

Beaver Cr Rapid Bio-Assessment Inventory 2009

Conducted by: **Bio-Surveys, LLC**
strask@casco.net
541-487-4338

Conducted for: Marys River Watershed Council

**Funded by: Oregon Watershed Enhancement Board
Grant # 209-3041**



Marys River Watershed Council

P.O Box 1041
Corvallis, OR 97339

541-758-7597

www.mrwc.org

outreach@mrwc.net

Table of Contents

Introduction	1
Methodology	2
Survey Results	
Beaver Creek	3
Starr Creek.....	9
Henderson Creek	11
Duffy Creek.....	14
Mercer & Powell Creeks	16
Trib A of Beaver Cr.....	17
Recommendations	19
Cutthroat Trout Abundance & Distribution Graphs.....	22
Temperature Profile Graphs	25
Map.....	30

Introduction

A Rapid Bio-Assessment snorkel inventory was conducted in the Beaver Creek subbasin, a tributary of Muddy Cr in the Marys River Basin, between June 4 and July 20 of 2009. The mainstem Beaver Cr survey began just above the confluence with Muddy Cr and extended to RM 8.6. The survey was terminated in a zone of tight hillslope confinement with an approximate gradient of 10 percent on BLM ownership (Gleason Fk). All of the major tributaries of Beaver Cr with the potential of providing significant cutthroat habitat were also surveyed. This included Trib A of Beaver Cr, Starr, Henderson, Duffy, Mercer, Powell and their associated tributaries.

The intent of the inventory was to describe the current distribution and relative abundance of multiple age classes of cutthroat trout within the Beaver Cr subbasin and to compare this distribution with channel morphology, current land use and potential summer temperature limitations. An extensive effort to profile aquatic temperature gradients was conducted by deploying continuous data logging thermistors at 12 locations. These overlapping layers of physical habitat condition, fish distribution and temperature profile were expected to reveal information about how cutthroat are currently utilizing the aquatic habitats of the Beaver Cr subbasin. The assessment of these relationships has resulted in recommendations for enhancing or restoring the aquatic conditions in Beaver Cr to benefit the native cutthroat and to initiate a trend toward improving system function.

Methodology

Beaver Cr was identified as a subbasin of interest by an Assessment prepared by the Marys River Watershed Council and the EPA in 2003. This restoration screening process utilized a Habitat Suitability Index developed for cutthroat trout to identify reaches exhibiting restoration potential.

The Rapid Bio-Assessment snorkel inventory was designed to conduct a higher resolution inspection of the subbasin to describe actual fish abundance and distribution as well as link those distributions to morphological conditions on the ground. The survey was conducted by a single snorkeler to reduce the variability known to exist between surveyors. The survey was conducted over a broad temporal range (47 days) in an attempt to optimize conditions for snorkeling (visibility). Preliminary assumptions were made that the mainstem of Beaver Cr might have better visibility during the month of June than later in the summer when the decomposition of organics in low gradient reaches increased the abundance of tannins, reducing visibility. This broad temporal distribution may have influenced the inventory's ability to get a clear snapshot of the relative distribution of cutthroat between primary tributaries, but it had no influence on the distributions observed within each individual tributary. Tributary surveys were completed concisely in a 1 or 2 day window. In either case, the resultant cutthroat distributions observed should be considered a snapshot of a very dynamic distribution pattern that has the potential of exhibiting extensive in-season variation driven by changes in flow and temperature. Landowner contacts were made for all of the private and industrial ownerships prior to conducting the inventory. Approximately 2500 ft within the surveyed reaches were not surveyed due to denial of access.

The protocol was consistent for both mainstem and tributary reaches. The first pool above the stream or tributary confluence was selected as sample unit number one. Every subsequent 5th pool was inventoried after the initial pool selection to produce a 20% sample of the current distribution and abundance. This sampling protocol was consistent for Beaver Cr above the confluence of Mercer Cr, Duffy Cr and Henderson Cr. The survey protocol was not maintained for Beaver Cr below the confluence of Mercer Cr, for Starr Cr or for Mercer and Powell Creeks due to poor visibility. In these cases, a foot survey was conducted to get a general sense of passage issues and channel morphology. Snorkeling was conducted only opportunistically.

Individual survey segments exhibiting adequate visibility were sampled at a 20% frequency until the survey was terminated by the biologist because of diminishing pool surface areas, diminishing flow or the diminishing potential for meaningful restoration high in the system. The survey end points do not represent the full extent of cutthroat distribution.

Pools had to meet the minimum criteria of being at least as long as the average stream width. They also had to exhibit a scour element (this factor eliminates most glide habitats) and a hydraulic control at the downstream end. There were no minimum criteria established for depth. Only main channel pools were sampled. Side channel pools, backwaters and alcoves were not incorporated into the surveyed pool habitats.

The lineal distances represented in the database were estimated by pacing from the beginning of one sampled unit to the beginning of the next sampled unit. Total distances represented in the database are consistently greater than mapped distances using USGS 1:24,000 series maps. This is related to the level of sinuosity within the floodplain that is not incorporated in base map layers. If you are attempting to overlay this database on existing stream layer information there would be a need to justify lineal distances with known tributary junctions (these can be found in the comments column of the Access database).

Pool lengths and widths were generally estimated. Because pool widths vary significantly within a single unit, a visual estimate of the average width was considered adequate.

A cover/complexity rating was attributed to each pool sampled. This rating was an attempt to qualify the habitat complexity within the reach. The 1 - 5 rating is based on the abundance of multiple cover components within a sampled unit (wood, large substrate, undercut bank, overhanging vegetation). Excessive depth was not considered a significant cover component. The following criteria were utilized:

- 1 0 cover present
- 2 1-25 % of the pool surface area is associated with cover
- 3 26-50 % of the pool surface area is associated with cover
- 4 51-75 % of the pool surface area is associated with cover
- 5 > 75 % of the pool surface area is associated with cover

A numerical rating was given to each sampled unit for the surveyor's estimate of visibility. The following criteria were utilized:

- 1 excellent
- 2 moderate
- 3 poor

There was also commentary recorded within each of the surveyed reaches that included information on temperature, tributary junctions, the abundance of other species and adjacent land use. This information can be retrieved from the Access database provided as a deliverable for this project.

Beaver Creek Results

Distribution and Abundance

The distribution of cutthroat observed in Figure 1 represents only the zone from actual RM 3.7 at the Dunn driveway crossing to the 10 percent gradient contour in the headwaters of Gleason Cr (upper mainstem Beaver). It does not include observations from the mouth of Beaver Cr to the Dunn bridge, because poor visibility compromised the utility of the snorkel inventory method.

Within the inventoried reach there were distinct differences in channel form and habitat quality that directly influenced the abundance of cutthroat. To simplify, there are 3 unique zones of production with quantifiable differences in habitat quality (see *Physical Habitat Conditions*).

The first zone extends from approximately RM 4.4 to RM 5.3 on the Kelly property. It is a zone of high function that is represented by high sinuosity, complex riparian structure and the presence of the first interactive floodplain habitats. Summer cutthroat abundance was higher here than observed in the adjacent stream reaches both above and below. The actual rearing densities (avg. = .05 fish/m²) of cutthroat were still below what would normally be expected for habitats performing to capacity. This zone transitions abruptly at a bedrock slide (RM 5.3) that was functioning to at least delay upstream migrants (large numbers of both cutthroat and redbreast shiners were observed in the pool below). The slide represents the current upstream terminus of redbreast shiner distribution, which may be significant in limiting the intra-specific competition for food and habitat above and below this seasonal barrier.

This stream reach also exhibits very high densities of fresh water mussels. This is a very unique feature when compared to the remainder of the Beaver Cr subbasin. Their presence may suggest the presence of a stable bedload, confirming the previous assessment that the reach possesses a high level of residual function.

The second zone is between the bedrock slide at RM 5.3 and the beaver dam complex at RM 7.5 (above the confluence of Duffy Cr). Here, the mainstem of Beaver Cr is dominated by a simplified channel form that is primarily scoured to bedrock, exhibits limited sinuosity, and contains an apparent legacy of channel manipulation to facilitate agriculture (straightening and channel cleaning). The abundance of pool rearing cutthroat was lower in this reach with an average of 0.03 fish/m² of pool habitat.

The third zone runs from RM 7.5 at the beaver dam complex to the end point of the survey at RM 8.4, where the average rearing density for cutthroat increased dramatically to 0.11 fish/m² of pool surface area. This zone represents the highest level of proper function driven by the presence of a viable and winter-stable complex of beaver ponds. The greatest potential for the restoration of system function and the greatest chance of achieving successful restoration exists within this 0.9 mile subsection of mainstem Beaver Cr.

Migratory patterns

Fortunately, Beaver Cr was the site of extensive trapping and electrofishing during a concerted effort by ODFW in 1991-93 to begin to understand the precipitous declining trend in Willamette basin cutthroat populations (Review of T & E, Sensitive and Stocks of Concern, Northwest Region Fish Management Review White Paper, 1993). Migration timing and fish bio-metrics data were collected for cutthroat at the irrigation dam (Thompson Dam) on the lower mainstem of Beaver Cr (actual RM 1.9) during the fall, winter and spring of 1992 and 1993. Some very interesting information resulted from this effort that is uniquely specific to the lower Beaver Cr mainstem.

This data concluded that the bulk of the **downstream** migration for immature juvenile cutthroat occurred between the months of November and December. This would concur with other known cutthroat life history patterns as juveniles disperse downstream into lowland habitats with an increase in fall and winter flows. What is not well understood is whether this is a volitional migration pattern (a genetically programmed survival strategy) or one driven by habitat degradation (loss of adequate off channel habitat for the provision of low velocity winter refugia). Very different downstream patterns were observed between inventoried years, which may suggest that movement of juveniles is highly dependent on flow regimes.

The **upstream** migration of cutthroat at the Beaver Cr trap was determined to be 96% three and four year olds; 91% of these older age class fish were classified as spawners from an analysis of scale resorption. The period of migration extended from November to May (when sampling was terminated) with peak abundance observed during the months of April and May. The data suggests that additional upstream migrations of cutthroat may have extended beyond the end of the trapping window in May.

As in most forays to understand the life histories of a highly migratory species, the Beaver Cr trapping data also raises some obvious questions.

- 1) Is there an upstream migration that may extend farther into the summer for cutthroat of all age classes that may be driven by a need to seek cold water refugia as mainstem temperatures become elevated?

- 2) Where are these late spring spawners headed to complete their reproduction in the subbasin (this late migration potentially compromised by receding summer flows and its effect on tributary access)?
- 3) What is the destination for juvenile out-migrants and how does increasing summer temperature in the mainstem affect their survival?

These may be issues of emphasis when tackling existing data gaps and attempting to develop future monitoring strategies.

Physical habitat conditions

The lower portion of mainstem Beaver Cr from its confluence with Muddy Cr to actual RM 3.7 on the Dunn property courses through tillable agricultural lands. Although there are observable differences in current land use within this reach, the legacy of crop production is evident. Activities that have historically benefited farming (leveling, filling wetlands, drain tiling, riparian encroachment, etc.) have also reduced the capacity of lower Beaver Cr to function as the integrated system of channels, wetlands and complex riparian woodlands that once existed there. The loss of system function in this reach is most starkly represented by the current condition of the active channel. The channel is deeply incised within its historical floodplain. This channel incision is muted near its confluence with Muddy Cr because of the influence of the Muddy Cr floodplain. The incision however, quickly rises to 8 ft at actual RM 0.3 and peaks at 12 ft at actual RM 3.7.

Research conducted for the Willamette basin suggests that a component of this channel incision is related to down cutting occurring in the mainstem Willamette River. There is also, however, a distinct lack of instream wood complexity that has contributed to this observed issue of deep channel incision. The missing wood complexity is a combination of a long legacy of channel realignment, channel clearing (excavation to facilitate drainage and moderate flooding) and a loss of potential large woody recruits from the riparian corridor.

Deep channel incision reduces the frequency of floodplain connectivity. A loss of floodplain connectivity establishes a trajectory toward habitat simplification. Because Beaver Cr can no longer access its historic floodplain during most winter flow events, those floodplain habitats that used to depend on seasonal stream linkages have dwindled (ash swales, seasonal wetlands). These habitats were likely key winter refugia for the native cutthroat population and also provided important ground water storage that mitigated for elevated stream temperatures well into the summer.

Narrow riparian corridors exist in the majority of this lower 3.7 miles. Many stream segments exhibit a riparian canopy that emanates only from within the active channel. Farming occurs right up to the edge of the floodplain terrace. In general, limited direct solar exposure occurs except for several distinctly barren stream segments between the confluence of Starr Cr at RM 2.3 and RM 3.2. There are 3 riparian voids within this 0.9 mile reach that total approximately 2,500 lineal ft of no riparian canopy. To be clear, these zones of weak riparian canopy, although worthy of mention, do not represent an issue regarded as high priority for immediate restoration. Addressing these sites would have little to no impact on the thermal limitations to salmonid production that become acute higher in the subbasin.

The loss of horizontal channel meander in this lower 3.7 mile segment of mainstem Beaver Cr reduces the stream's ability to recruit riparian wood resources to the active channel.

The observed low wood densities result in more vertical scour and a continuous loss of nutrient rich migratory substrates (detritus bearing silts, sands and gravels).

Ditching and drain tiling are present in this reach and are designed to expedite the runoff of winter rains to the mainstem. Farming practices differ for different locations and different crops and the capacity to monitor these types of hydrologic linkages and the compounds they might deliver is limited. However, it's adequate at this level of assay to suggest that activities designed to accelerate runoff may result in increasing the negative impacts to water quality in the mainstem of Beaver Cr.

Recognizing that system functions have been modified in the lower mainstem of Beaver Cr is the easy part of attempting to understand how a stream system is currently working. Making recommendations to restore these types of modifications becomes a difficult exercise in quantifying and then balancing social values. A summary of this lower 3.7 miles would conclude that there are many missing natural assets that are necessary in combination to form a functioning aquatic system. Some landowners have begun to address these limitations through a variety of actions, including increasing riparian setbacks and wetland conservation. Input from landowners is needed to identify further beneficial and feasible opportunities for watershed improvements.

ODFW conducted an aquatic habitat inventory from the mouth of Beaver Cr to the bridge crossing just above the confluence of Duffy Cr in 1992. This inventory pre-dates the winter high flow events of 1996 which may render it unrepresentative of current conditions. There are however some very interesting metrics in this inventory that give us a sense of historical condition. The most powerful may be the inventory's summary of beaver pond habitats. In 1992, the surveyed segment of mainstem Beaver exhibited a total of 21 beaver ponds containing 28% of the total available summer pool surface area. In contrast, the 2009 inventory conducted on that same reach observed only 2 beaver pond units (percent contribution to pool surface area could not be calculated). The dramatic decline in the abundance of beaver pond habitats has altered the functionality of this mainstem segment significantly. The effects have probably resulted in a net loss of stored bedload (organics, silts, sand and gravel). There has definitively been a net loss in deep pool habitats for both the summer and winter rearing of endemic fish populations. There has also certainly been a dramatic decline in floodplain connectivity and ground water storage.

A stable beaver colony currently exists in the Beaver Cr mainstem just above the county road crossing above the confluence of Duffy Cr at RM 7.5. This colony consists of a series of 3 winter-stable dams that have aggraded the deeply incised active channel approximately 5 vertical feet. The presence of this colony has rendered the 0.7 mile segment of Beaver Cr between RM 7.5 and the confluence of South Cr as the most functional and productive anchor habitat for rearing resident cutthroat year round. In addition, the ecosystem services provided by this colony (storage of ground water across the entire floodplain, nutrient and bedload storage and the development of extensive wetland habitats for amphibians and wildlife) add tremendous value to the conservation, maintenance and enhancement of this habitat type. Conversations with Benton County road maintenance staff indicates that there has been continuous annual beaver dam removal in the upper mainstem of Beaver Cr associated with the county road crossing just above the confluence of Duffy Cr. This activity may have long term implications for channel morphology in this area (accelerating channel incision).

There is a section of stream channel between RM 4.4 and RM 5.3 (Kelly property) that exhibits functional channel characteristics not observed in the mainstem below or the mainstem above to RM 7.5. The unique features consist of a high level of sinuosity, moderately low and interactive floodplain terraces, significant wood loading from a functional riparian canopy, deep

bedload accumulation and an extensive population of fresh water mussels. The historic channel manipulation observed above and below this site, that appear to include channel straightening, wood removal and drain tiling, do not appear to have occurred in this ½ mile reach. This zone’s current high level of function suggests that efforts to conserve and enhance its complex characteristics would likely result in an immediate and quantifiable biological response.

The 1.7 mile stream reach between the bedrock slide (upper end of Kelly property) and the confluence of Duffy Cr exhibits severe channel simplification. Large stretches of active channel are scoured to bedrock and exhibit limited wood or bedload retention. It is unclear whether this was the result of a stream clearing event or the result of a debris flow event. There is a legacy of agriculture (primarily livestock grazing) and channel simplification may be the result of historical channel manipulation (straightening) to limit channel meander and minimize the cost of fencing.

Spawning and Incubation

The distribution of the 0+ age class of juvenile cutthroat gives us some indication of important zones for spawning and incubation (Figure 5). The assumption here is that the densities of emergent fry are likely to be higher near their points of origin (adult spawning locations). The presence of 0+ age fry in the mainstem of Beaver Cr is nearly non-existent below the extensive Beaver dam complex at RM 7.5. Densities increase rapidly above this productive habitat and average 0.2 fish/m² of pool surface area to the end point of the survey where gradients increased to 10%. A large part of this increasing abundance is driven by the changes in gradient near the headwaters of the subbasin. Increasing gradients provide the hydraulic potential to scour, sort and cleanse embedded gravels providing opportunities for successful spawning and higher egg / fry survival.

In summary, the upper 1.34 mile segment of the mainstem of Beaver Cr (including South Cr) is critical for the spawning and incubation stage of the endemic cutthroat population. Clearly each of Beaver Creek’s contributing tributaries also provides a primary spawning reach (driven by gradient) that has the potential of contributing to annual stock recruitment within the subbasin. To get a sense of the relative significance of the spawning habitat in each of these tributaries, see the table below. This table has been compiled from a review of the 0+ age class distribution in each contributing tributary (including the mainstem).

Table 1

<u>Stream Segment</u>	<u>Miles of spawning potential</u>	<u>Assessment of Quality</u>	<u>Accessible to fluvial migrants</u>
Beaver Cr	1	Good	Yes
Beaver Trib A	0.38	Fair	No
South Cr	0.34	Good	Yes
Starr	0.33	Poor	No
Starr Trib D	0.41	Good	Yes
Henderson	0.49	Good	No
Duffy	1.67	Good	Yes
Mercer	0.19	Poor	No
Powell	0.28	Poor	Yes

From a sub basin perspective it is important to note that approximately 24% of the potential spawning habitat is currently inaccessible to the fluvial (lower river migrant) life history strategy due to impassable dams and culverts. This implies that approximately 3.9 miles of potential spawning habitat currently is accessible to fluvial cutthroat stocks. Variable qualities of gravels exist within different stream reaches that also greatly influence egg / fry survival rates.

The gravels in the upper mainstem of Beaver Cr and its headwater tributary South Cr are high quality. Long range management strategies for the Beaver Cr sub basin should include adequate riparian protection for this reach to ensure that the existing large woody debris resources are maintained. The long term contribution of these riparian resources to the active channel in this location is critical for capturing, retaining and sorting high quality spawning substrates. In addition, this 1.34 mile upper mainstem Beaver site would be critical for protection from sources of chronic sediment delivery.

Temperature

Continuous temperature monitoring was conducted on the mainstem of Beaver Cr between 6-15-09 and 10-15-09. Data was collected from the three mainstem sites described as follows: (*see pages 25-26*)

Figure 7.... Lower mainstem Beaver Cr at the Buchanan bridge crossing (RM 0.3)

Figure 8.... Mainstem Beaver Cr directly above beaver dam complex (RM 7.7)

Figure 9.... Mainstem Beaver Cr above the confluence of Duffy Cr (RM 7.1)

The contribution of cool water from the headwaters of the Beaver Cr subbasin as documented by Figure 8 was extremely high quality for the pinch period between mid July and mid August. Only 4 days exceeded the 64 degree DEQ metric of concern for elevated stream temperatures and that exceedance was only for a few hours each day.

These high quality flows entered a large beaver dam complex just downstream of the temperature monitoring site that consisted of a series of three winter-stable dams that were effectively inundating approximately 3 acres of floodplain terrace (cover page photo). A temperature logger was also deployed below this beaver complex (Figure 9) in an attempt to quantify the impact of this large beaver complex on downstream temperature profiles.

The beaver dam complex appeared to have elevated downstream temperatures with a shift from 4 days in exceedance (above 64 deg F) above the complex to 22 continuous days of exceedance for the same time period below the complex. The striking difference between the temperature profiles at this site and any other monitored site in the basin was the range of diurnal fluctuation. Only 2 of the 22 continuous days of exceedance sustained temperatures above 64 deg for a continuous 24 hr period. Diurnal (daily) temperature fluctuations of 9 deg F were observed below the beaver ponds during the warmest summer period as compared to a 5 deg diurnal fluctuation upstream of the ponds and a 2.5 deg diurnal fluctuation at the site near the mouth of Beaver Cr (Figure 7) during the same time period.

The site exhibits converging biological and morphological characteristics that are currently responsible for aggravating elevated downstream temperatures. As you can observe in the cover photo, beaver have succeeded in flooding historic pasturelands with no recent legacy of a riparian canopy. This exposes large surface areas of shallow water to extensive solar impact. An effort to initiate a complex willow community on this site would both mitigate for the current solar impacts and provide a viable future food source for the beaver that have created a rich and

diverse habitat segment that is providing a broad array of ecosystem services to Beaver Cr. (floodplain connectivity, winter habitat, sediment retention, aquatic food production, amphibian and waterfowl habitat, etc.)

At RM 0.3 (Figure 7) on the lower mainstem of Beaver Cr, the temperature profile mimics the observations made just below the beaver dam complex. This suggests that a large portion of the current impacts on mainstem temperature profiles begins high in the mainstem as a result of this beaver complex.

The major tributaries (Starr, Duffy, Henderson and Mercer/ Powell) all contribute temperatures to the mainstem at levels lower than were observed just below the mainstem beaver dam complex (RM 7.1). The one exception to this observation is observed in Trib A of the mainstem of Beaver Cr which enters at RM 5.2, just above the confluence of Henderson Cr (RM 5.1). This stream contributes extremely warm flows to the mainstem (summer peak temp of 82 deg F). The unique conditions associated with this tributary component will be discussed below in the Tributary section (see Trib A of mainstem Beaver).

Tributary Results

Starr Creek

Distribution and Abundance

The RBA snorkel inventory was not effectively implemented for Starr Cr because of poor visibility that compromised the methodology. There were however, multiple opportunities to snorkel select pools (N=16) from the Starr Cr confluence with Beaver Cr to its headwaters. This partial effort was successful in getting a relative estimate of abundance (density per pool surface area) and distribution from the lower to upper reaches.

In summary, extremely low cutthroat densities were observed throughout all of Starr Cr without exception (only 38% of all pools sampled contained cutthroat). Even in the most functional stream segment (Trib D), that exhibited high quality spawning gravels, cutthroat abundance was poor.

When compared to all of the other tributary and mainstem segments inventoried during the 2009 RBA inventory of the Beaver Cr subbasin, Starr Cr exhibited an unusual absence of cutthroat.

Some of this low abundance falls into place when reviewing the current distribution of physical habitat (see physical habitat conditions) but not all of it. There may be other water quality issues beyond what was preliminarily explored (temperature) or unknown historical events that have played a role in influencing the current distribution and abundance of cutthroat.

To get some historical perspective we consulted with some longtime local land stewards (Ken and Trudy Avery and Gary Smith) to explore how their recollections of Starr Cr compared to our current observations. Ken grew up fishing on Starr Cr and can recall poor cutthroat fishing in lower Starr Cr in general. He remembers significantly higher abundances of cutthroat in mainstem Beaver Cr at the confluence of Starr as well as definite increases in abundance in upper Starr where the gradient increased to provide swifter flows and a pool/riffle complex.

Gary remembers as a kid, at their place at approx. RM 2.4, they could catch 2-3 cutthroat up to 14" in size, pretty much any day of the year. He also recalls about a ½ mile of continuous beaver ponds downstream of their place.

Migratory patterns

Insignificant data was collected in Starr Cr to conduct a viable assessment of cutthroat migration patterns. So many of the pools sampled contained no cutthroat that no consistent patterns in distribution were clear.

A single observation at RM 2.0 of a large concentration of redbase shiners (N=200) was very unusual and may have been the result of a spawning migration. These fish appeared gravid (pregnant) and displayed bright coloration. Redside shiners were present both above and below this location but not in this concentration.

Access to the available spawning gravels in the Starr Cr subbasin for cutthroat was completely truncated in Tribs B, C and all of the Starr headwaters (Trib A was dry at the time of survey). This condition over time could have genetically suppressed the presence of a migration pattern.

Physical habitat conditions

There are several outstanding habitat issues that are worthy of review. There is a 5 ft vertical rock ford just above the confluence with Beaver Cr that is functioning as a major hydraulic control for the lower 1.28 miles of Starr Cr below the first county road culvert. Without this device, lower Starr would be experiencing much deeper channel incision than is currently observed here (5ft). In addition, the graded riffle that forms the ford is well seated and does not deny access to upstream migrants even during low summer flows. The depth of channel incision increases at the confluence of Trib A (RM 0.73) to 8 vertical ft.

The lower mainstem (below RM 1.28 at the first county road crossing) is dominated by a highly erodible but impervious clay substrate. Importantly, there is no observable gravel lens within the adjacent stratified terraces. This suggests that a very long history of hydric (wetland) soil types exist for the lower valley. It also definitively precludes this zone from being a target for spawning adults or having the capacity to recruit spawning gravels from the natural process of channel meander. This erodible clay substrate predisposes rearing salmonids to the type of chronic turbidity that has been observed in laboratory experiments to cause emigration from the reach as well as negative impacts on growth (Sigler, Bjornn and Everest, 1984).

This lower mainstem also exhibits a long history of channel manipulation (straightening and cleaning). The channel is U shaped with no inner terrace development. Stream adjacent agriculture has probably existed here for close to a century (undocumented).

Above the first county road crossing, the legacy of channel manipulation to facilitate agriculture disappears. The channel immediately transitions to a higher level of sinuosity and Starr Creek exhibits excellent floodplain interaction with only 3 vertical ft to the primary floodplain terrace. There are oaks in the riparian here greater than 100 yrs old indicating a significant difference in historical management of the riparian corridor.

There were a total of 9 active beaver dams during the 2009 summer inventory in all of Starr Cr. Two of these were just above the first county road crossing and the remainder were above the double-perched culverts at RM 2.65. There was also a legacy of beaver in Tributary B

but no current activity was observed. Tributary B has potential for providing additional spawning capacity if the perched double-barreled plastic culvert on the county road was replaced with a fish passable culvert.

Spawning and Incubation

The abundance of accessible spawning gravel is the most likely seasonal habitat limitation for the production of cutthroat in Starr Cr. Although the abundance of spawning gravel was not quantified during this RBA inventory, the absence of suitable gravel was evident. The only locations where gravels suitable for cutthroat spawning were observed were in Trib D and the 0.33 mile headwater segment of Starr. Only Tributary D was accessible to migratory cutthroat. There was a perched Benton County Rd culvert directly below the confluence of Trib D that may have played a minor role in delaying spawning migrations destined for Trib D but the plunge pool below this 8" perch provides an adequate jump pool for migratory adult cutthroat during most flow regimes.

The spawning gravels in Trib D are perfect for cutthroat. The importance of this short spawning reach (approx. 0.41 miles) for addressing the possible limitation of spawning gravel access is high. Within the 0.41 mile segment identified, the gradient optimizes for gravel storage and silt flushing in only the first 1,100 ft. After this point the gradient increases and well sorted fine gravels are less frequent. Actual gravel abundance was not quantified during the RBA inventory.

Temperature

Figure 13 documents the results of a continuous temperature logger deployed from June 5th to October 15th, 2009 on the Ferris property in the lower mainstem of Starr Cr. The data suggests that Starr Cr and its endemic cutthroat are not suffering severe impacts from elevated summer temperature profiles. Starr Creek's continuous excursion above the DEQ metric of 64 degrees for water quality was brief (10 days) and closely matched the timing, duration and peak observed in Mercer, Powell, Duffy and Henderson. The consistencies in these patterns suggest that the underlying environmental factors of channel morphology, flow and ambient air temperature are playing a formative role in shaping the instream summer temperature profile.

Henderson Creek

Distribution and Abundance

Henderson Cr essentially functions as two partially independent stream segments in a review of cutthroat trout distribution. A man made pond at RM 1.7 currently truncates fluvial salmonid access to the headwaters of the basin that contains the primary spawning reach. This 0.5 mile headwater segment is however accessible to a significant cutthroat population (unquantified) thriving in the two large impoundments above the 8 ft perched culvert at RM 1.7.

The abundance of older age cutthroat was second only to Duffy Cr within the larger Beaver Cr subbasin averaging 0.11 fish/m² of pool surface area throughout their distribution. The outstanding significant difference in distribution between Duffy Cr and Henderson Cr was that the lower quality pool habitats (low pool complexity) in Henderson did not exhibit significant

fish presence whereas similar low complexity pools in Duffy Cr almost always contained fish. A possible explanation for this condition is that cutthroat distribution in Duffy Cr may have been primarily residents and cutthroat in Henderson may have had a higher frequency of fluvial migrants.

Migratory patterns

There was evidence of an upstream migration from the mainstem of Beaver Cr occurring in Henderson Cr. The increasing concentration of mature 2 and 3 year old adult cutthroat in the ¼ mile segment just below the perched culvert at RM 1.7 is a probable indicator (Figure 3). The presence of a higher frequency of mature cutthroat in this zone (as opposed to the 1+ age class), suggests that the migration may have been spawning related. The unusually high concentration of fry in lower Henderson may be the result of this spawning activity.

The Henderson Cr survey was initiated on July 15, approximately the same time that temperatures began to continuously exceed 64 deg in the mainstem of Beaver Cr. Therefore a case could be made that some of this upstream migratory behavior was temperature driven. A broader temporal inventory would be required to sort out the primary driver.

In addition, a bedrock slide on the mainstem of Beaver Cr that appeared to be affecting older age cutthroat and redbreast shiner migration existed just 1,700 ft above the confluence of Henderson Cr.

Two potential barriers to migration, a small concrete dam at RM 1.4 and a segmented concrete culvert at RM 1.55 did not appear to be impacting the upstream migration of 1+ or older cutthroat.

Physical habitat conditions

There is no historical Aquatic Habitat Inventory data available for Henderson Cr. The following observations were made during the snorkel inventory conducted by Bio-Surveys in 2009. The active channel from the culvert at the Beaver Cr road crossing to RM 0.9 would be classified as terrace confined and moderately entrenched (5 ft vertical). This is a zone that exhibits very poor winter habitat potential. The stream segment from RM 0.9 to the Coon pond at RM 1.7 exhibits lower inner terraces and an interactive floodplain during winter flow regimes. The abundance of instream wood also improves from non existent in the lower confined segment to low densities in the section between RM 0.9 and 1.7. This low wood density has a direct impact on bedload retention and consequently the availability of spawning gravel.

It is important to identify the lack of potential gravel recruitment to the lower 1.7 miles of mainstem Henderson from its headwater reaches. All downstream resource migration is truncated by the two impoundments on the Coon property that function as sinks for migratory sands, silts and gravels.

The series of two manmade ponds on the Coon property are a dominant habitat feature within Henderson Cr and are currently providing large volumes (unquantified) of rearing surface area that function as high quality summer and winter habitat. The location of optimum headwater gradients just above this pond series are providing abundant high quality spawning gravels for resident cutthroat rearing to adult in these two ponds.

Spawning and Incubation

Spawning gravels appropriate for cutthroat were first observed in the lower end of Henderson Cr. Two redds were observed directly above the Beaver Cr Rd culvert that appeared to be Pacific Lamprey (based on size and shape).

The highest average density (0.19 fish/m²) of the 0+ age cutthroat was observed in this tributary when compared to all other stream segments in the Beaver Cr basin. This would not be intuitive when considering the lack of access to headwater spawning gravels. In addition, two distinctly different age classes of emergent fry were observed in Henderson that were not observed anywhere else in the Beaver Cr subbasin. This suggests the existence of two distinctly different spawning peaks (early and late). This could be the presence of the adfluvial life history exhibited by the pond rearing cutthroat in the tributary. Obviously, significant spawning is occurring somewhere in Henderson Cr that is extremely important to the maintenance of the Beaver Cr cutthroat population.

A relatively large unknown exists within this tributary that the current inventory was unable to solve. What is the origin of the large number of 0+ age juveniles observed below the impoundments? Are they the result of spawning activity below the ponds (most intuitively likely) or could these juveniles be succeeding in navigating through both lake environments to abundantly seed the stream habitats below (intuitively least likely because of extensive predation). Without a clear understanding of their origin we would suggest erring on the conservative side when designing restoration prescriptions by identifying any opportunity to enhance gravel retention and sorting below RM 1.7 to improve production.

Temperature

The summer temperature profile of Henderson Cr was excellent with only a brief 10-day excursion of continuous daily peaks above the 64 deg water quality standard (Figure 12). This pattern nearly identically matched the patterns observed in Starr, Duffy, Mercer and Powell. The obvious implications here are that the impoundments on the Coon property do not appear to be having any severe negative affect on the cumulative temperature profile of mainstem Beaver Cr. As in all attempts to understand how a system is functioning, we often end up with more questions than answers. In the case of Henderson Cr, additional temperature monitoring would be highly desirable to answer the following questions:

- 1) What is the ambient stream temperature profile upstream of the second impoundment through the course of the summer and how does this compare to the outflow temperature from the lowest pond?
- 2) What is the summer temperature profile of the lower pond at depth? Is the stratification differential significant enough to warrant the development of a subsurface withdrawal?

There is the potential that a subsurface withdrawal of cooler stratified water from the impoundment could even improve downstream water quality and have a positive benefit to the cumulative temperature issues that are currently limiting the mainstem of Beaver Cr.

Duffy Creek

Distribution and Abundance

The Duffy Cr snorkel inventory extended 2.5 miles above its confluence with the mainstem of Beaver Cr to a point where the aquatic habitat began to diminish in surface area and gradients increased. The end point of the survey does not represent the end of cutthroat distribution for the tributary, only diminishing production potential.

The significant abundance and broad distribution of older age class (>1+) cutthroat in Duffy Cr (Figure 4) suggests that this tributary is currently functioning as a key anchor habitat for both resident and fluvial cutthroat life histories. When compared to the next most productive stream segment in the subbasin (mainstem Beaver), the current production, relative average density and potential for improving system function all indicate that Duffy Cr is a key anchor habitat and the most obvious basin-wide candidate for receiving an intensive restoration focus.

As a simple metric for comparing current status, we used total fish/mile as an attribute for comparing the current level of production. The Beaver Cr mainstem from the Dunn bridge at actual RM 3.7 to the headwaters of Gleason Cr (including South Cr) averaged 73 older age class cutthroat/mile. Duffy Cr averaged 230 older age class cutthroat/mile of sampled habitat (these are not population estimates because only pools were sampled). The Duffy Cr inventory encountered 575 cutthroat in 2.5 miles of habitat and the Beaver Cr inventory encountered 650 cutthroat in 8.9 miles of habitat. Even the most productive one-mile segment of Beaver Cr (above the beaver dam complex at RM 7.5) did not exhibit rearing densities as high as the average density for all of Duffy Cr (0.12 fish/m²).

Migratory patterns

The desirable summer temperature profile discussed below in the temperature section of this analysis would suggest that we might expect to find indicators of an upstream temperature dependant migration from the mainstem of Beaver Cr. This would be resident cutthroat escaping elevated mainstem Beaver Cr water temperatures by seeking out cooler tributary refugia. An obvious pattern of this type of migratory behavior was not evident from the distribution patterns observed in Figure 4. The Duffy Cr survey was initiated on July 10, 2009 and was slightly prior to the extended period of elevated stream temperatures that were observed in the mainstem of Beaver Cr that began around July 15 (Figure 9). It is possible that an inventory conducted later in the summer would have observed even higher cutthroat rearing densities in Duffy Cr. as mainstem Beaver Cr began to sustain the temperatures above 64 deg known to be stressful to juvenile salmonids.

There were two culverts in the Duffy Cr corridor that also did not appear to be influencing the distribution of upstream migratory cutthroat at the time of the survey. The first culvert at RM 0.4 exhibited a 4" perch and did not represent a velocity barrier to upstream migrants. The second culvert at RM 1.1 exhibited a 16" perch and would negatively influence the upstream migration of juveniles if that migratory behavior was present.

Physical habitat conditions

No historical habitat inventory data was available for Duffy Cr and so the following general observations were gathered during the 2009 RBA snorkel inventory conducted by Bio-

Surveys. From the confluence with Beaver Cr to approximately RM 0.4, Duffy Cr exhibits a terrace confined channel and a history of channel manipulation (realignment).

The most outstanding physical habitat observation for Duffy Cr was the extensive legacy of beaver dam complexes between RM 0.4 and RM 0.8. Within this stream segment there was clear evidence of at least 4 historical beaver dam complexes (multiple dams/site). At each of these sites, large accumulations of legacy conifer were observed buried as transient woody debris in deep accumulations of silt, sand and organic fines. Currently there is no evidence of beaver use within this segment and the active channel is in the process of simplifying (straightening and exhibiting vertical entrenchment).

A limited number of full spanning woody debris jams currently exist in lower Duffy Cr. However, at the sites where wood is present, significant aggradations of transient bedload are occurring (1.5 ft vertical). This suggests that gravel resources are being recruited to the active channel and that the potential exists for restoring floodplain interaction through strategic wood placement and its resultant bedload aggradation.

The first full spanning beaver dam was observed at RM 1.0 and a major beaver complex existed at RM 1.1 (summer dam 2.5 ft vertical). There were a total of three beaver dams in all of Duffy Cr during the 2009 inventory. Only one appeared to be winter-stable.

Low terraces exhibiting the morphological potential for the development of off channel habitat complexity became common above the stable beaver dam at RM 1.1. The broad floodplain that facilitates the existence of these terraces extends to the confluence of Cheyenne Cr.

The riparian canopy throughout almost all of Duffy Cr is robust and provides excellent shade to the aquatic corridor. Minor excursions from this condition in the lower $\frac{3}{4}$ mile of stream corridor are primarily the result of the beaver pond legacy and currently provide an excellent mix of riparian plant community that bolsters habitat diversity.

Spawning and Incubation

Zero age cutthroat (young of the year) were consistently present above the beaver dam complex at RM 1.1 (Figure 6). Utilizing this as an indicator of significant zones of importance for spawning and incubation suggests that a maximum of 1.6 miles of stream corridor is currently providing some habitat for adult spawning. Spawning gravels were not quantified in the Rapid Bio-Assessment that occurred during the summer of 2009. There were however observations during that survey of appropriately sized gravels for cutthroat in the 1.6 mile segment above the last culvert crossing.

Temperature

The summer temperature profile of Duffy Cr is represented in Figure 10. A 9 day period between July 26 and Aug 3 exceeded the DEQ standard for salmonids of 64 deg. The daily periods of elevated temperatures were brief with excellent diurnal recovery. Summer stream temperatures in Duffy Cr would be classified as good quality but susceptible to any significant modifications to the existing riparian canopy. This can be contrasted to the headwater section of mainstem Beaver Cr that is delivering high quality summer temperatures and therefore currently more resilient to riparian impacts.

Mercer and Powell Creeks

Distribution and Abundance

The RBA snorkel inventory was not successfully completed on either Mercer or Powell Cr because of consistently poor visibility. The stream was still traversed from the mouth to the end of potential fluvial cutthroat access. Occasional sightings of cutthroat were observed to verify their presence but no pool rearing densities were quantified.

Migratory patterns

No migration patterns were documented because no snorkel inventory could be conducted. The ground truthing of Powell Cr did reveal that unencumbered access was available to fluvial migrants to approximately RM 1.7 where a steep boulder cascade likely limits access to the headwaters. This cascade is 600 ft downstream of an impassable perched culvert under a deep road fill. The replacement of this culvert would be classified as low priority because of the natural cascade barrier that exists just downstream.

In addition, there was no impedance to migration on Mercer Cr until the dam on the Berry property at approximately RM 1.4.

Physical habitat conditions

Mercer and Powell Creeks converge in a large wetland complex (approx 18 acres) at RM 0.3. The wetland is well seated and exhibits an advanced succession of salix (willow) species. Beaver are currently a dominant keystone species within the wetland and the presence of their full spanning dams has facilitated an expansion of the wetland surface area from its historical perimeter. The presence of this wetland below the manmade ponds on the Jensen property has been a substantial asset for mitigating the extremely elevated temperatures emanating from the Jensen pond during June through late July (Figure 15). Fortunately, the outlet flow from the Jensen pond returns to subsurface filtration early in August and results in cooler contributions to the Mercer/Powell wetland.

It is unclear from the field inventory how the Jensen ponds are fed during spring and summer. No upstream linkage was observed. If it is ground water that is being heated to between 70 and 80 degrees throughout much of June and July then attempting to keep that super heated flow from contributing to mainstem Mercer would be a highly desirable restoration action to improve water quality in mainstem Beaver Cr.

Spawning and Incubation

Within Mercer Cr, only one very small stream segment, extending 0.19 miles above the Berry pond, exhibits potential for cutthroat spawning. There were low quantities of low quality gravel observed in this stream segment. These gravels may be inaccessible to fluvial migrants because of the pond and associated dam on the Berry property. In consultation with Mr. Berry it was evident that the pond is drawn down seasonally to provide flushing and unimpeded upstream access. However, without knowledge specific to Mercer Cr on the run timing of spawning adult cutthroat, it would be difficult to assess if the window of opportunity for passage accurately matches peak cutthroat spawning migration.

There were no other spawning gravels observed in Mercer Cr and the absence of this resource is likely to be the primary limitation to production within the tributary.

Within Powell Cr there was a more substantial abundance of spawning gravels available for cutthroat. These gravels extended for 0.28 miles between RM 1.4 and RM 1.7 (as measured from the confluence of Beaver Cr). Even though gravel abundance was significantly higher than observed in Mercer Cr, the presence of high sediment volumes suggested that gravel quality was poor. The current condition of the available gravels suggests that egg/fry survival would be low.

Temperature

Figure 14 describes the summer temperature profile of the combined Mercer/Powell system just above the confluence with mainstem Beaver Cr. You will note that exceedance of the 64 deg DEQ water quality standard is only continuously sustained for 10 days. This level of exceedance was common for all of the other primary tributaries except the very headwaters of mainstem Beaver (which was lower).

Both the Jensen pond and the Berry pond over flows have a major negative impact on downstream water quality. The ability of the impoundment on the Berry property to deliver 6 degree cooler water than the surface spill by utilizing the existing gate valve may substantially outweigh any negative consequences of limited access to adult spawners. This assessment relies on the conclusion that elevated summer temperatures are the primary limitation to fish production in the mainstem of Beaver Cr.

It is possible to conceive that by dealing with the elevated temperature profiles associated with the Jensen pond and the Berry pond, with limited adjustments of pond management, that the wetland at RM 0.3 could assist in delivering substantially cooler flows to mainstem Beaver Cr.

Trib A (of mainstem Beaver Cr)

Distribution and Abundance

The snorkel inventory was not successfully completed on Trib A because of poor visibility caused by the presence of beaver in the lower end and deep pond habitats in the middle section. Two pools were snorkeled at RM 0.52 above the Henderson Rd crossing that contained low densities of older age class cutthroat. It was clear from discussions with the landowner and from visual observation that cutthroat were abundant in the deep man made pond habitats between Beaver Cr Rd and Henderson Rd. The habitats between Beaver Cr and the culvert crossing on Beaver Cr Rd may not have been as well populated because of severe temperature limitations in shallow beaver pond habitats.

Migratory patterns

Because of the high average summer temperature profile, no upstream migrations of juveniles are occurring. This was verified by snorkeling the pool below the pond outfall just above the Beaver Cr Rd crossing. No accumulation of migrant fish was observed at this barrier. In addition, providing access above this barrier for spawning migrations or temperature dependant movements would be a poor use of restoration resources.

Physical habitat conditions

Trib A drains a very small watershed area (approx. 270 acres). The spring fed tributary was delivering 55 deg surface flows during late July. Local residents describe the tributary as maintaining substantial summer flows even during periods of drought when the adjacent Henderson Cr has been observed dry.

The tributary currently functions to produce a genetically isolated deme of a larger subbasin population of cutthroat because of the barrier created by the outlet structure at the pond directly upstream of the Beaver Cr Rd culvert crossing. This barrier has been in place for approximately 45 years. Adults rearing in the extensive pond habitats have access to low volumes of fine spawning gravels upstream of the Henderson Rd culvert crossing but migratory cutthroat from the Beaver Cr mainstem do not.

Spawning and Incubation

All of the spawning gravels exist within a 0.38 mile stream segment that begins at the Henderson Rd culvert crossing. The survey did not quantify spawning gravel volumes but the inventory observed that “fine gravels are present for cutthroat but not abundant”.

Providing access to these gravels for fluvial components of the Beaver Cr population is not an issue of concern. Other higher quality spawning locations exist in the basin for this component of the population. The more valuable contribution is the supplementation to the endemic population provided by the extensive man made ponds.

Temperature

A temperature logger was placed in Tributary A on the Kelly property just downstream of the Beaver Cr Rd culvert crossing. The resultant temperature profile was the highest continuous contribution of warm water to the mainstem of Beaver Cr observed in the basin. Temperatures first exceeded DEQ upper limits on June 19. Between June 23rd and September 26th daily exceedance of the 64 deg value was observed in 92 of the 96-day period (Figure 11). Temperatures reached a seasonal peak of 82.5 deg on July 29th.

The elevated summer temperature profile of Tributary A has a definitive negative impact on the water quality of mainstem Beaver Cr and compounds a situation that already poses a limitation to mainstem Beaver Cr salmonid rearing during summer flow regimes. Tributary A was delivering approximately 0.2 cfs on July 15th, 2009.

A 6 degree differential was measured during the inventory on July 15th from the culvert on Henderson Rd (55 deg @ 09:30) to the culvert on Beaver Cr Rd. (61 deg @ 09:15). The situation is caused by the skimming of surface flows in two back to back pond habitats by overflowing into a vertical stand pipe. The situation can be easily modified by altering the surface runoff to a subsurface overflow that draws off of a colder stratified layer at the bottom of the pond.

Recommendations

The following recommendations are specific for each of the reviewed stream segments. We would like to be clear that some of these suggestions should be viewed as much higher priority than others. Prioritization would highlight the implementation of actions that accomplished two goals simultaneously. If the restoration action addresses the current issue(s) that limits the production, expansion of range or survival of the chosen indicator species (cutthroat) and also restores long term function to ecosystem process, it is high priority.

This suggests that some knowledge of limiting factors has been achieved. The rapid bio-assessment inventory was not designed to tease out habitat limitations. However, as one of the few basin scale ground based inventories existing for the Beaver Cr subbasin (the only other being ODFW AQHI, 1992), it would be negligent of us not to utilize the layers of information reviewed in this process to project some general preliminary conclusions.

It is clear from this analysis that **summer temperature profiles in the mainstem** which exceed DEQ standards for water quality limit fish distribution and therefore limit complete utilization of the available mainstem Beaver Cr habitats for salmonid production. It is clear that **deep channel incision and the associated isolation of historical floodplain habitats** also limits salmonid production and negatively impacts summer water quality in the majority of stream reaches. It was also revealed that lack of **access to spawning and incubation habitats** may be limiting cutthroat in at least the Starr Cr subbasin.

An additional general recommendation that consistently rose to the surface in each stream segment was the need to restore the natural processes that result in storing ground water within floodplain terraces for extended delivery to the mainstem well into the summer pinch period. Two significant components that are currently missing and that would have historically been present are abundant wetlands and beaver impoundments.

Beaver Creek

- Riparian planting plan for the Kelly property for the provision of a long term recruitment source of large conifer to the aquatic corridor.
- Instream log placement strategy for the Kelly property to maintain the current level of bedload retention and sinuosity and to enhance floodplain interaction.
- Riparian planting and agricultural riparian buffer setback as a blanket treatment for any property within the 1.7 mile reach between the Kelly property and Duffy Cr. The objective would be to diminish direct solar impact to the aquatic corridor and to provide a future source of LWD for the active channel.
- Instream log placement strategy for the 1.7 miles of simplified stream corridor between the Kelly property and the confluence of Duffy Cr. The objective would be to increase bedload retention and develop the missing pool/riffle complex.
- Extensive riparian planting strategy for the beaver/wetland complex at RM 7.3. The focus of this planting effort would be to provide an abundance of forage species (willow, ash, vine maple, cottonwood) specific for beaver to encourage the long term stability of this well seated colony. In addition, the current lack of riparian vegetation at this site is negatively influencing downstream temperature profiles and the provision of extensive

shade at this site directly addresses a basin scale limitation to summer cutthroat production. Livestock fencing is likely to be a valuable component of a riparian planting strategy at this site.

- Random wood loading across the floodplain width of the existing beaver marsh above the confluence of Duffy Cr that would provide a source of legacy wood to help prevent deep channel incision upon abandonment of the site by the current resident colony.
- Instream log placement for the stream segment beginning just above the influence of the beaver dam complex at RM 7.3 to the confluence of South Cr. to maintain the current level of bedload retention and sinuosity and to enhance floodplain interaction.
- Coordinate restoration and municipal maintenance efforts in mainstem Beaver Cr to develop creative solutions for protecting the road and bridge infrastructure while also promoting the long-term recovery of a healthy beaver population.
- Prioritize the development of ash swale and wetland habitats in the lower 3.7 miles of mainstem Beaver Cr. to restore this segments ability to store winter rains as ground water.
- Modify the current matrix of drainage ditches and tile lines to recharge lower mainstem ground water tables through the development of floodplain galleries. De-link this drainage infrastructure from direct delivery to the mainstem of Beaver Cr.

Starr Creek

- Replace double-barreled perched culverts under Starr Cr Rd on Tributary B (left Trib). 1000 ft downstream of the first county road culvert over Starr Cr at RM 1.28. This activity has the potential of addressing a likely primary limitation for Starr Cr cutthroat, the absence of accessible spawning gravel.
- Replace the perched double barreled driveway culvert at RM 2.65. This culvert terminates all upstream cutthroat migrations. This replacement also addresses the primary limitation for cutthroat in the subbasin, the absence of accessible spawning gravel.
- Replace the undersized culvert at RM 2.8 (last culvert on Starr Cr rd.) for improving resource migration and unimpeded access to migratory cutthroat.
- Consider employing beaver baffles at each culvert retrofit as a long-term strategy for beaver maintenance at these road crossings that doesn't involve removal of the beaver or their dams.
- Encourage the preservation of the wetland habitats that exist in lower Starr Cr observed directly above the rocked ford on the south side of the active channel.

Henderson Creek

- Deploy additional temperature monitoring devices to evaluate the benefits of a potential outflow retro fit (Coon Pond).
- If shown to be beneficial through temperature monitoring, retrofit the outflow of the pond on the Coon property to withdraw a subsurface feed to the stream channel below instead of skimming elevated temperatures from surface spill.

- Develop restoration prescriptions that boost the retention of spawning gravels below RM 1.7. This may involve very specific structure placement (locations with optimum gradients) and the augmentation of spawning gravel resources (because of the lack of natural recruitment due to the upstream pond impoundments). An additional field inventory would be required to pinpoint sites for this effort.
- Intensify the RBA snorkel inventory on the stream segment from the confluence of Beaver Cr and Henderson Cr to Coon pond for a single season. This would involve a series of once/month inventories beginning in April and extending through August. The additional inventory data would assist in establishing a solid understanding of system function as well as provide high resolution guidance to the development of an appropriate restoration prescription.

Duffy Creek

- At the first upstream private property is the confluence of a seasonal hillslope tributary that exhibits excellent potential for the development of an off channel alcove.
- Design and implement an instream structure placement project between RM 0.4 and RM 0.8 that attempts to recreate the floodplain interaction observed in this zone of historical beaver complexes. Heavily augment the legacy beaver terraces within this zone with willow plantings to encourage beaver recolonization.
- Design and implement an instream structure placement project between RM 1.1 and RM 2.2 at the confluence of Cheyenne Cr. This zone exhibits tremendous opportunity for improving floodplain interaction that will enhance the abundance of winter habitat as well as create additional summer pool surface area with the injection of full spanning wood complexes. The zone exhibits excellent access and the absence of a residential interface suggests that the treatment would be low risk.
- Replace or remove the undersized culvert at RM 1.1. This culvert exhibits a 16” vertical perch during summer flow regimes. The likelihood of this culvert negatively influencing the upstream migration of juvenile cutthroat is high (undocumented).
- Develop a long term riparian management plan for Duffy Cr that can be used as a guideline for future upslope timber management activities in the subbasin. The goal here is to provide the information and fiscal assistance to private landowners managing upslope forests in the future, recognizing the importance of the intact RMA that currently exists and providing incentives to maintain that integrity.

Mercer and Powell Creeks

- Develop a design alternative for the Jensen Pond that alleviates the contribution of super heated outflow to mainstem Mercer. This may involve augmenting the dike height on the SW corner of the lower pond to deepen the pond. This would allow for the development of a subsurface drain that would draw from a cooler stratified layer. The pond is currently not deep enough to stratify.
- Discuss the possibility of maintaining a sub surface release from the pond on the Berry property with the landowner. This would initiate cold water delivery from the headwaters of Mercer Cr to aquatic habitats downstream and be extremely valuable for addressing the cumulative impacts of elevated temperature on mainstem Beaver Cr.

- Plan to maintain continuous temperature monitoring during successive summers to monitor the impacts of adjustments to pond management or design.
- Establish an adult trapping site at the Berry pond impoundment to determine spawning adult run timing. This will assist in establishing best management criteria for operating the dam.
- Encourage the preservation of the wetland habitats that exist above the Decker Rd crossing on Powell Cr. These habitats are currently functioning to store critical ground water across a broad floodplain. This tactic directly addresses a Beaver Cr basin limiting factor.

Trib A (of mainstem Beaver Cr)

- Install a subsurface overflow device or adjustable gate valve that will draw cooler stratified flows from the bottom of the back to back impoundments. This activity directly addresses a primary limitation to current system function (elevated summer temperatures in the mainstem of Beaver Cr).
- Consider the planting of a complex inner riparian shelter belt adjacent to the manmade impoundments for the provision of additional shade that could help mitigate for the observed elevated summer temperature profile.

Cutthroat Trout Abundance and Distribution

Figure 1

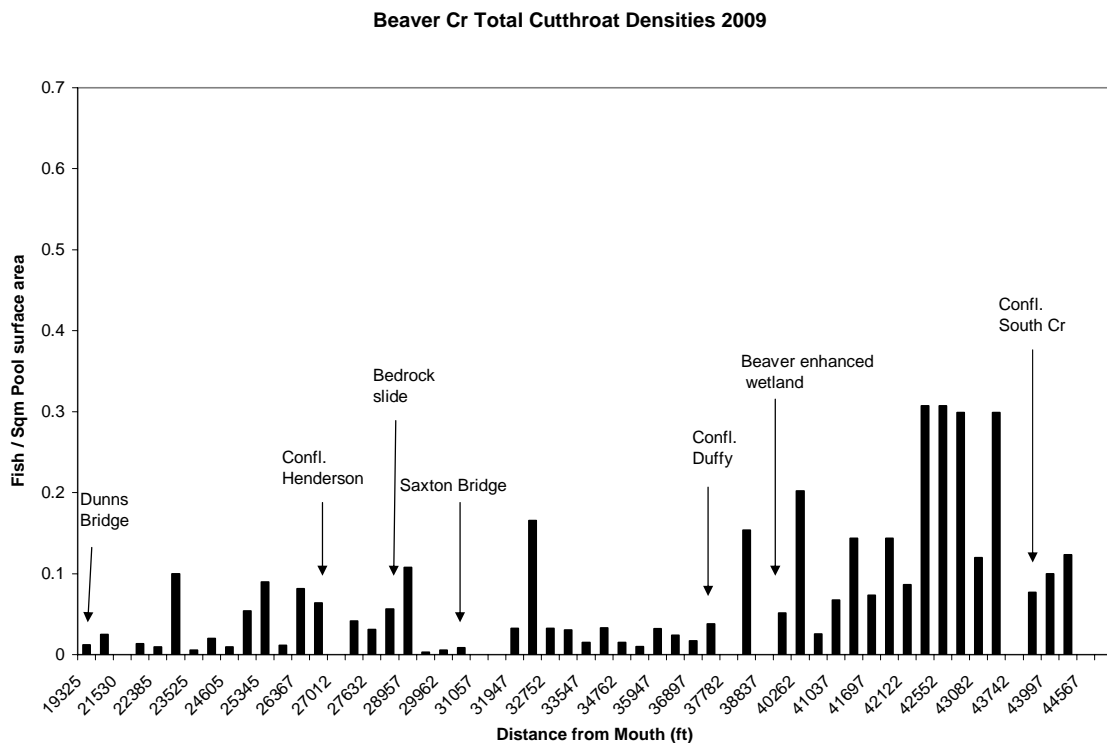


Figure 2

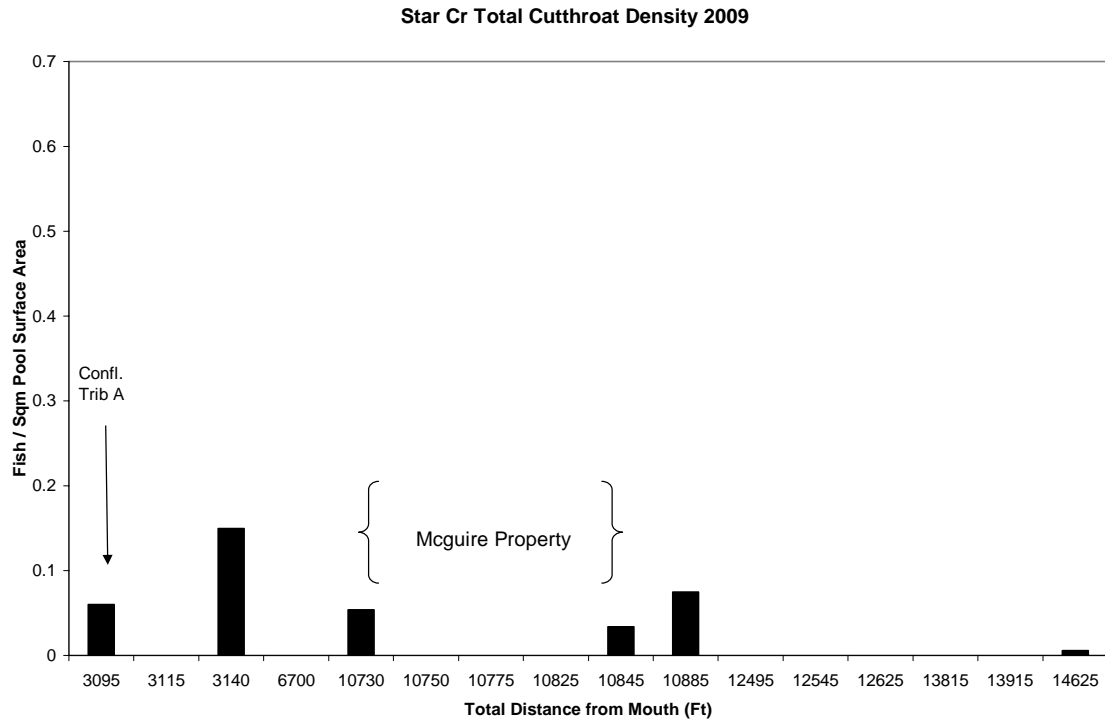


Figure 3

Henderson Cr Total Cutthroat Density 2009

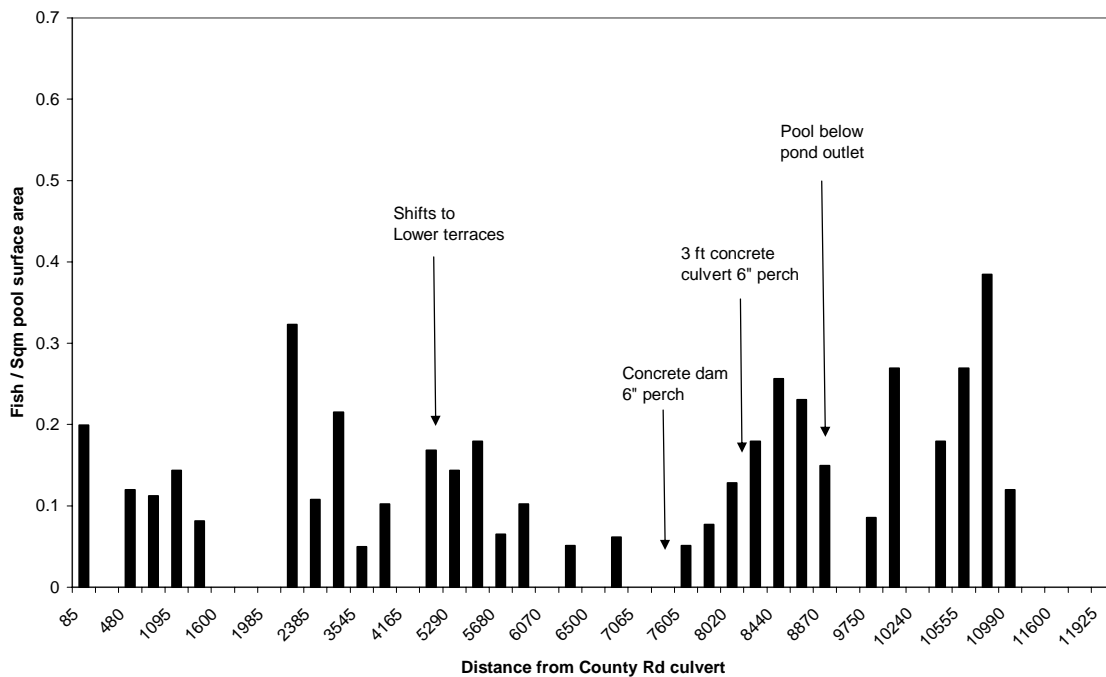


Figure 4

Duffy Cr Total Cutthroat Densities 2009

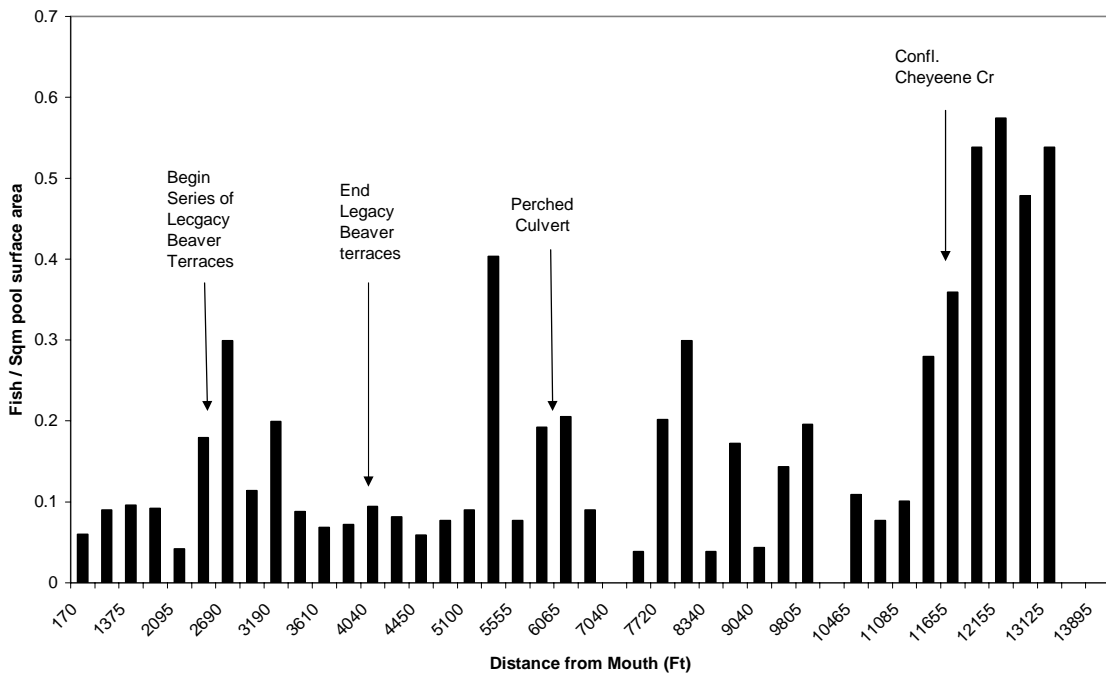


Figure 5

Beaver Cr 0+ Cutthroat Densities 2009

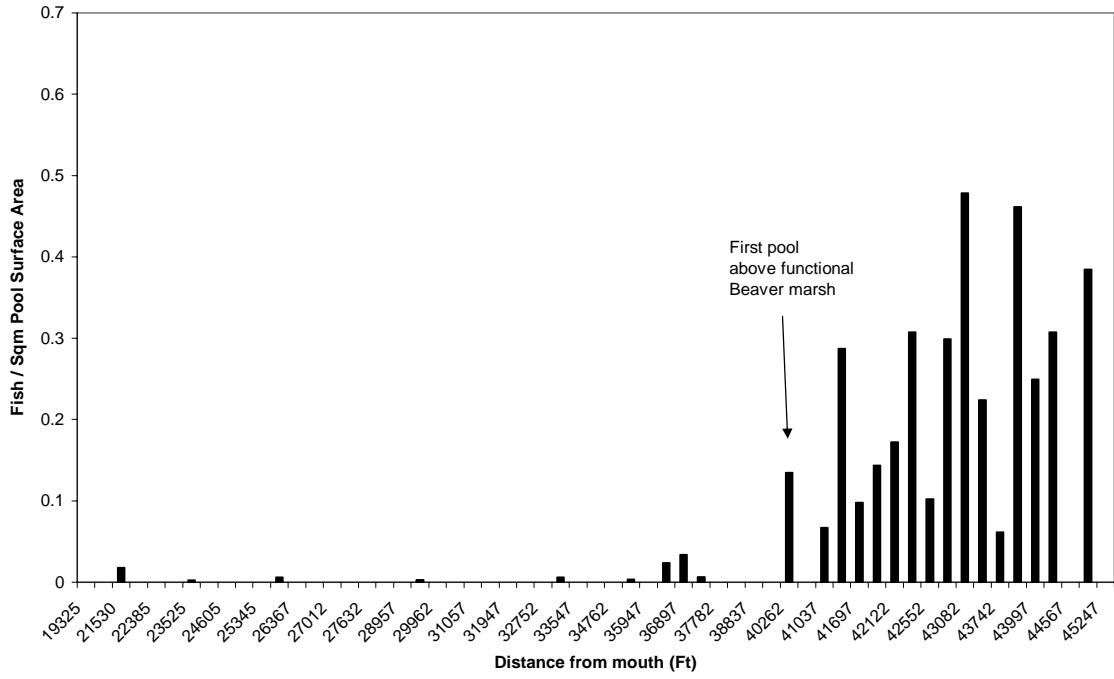
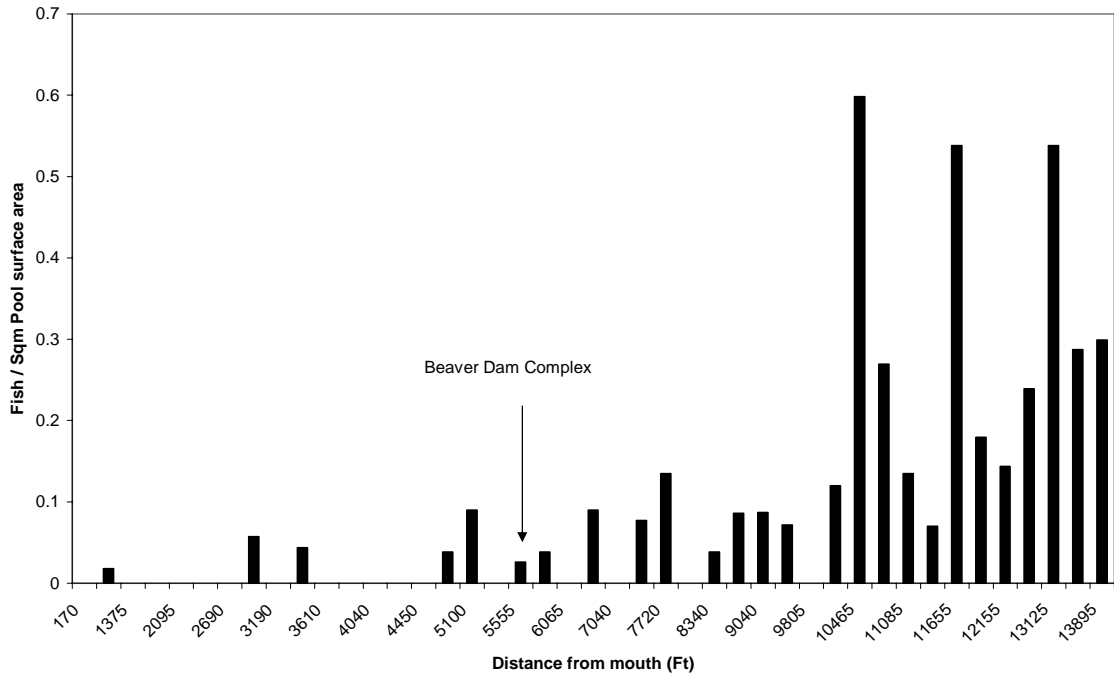


Figure 6

Duffy Cr 0+ age Cutthroat density 2009



Temperature Profiles

Figure 7

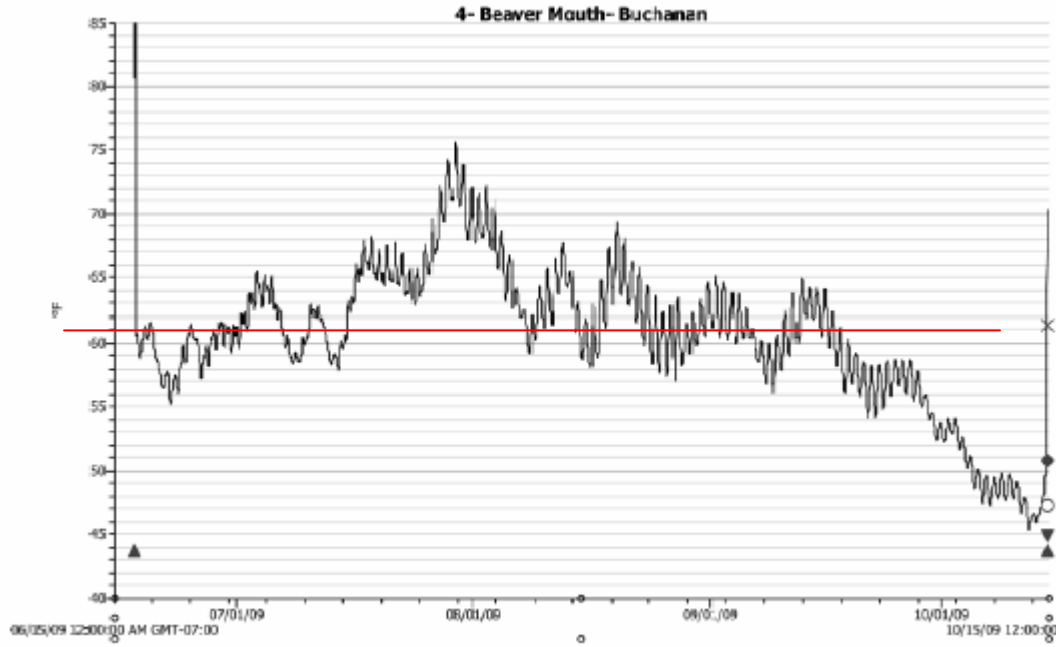


Figure 8

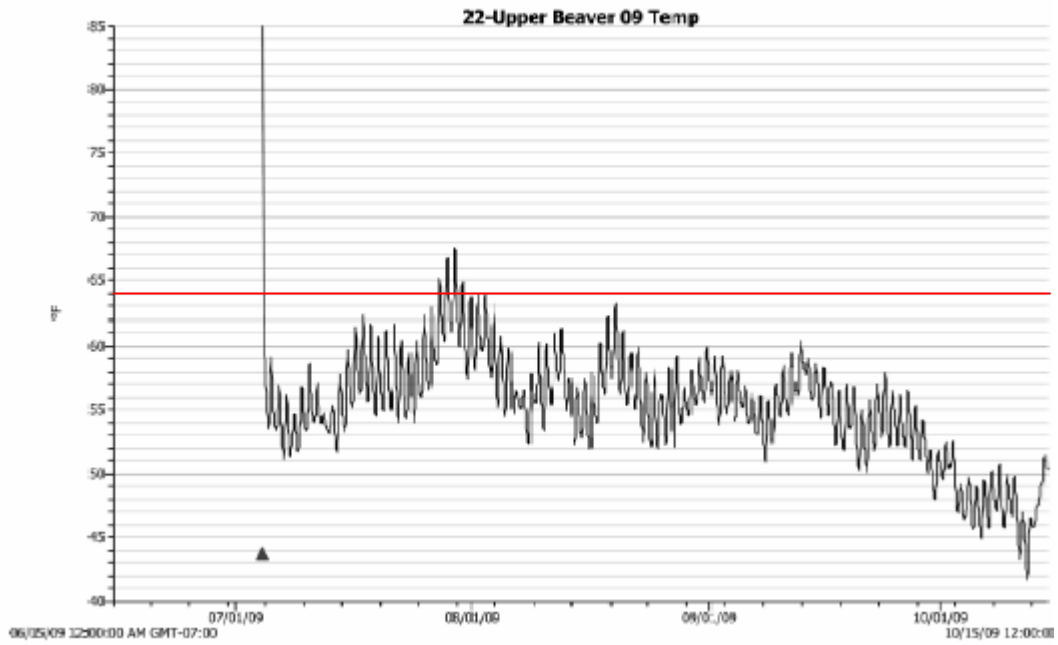


Figure 9

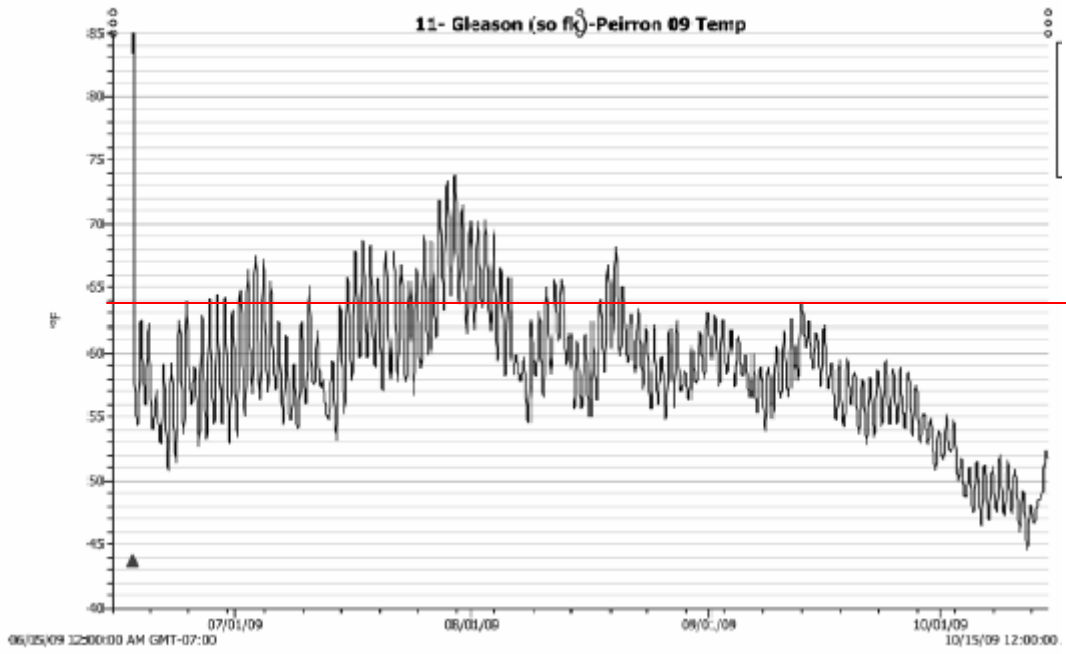


Figure 10

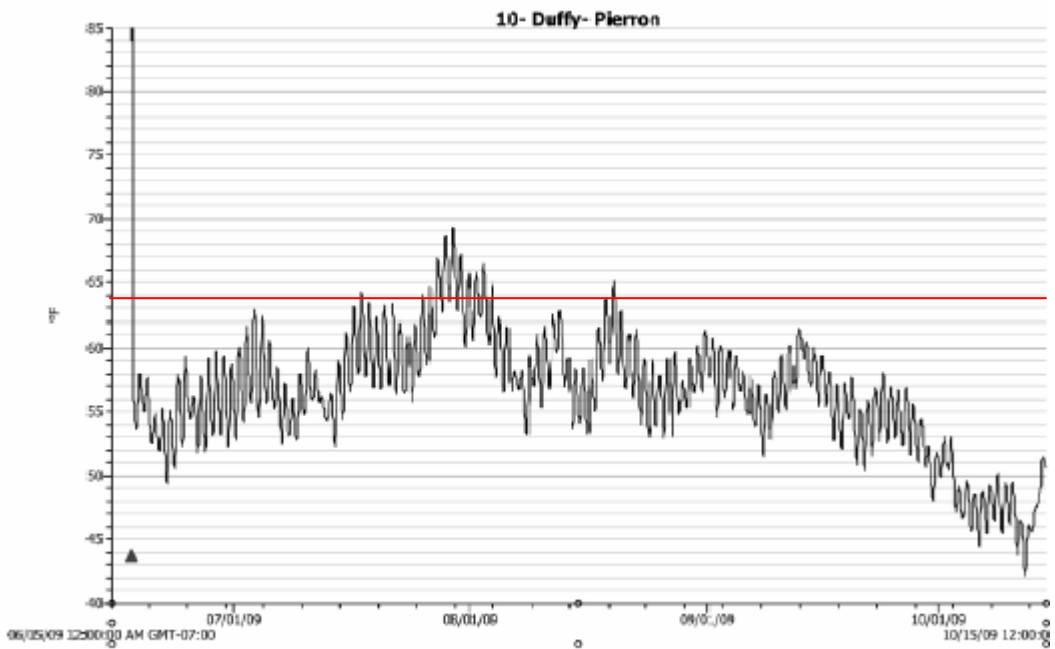


Figure 11

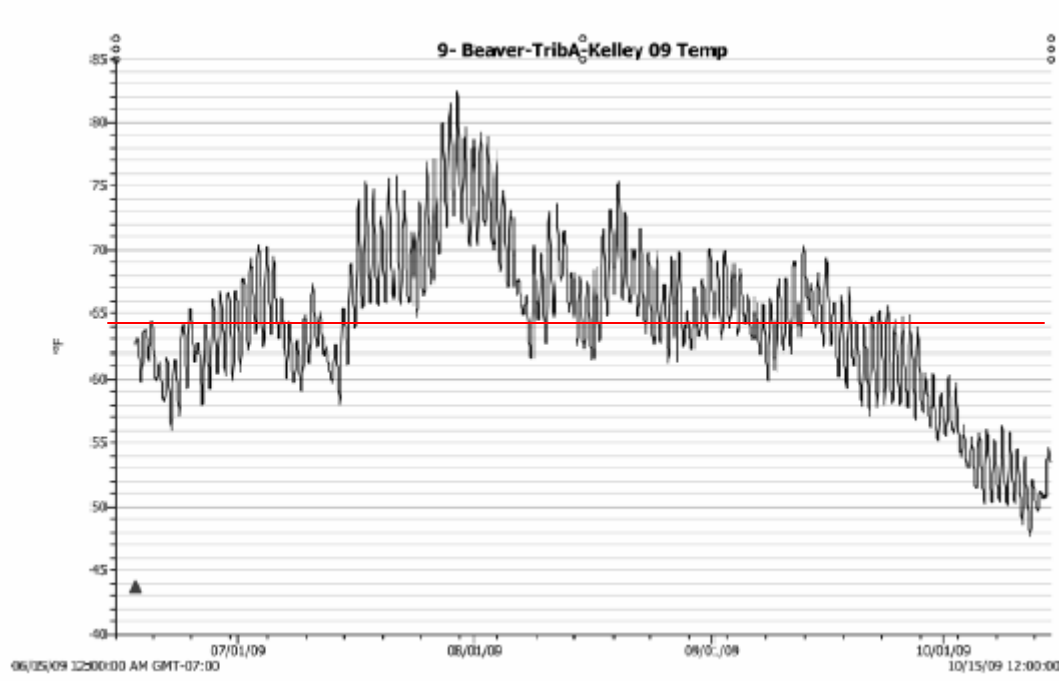


Figure 12

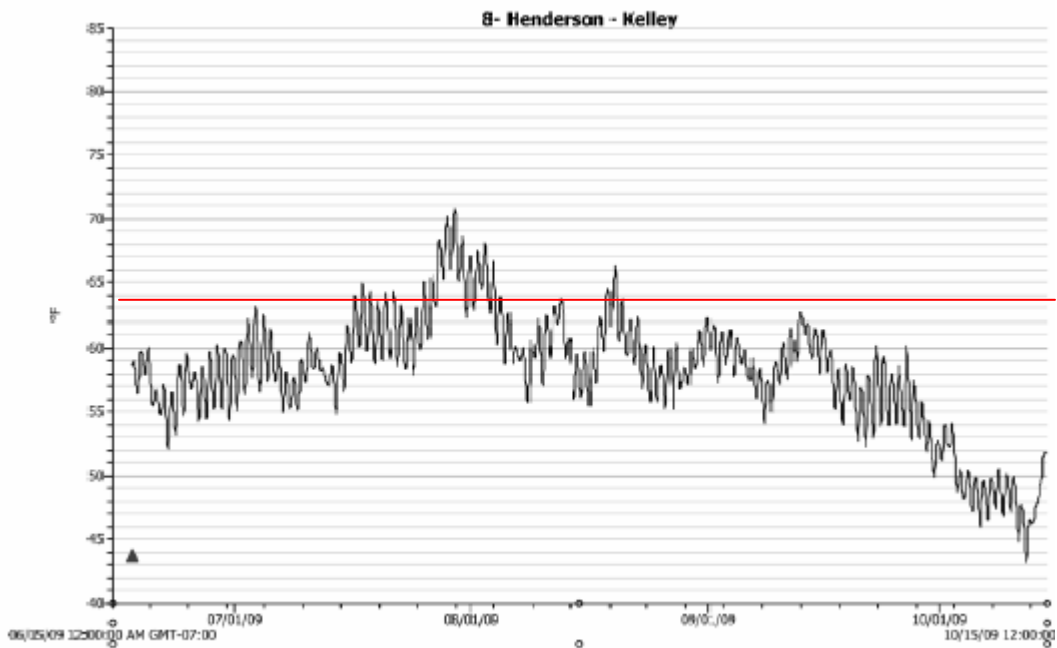


Figure 13

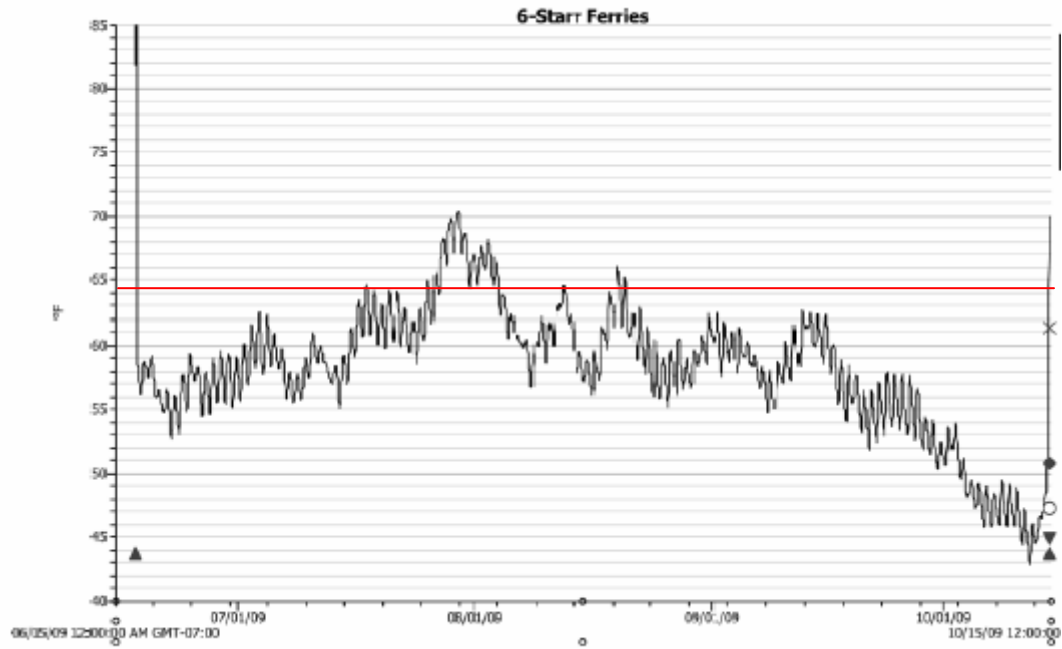


Figure 14

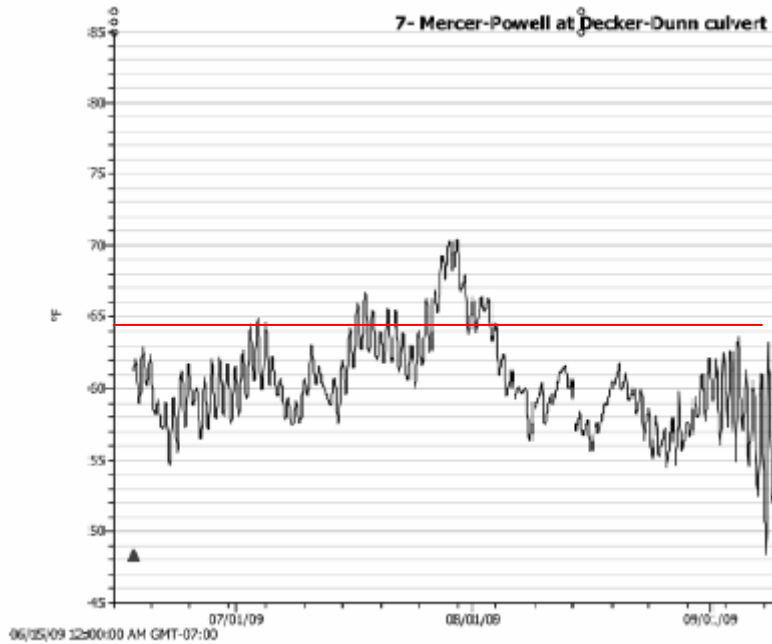


Figure 15

Mercer Cr @ Jensen Pond outfall

