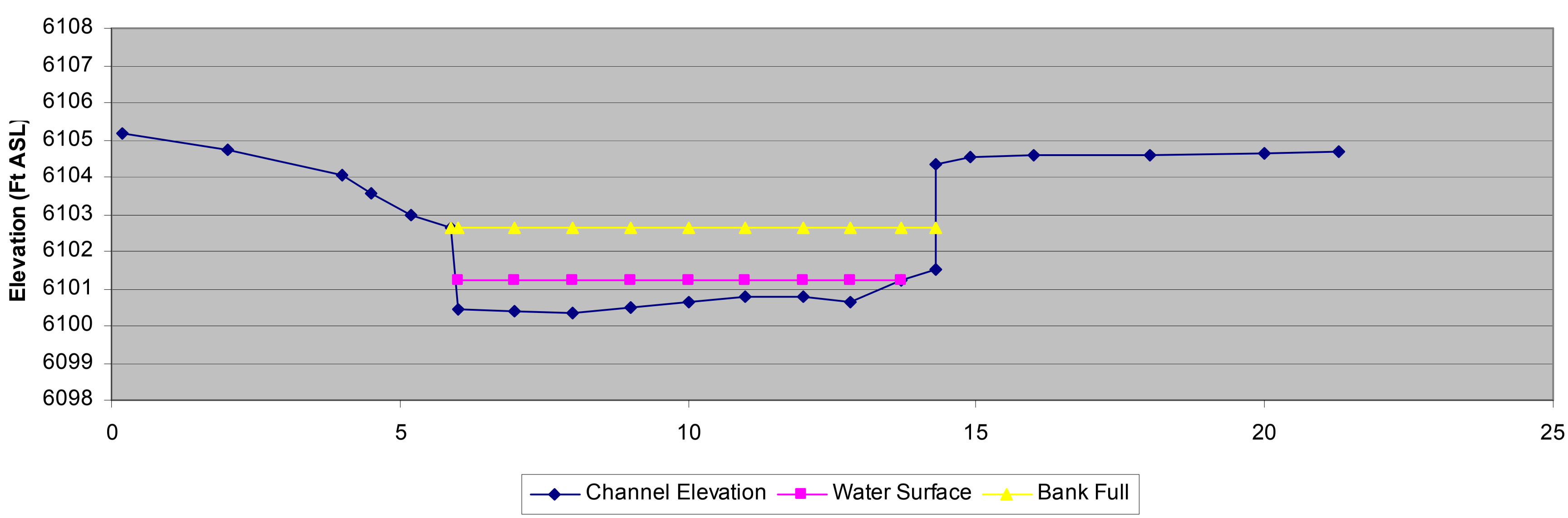

Cross Section #1 @ Glide 1
Elevation (ft ASL)
6075
6074
6073
6072
6071
6070
6069
6068
6067
6066
6065
0
5
10
15
20
25
30
Channel Elevation
Water Surface
Bank Full

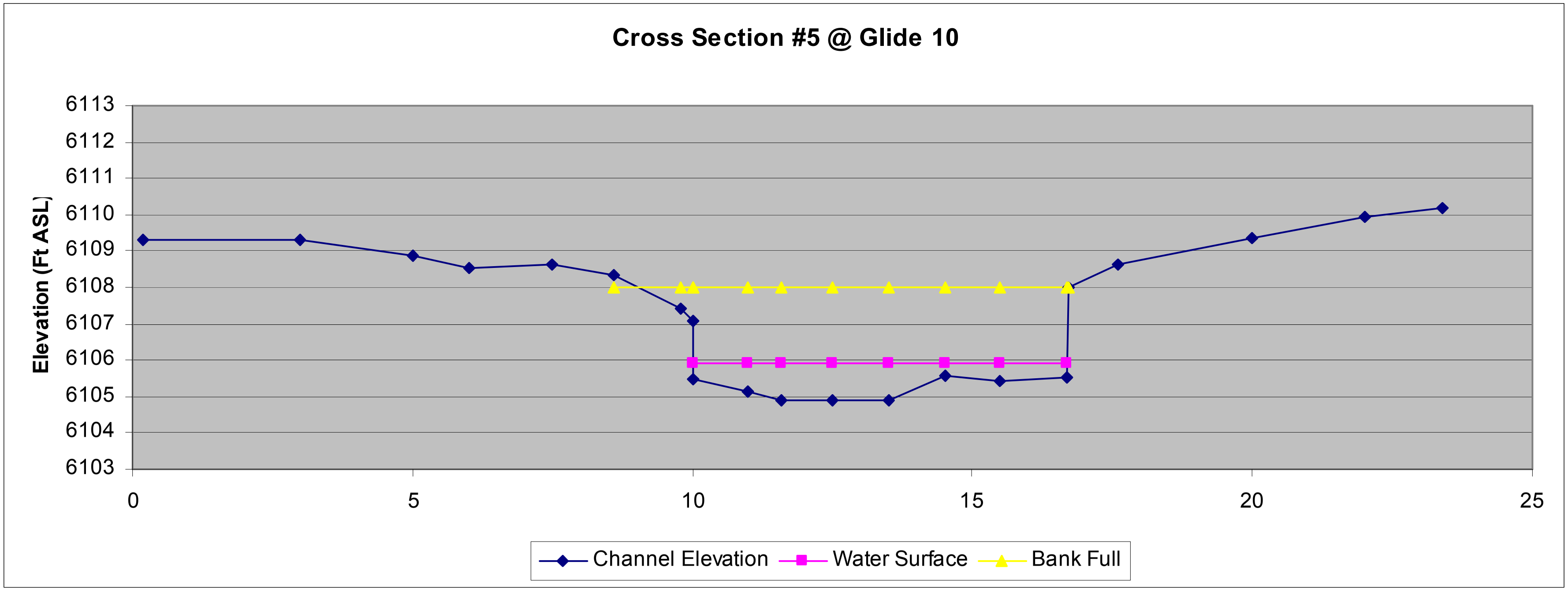

Cross Section #2 @ Glide 2
Elevation (Ft ASL)
6075
6074
6073
6072
6071
6070
6069
6068
6067
6066
6065
0
5
10
15
20
25
Channel Elevation
Water Surface
Bank Full

Cross Section #3 @ Riffle 7



Cross Section #4 @ Glide 8




Cross Section #5 @ Glide 10
Elevation (Ft ASL)
6113
6112
6111
6110
6109
6108
6107
6106
6105
6104
6103
0
5
10
15
20
25
Channel Elevation
Water Surface
Bank Full

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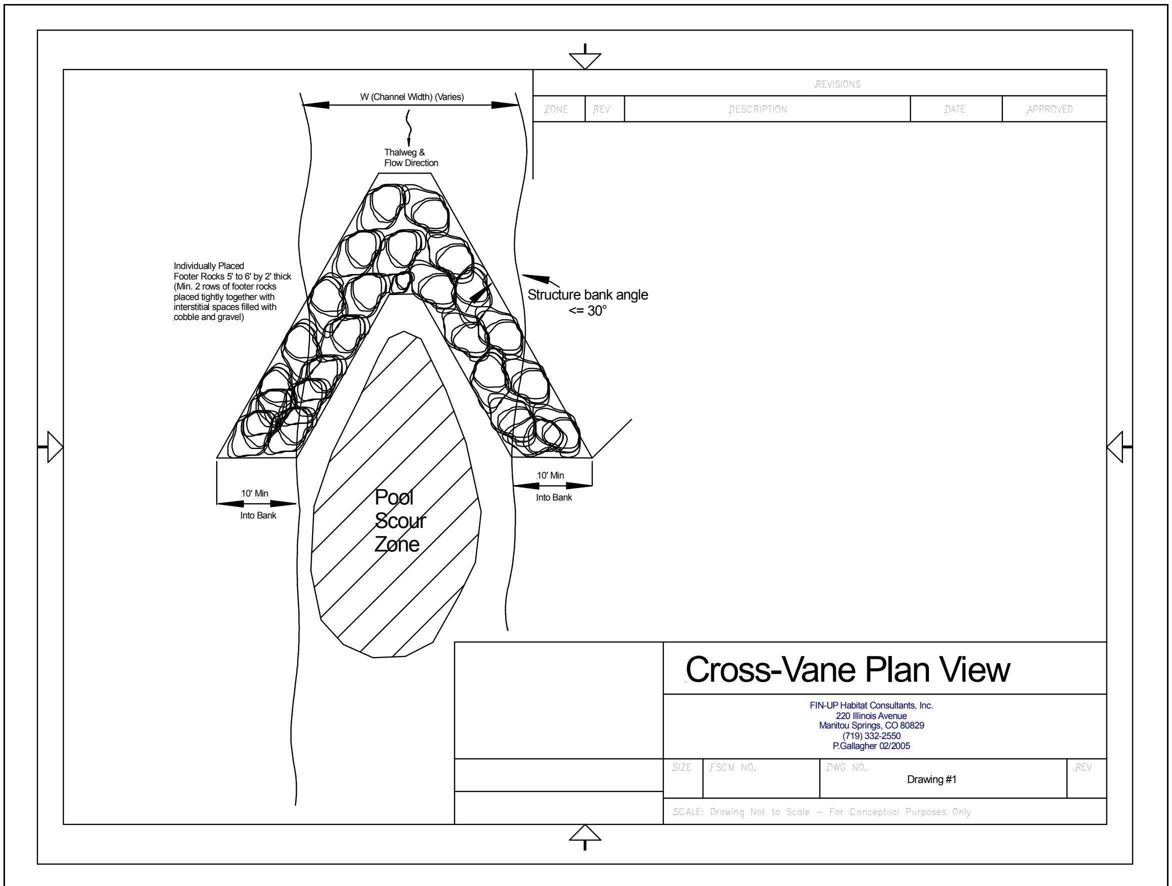
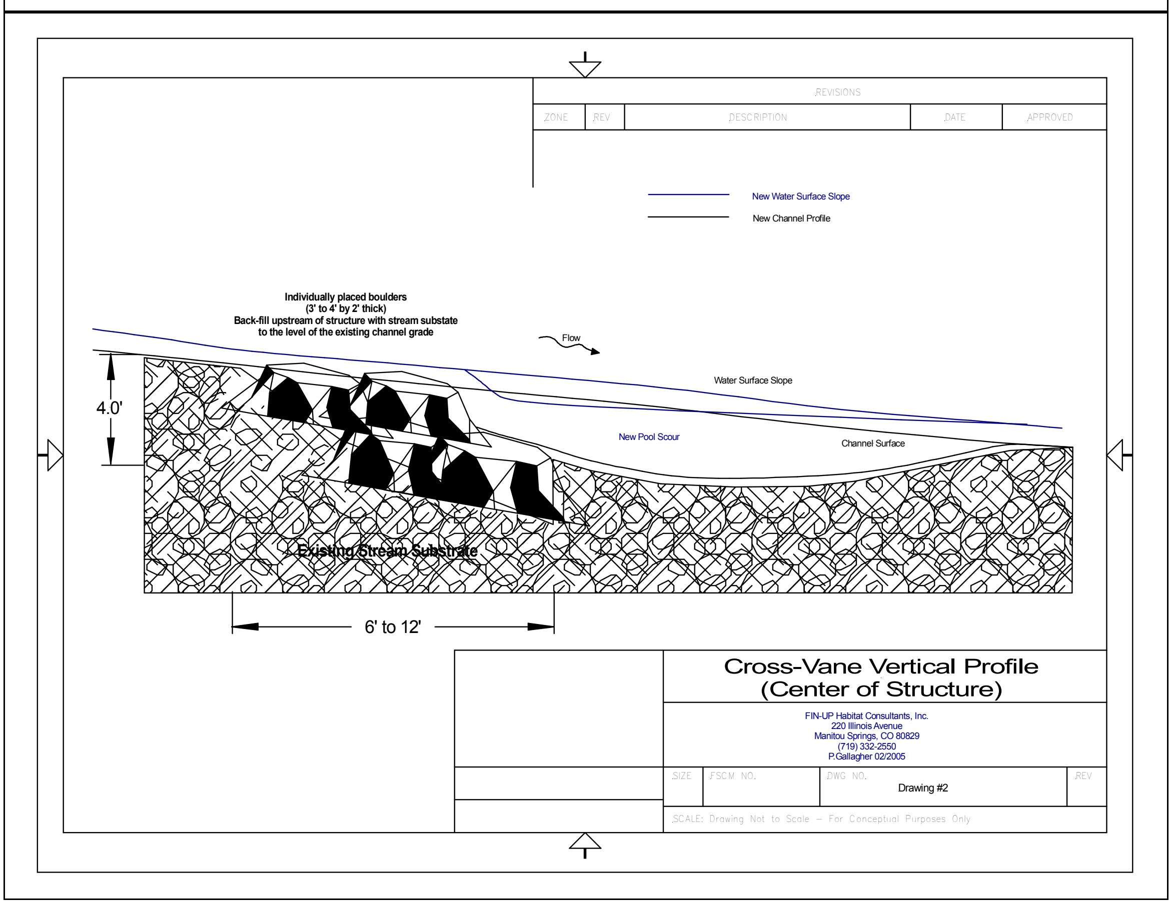
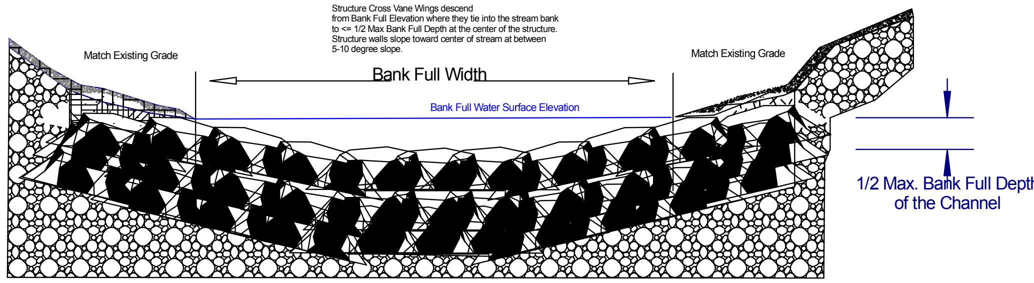
STREAM CHANNEL STRUCTURE DRAWINGS





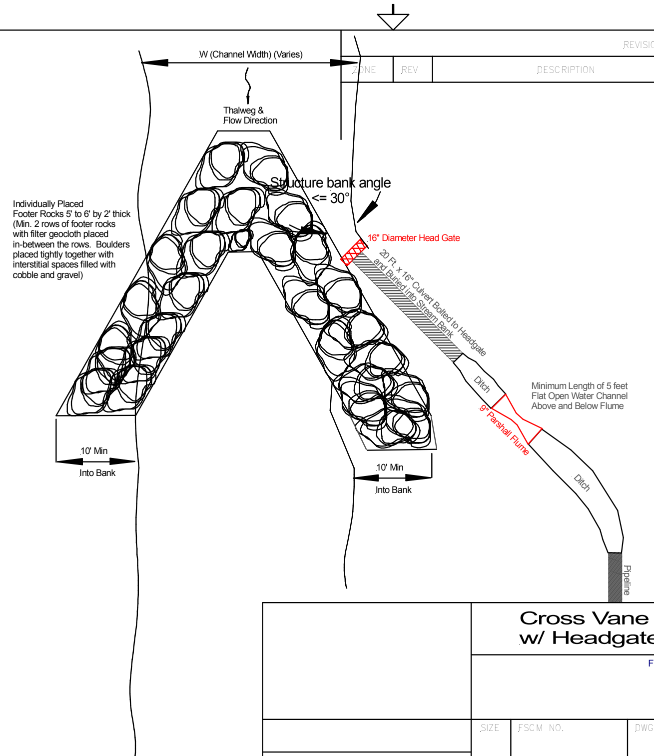


Cross-Vane Vertical Profile Cross Section Elevations)

FIN-UP Habitat Consultants, Inc.
220 Illinois Avenue
Manitou Springs, CO 80829
(719) 332-2550
P.Gallagher 09/2005

SIZE | FSCM NO. | DWG NO. Drawing #3 | REV

SCALE: Drawing Not to Scale – For Conceptual Purposes Only



Cross Vane Diversion Structure w/ Headgate and Parshall Flume

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SIZE | FSCM NO. | DWG NO. Drawing #4 | REV

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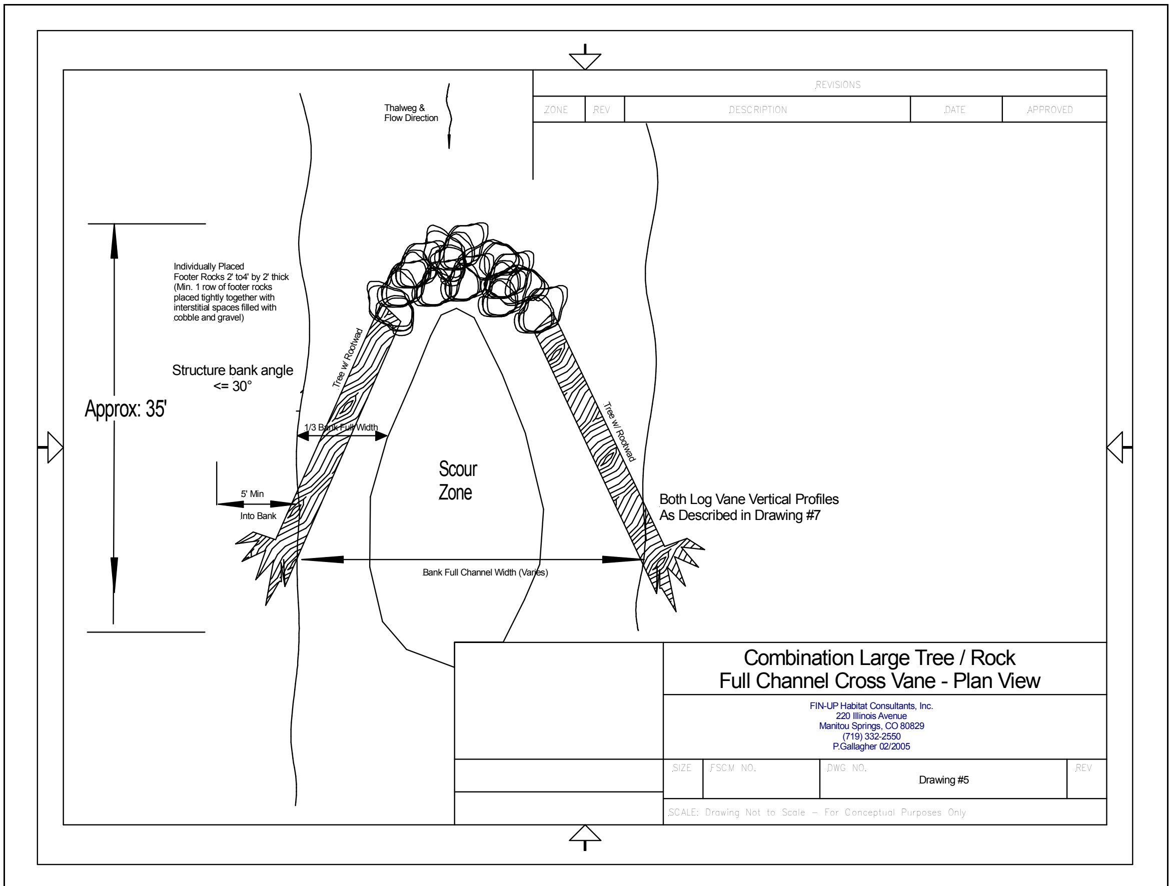
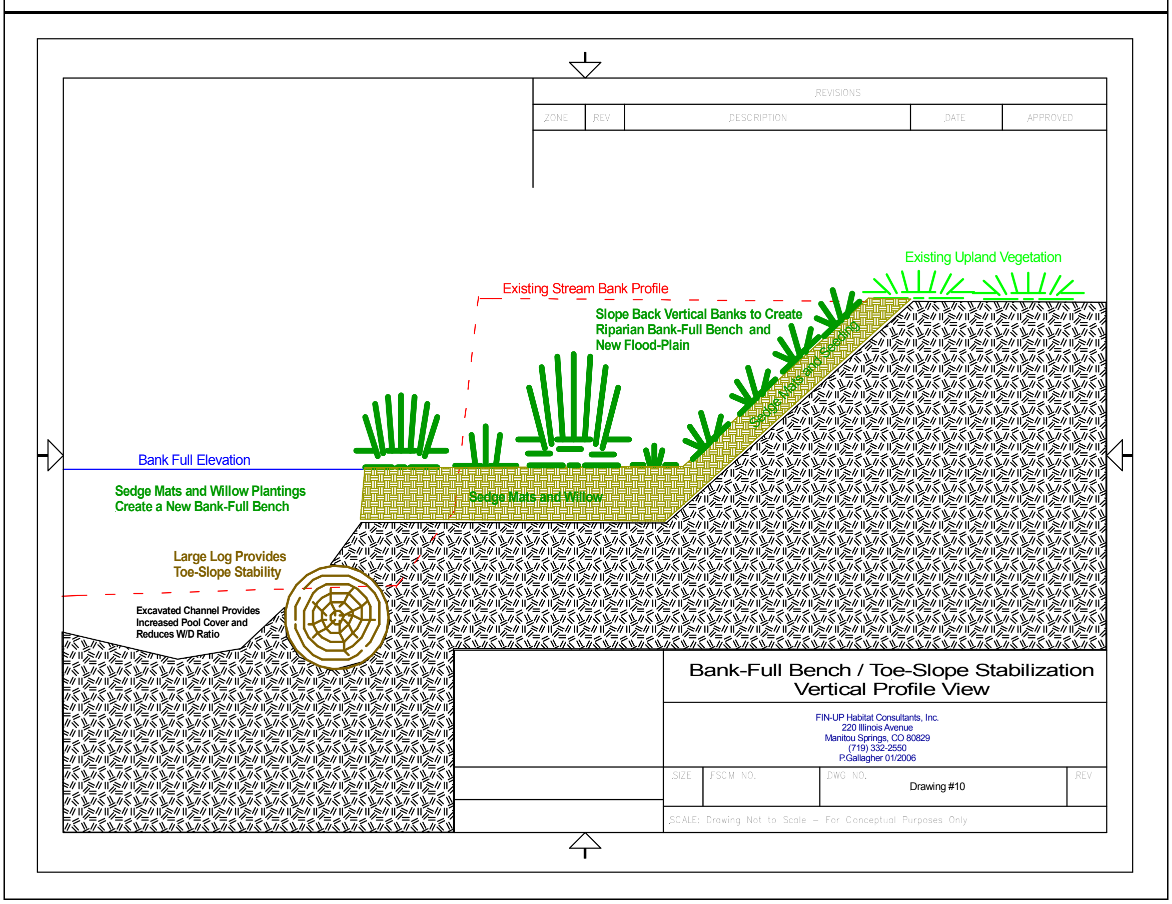

REVISIONS
ZONE
REV
DESCRIPTION
DATE
APPROVED
Thalweg &
Flow Direction
Individually Placed
Footer Rocks 2' to4' by 2' thick
(Min. 1 row of footer rocks
placed tightly together with
interstitial spaces filled with
cobble and gravel)
Structure bank angle
<= 30°
Approx: 35'
Tree w/ Rootwad
1/3 Bank Full Width
Scour
Zone
Tree w/ Rootwad
5' Min
Into Bank
Both Log Vane Vertical Profiles
As Described in Drawing #7
Bank Full Channel Width (Varies)
Combination Large Tree / Rock
Full Channel Cross Vane - Plan View
FIN-UP Habitat Consultants, Inc.
220 Illinois Avenue
Manitou Springs, CO 80829
(719) 332-2550
P.Gallagher 02/2005
SIZE
FSCM NO.
DWG NO.
Drawing #5
REV
SCALE: Drawing Not to Scale - For Conceptual Purposes Only


REVISIONS
ZONE
REV
DESCRIPTION
DATE
APPROVED
Existing Upland Vegetation
Existing Stream Bank Profile
Slope Back Vertical Banks to Create
Riparian Bank-Full Bench and
New Flood-Plain
Sedge Mats and Seeding
Bank Full Elevation
Sedge Mats and Willow Plantings
Create a New Bank-Full Bench
Sedge Mats and Willow
Large Log Provides
Toe-Slope Stability
Excavated Channel Provides
Increased Pool Cover and
Reduces W/D Ratio
Bank-Full Bench / Toe-Slope Stabilization
Vertical Profile View
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220 Illinois Avenue
Manitou Springs, CO 80829
(719) 332-2550
P.Gallagher 01/2006
SIZE
FSCM NO.
DWG NO.
Drawing #10
REV
SCALE: Drawing Not to Scale - For Conceptual Purposes Only

PHOTOGRAPHS OF TREATMENT TYPES

Cross Vane Structure on Cheyenne Creek below I-25 Overpass. Colorado Springs, El Paso County, Colorado

Cross Vane Structure on Fountain Creek below 21st Street Bridge, El Paso County, CO.

Cottonwood trees used as toe-slope stabilization with riparian benches. Cucharas Creek, Huerfano County, Colorado.

Boulders placed in clusters to create pocket water micro vortex habitats. South Platte River, Park County, CO.