APPENDIX C

ENGINEERING

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DESIGN BASIS

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1.0 BACKGROUND INFORMATION

1.1 Introduction

This section documents a portion of the hydraulic modeling and other related hydrology and hydraulic study work performed for this project and includes other engineering related basis for the project design. Normally, the hydrology and related modeling would be performed within the U.S. Army Corps of Engineers, Walla Walla District. However, a significant portion of the hydrology work for the project was performed as in-kind work by the sponsor in accordance with the Water Resource Development Act 2000 that specifically discusses this project and makes provision for the sponsor to receive credit as in-kind for study and investigation related costs. The University of Idaho performed the hydrology in-kind work for the sponsor and that work includes developing the general hydrology for the project, developing a hydraulic model of the Salmon River main channel for the project reach, and monitoring water temperature for the main channel, springs, and sloughs in the vicinity of the project.

1.2 Study Area

All restoration sites are located within Custer County, Idaho, within the Salmon River drainage basin. The most southern site identified to date for inclusion in the project is located at approximate main stem Salmon River mile 326 and the most northern site identified to date is located at approximate mile 320.

The land use adjacent to the Salmon River in the project vicinity, physical description of the basin, and general character of the run and discharge for the Salmon River are described in appendix B, section 1, Site Description (King, 2002).

1.3 History and Utilization Affecting the Salmon River

The discovery of gold in the Salmon River basin began to draw miners into that area by the mid-1800s. Figure 1-1 summarizes the mining activities of the basin upstream of the project. From around 1865 to around 1880, numerous small placer and hydraulic mines operated within the basin. These operations were directly located on the Salmon River or on tributaries. The discharge of sediment directly to the stream was common. A large hydraulic mining operation began around 1870 and continued until around 1900 (see figure 1-2). Hard rock mining began to dominate mining operations in the basin by the 1890s. While the hard rock mining did not work directly in the streams, the mill tailings were often situated adjacent to the stream. Also, timber harvest for mining timbers, structures, and fuel for the mill resulted in large clear-cut areas that generated sediment from surface run off (see figure 1-3). Dredging on the Yankee Fork began around 1932 and ended in 1953 with an interruption in operation during

World War II. Records indicate that the dredge removed 6,330,000 cubic yards between 1941 and 1952 (see figure 1-4). After the 1930s, the number of hard rock mines dwindled until a few larger mines remained. From the 1970s to the present, mining operations changed to comply with environmental regulations and only a few mines continue to operate today. Remediation of old mine sites is under way and this is reducing the sediment generated by run off from old mine sites.

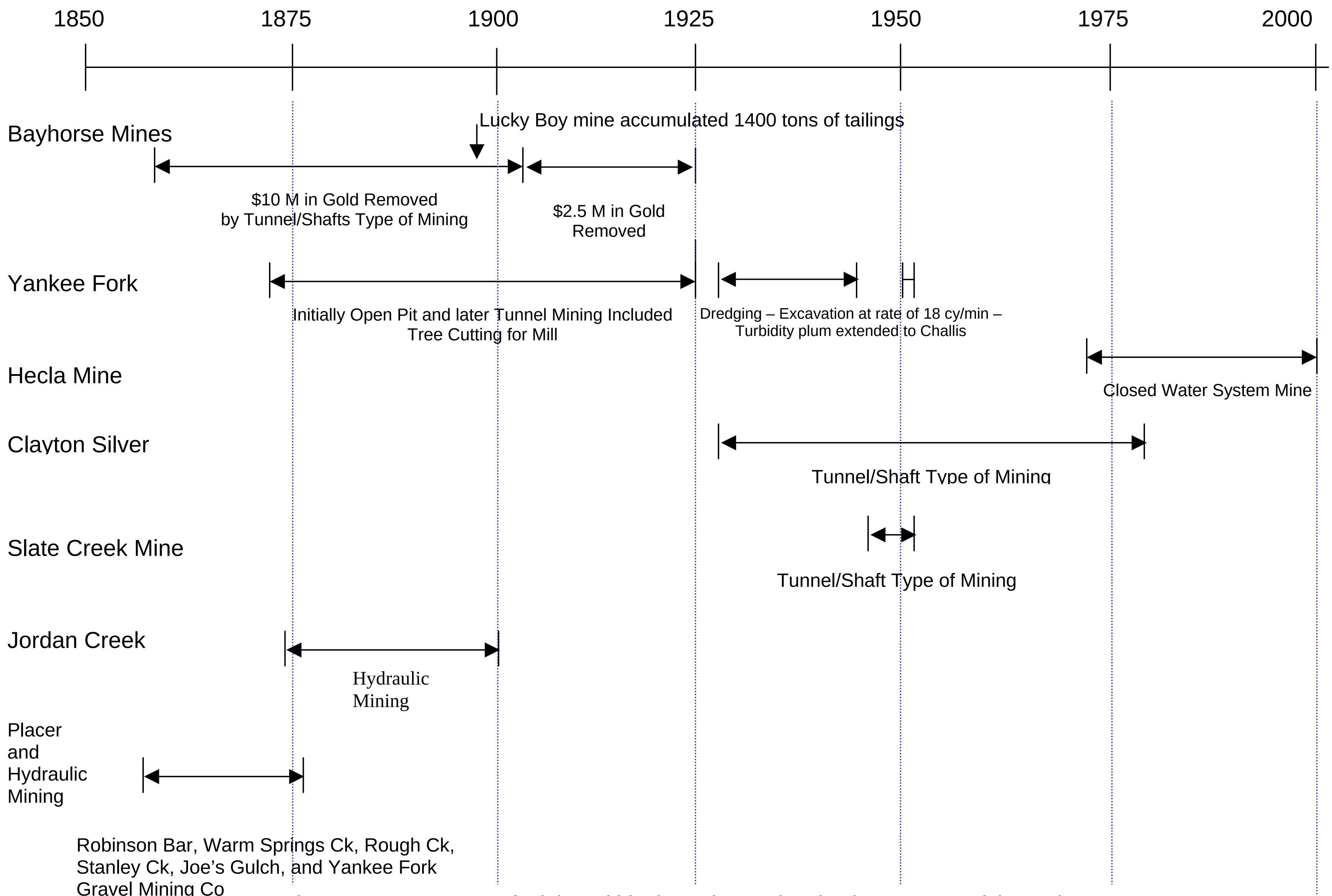

Figure 1-1 – Summary of mining within the Salmon River basin upstream of the project

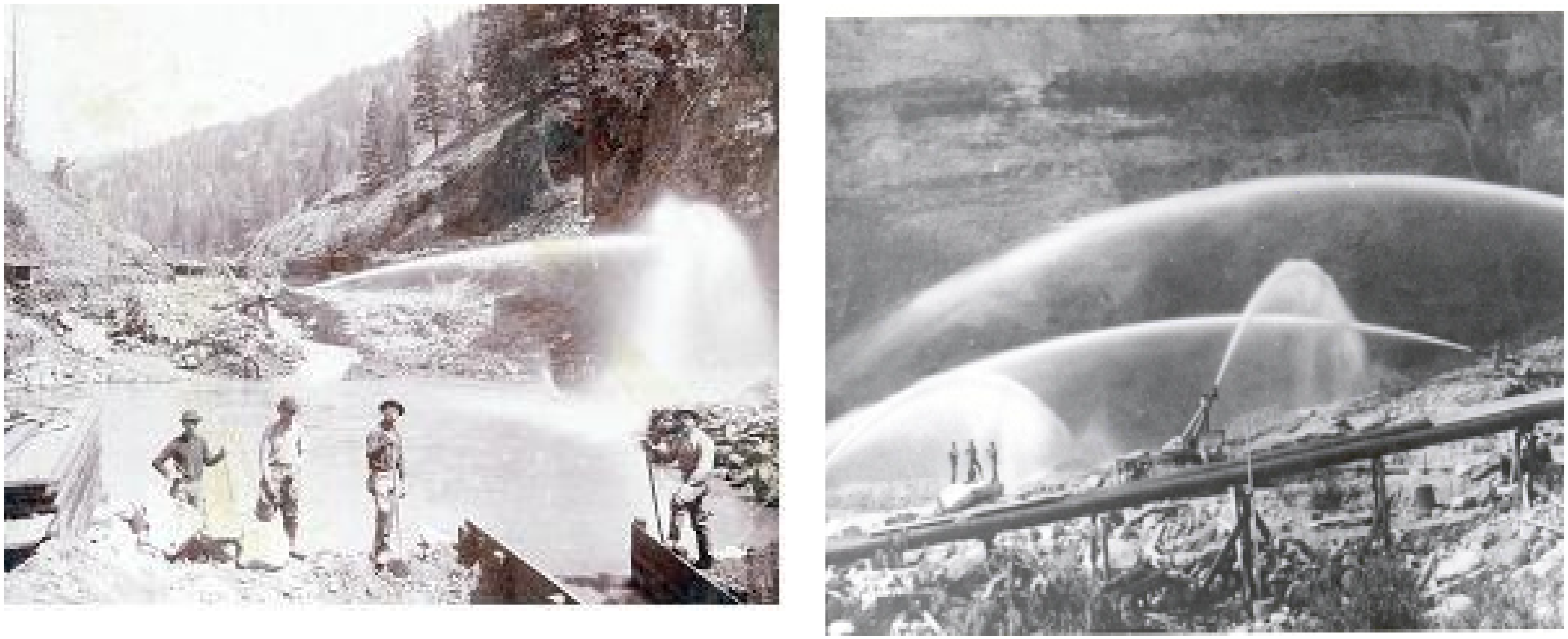

Figure 1-2 - “Jordan Creek Hydraulic Mining” courtesy of Yankee Fork Interpretive Center

Figure 1-3 - “Lucky Boy Mine” courtesy of Yankee Fork Interpretive Center

Figure 1-4 - “Bonanza after Dredging” courtesy of Yankee Fork Interpretive Center

Regional History of Sediment Causing Activities – Other than Mining

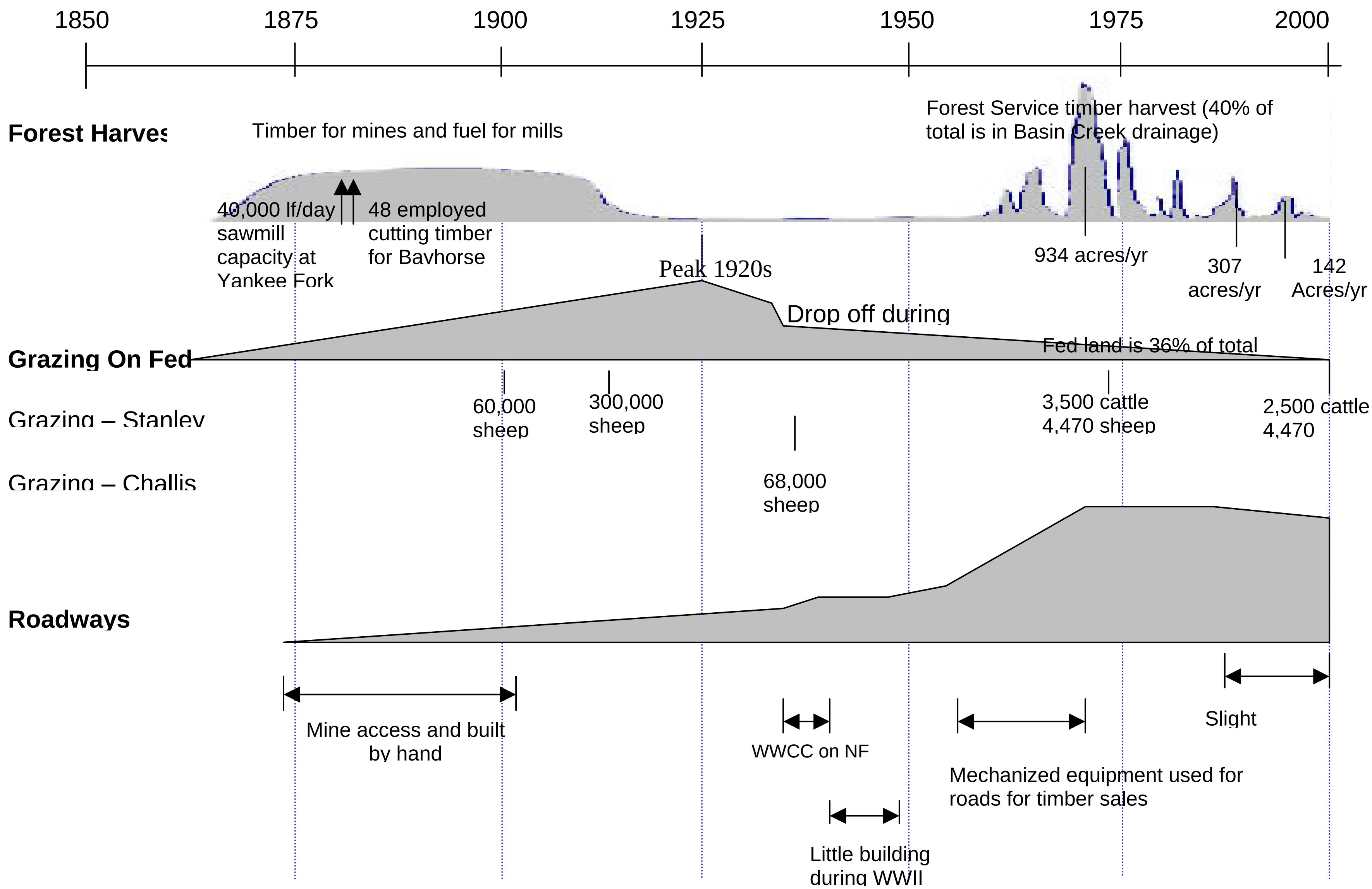

Figure 1-5 - Summary of other sediment source activities

Other activities in the basin affecting the amount of sediment in run off include forest harvesting, grazing, and roadways. As previously described, clear cutting of the forest occurred around the large mines from the late 1800s to the early 1900s. Timber harvesting on National Forest property within the basin has been relatively small. Since the mid-1970s the amount of timber harvesting has continued to decrease. The start of grazing within the basin coincides with the influx of miners to the region and increased until it peaked in the 1920s. Grazing has continuously declined since that peak. Figure 1-5 shows approximate numbers of cattle for selected years. The numbers are only for grazing within the national forest and BLM property and it is estimated that this grazing accounts for approximately 36 percent of the total grazing within Custer County. While timber harvest and grazing activities have decreased and should result in reduced sediment input, the amount of roadway within the basin has experienced a continual increase until the 1990s when the Forest Service started to decommission a few of the roads within the National Forest. The historic development and land use within the project basin were sources of significant sediment for the Salmon River. Many of these activities peaked in the 1940s and 1950s and have significantly declined to the present time. As described in appendix B, some actual measurement of sediment load was measured in the early 1970s. Quantitative measurements of sediment load over time are not available.

Other activities affecting the river include construction of a dam near the Yankee Fork confluence and bank protection and levee construction along the banks of the Salmon River in the area of the project. In 1910, a dam across the Salmon River was constructed near the Yankee Fork. This dam was breached in 1934 to allow salmon passage to spawning beds in the upper Salmon River. A significant section of the dam still remains within the channel. Landowners adjacent to the Salmon River have continually battled the floods and loss of their land to the river. Within the project, the landowners have constructed levees and placed extensive reaches of riprap and barbs to limit the River's damage. The approximate amount of levee and bank protection work is summarized below.

- Total length of project reach 77,000 feet (ft)
- Levees (one side of channel or other, or both) = 9,000 ft (approximately 12 percent of project length)
- Riprap, barbs, or levees (on one side or the other, or both) = 21,500 ft (typically coincides with levee) (approximately 28 percent of project length)

An example of a levee on the Salmon River within the project area is shown in figure 1-6 and the locations of levees and bank protection is summarized on figure 1-7.

Figure 1-6 - Levee on Salmon River

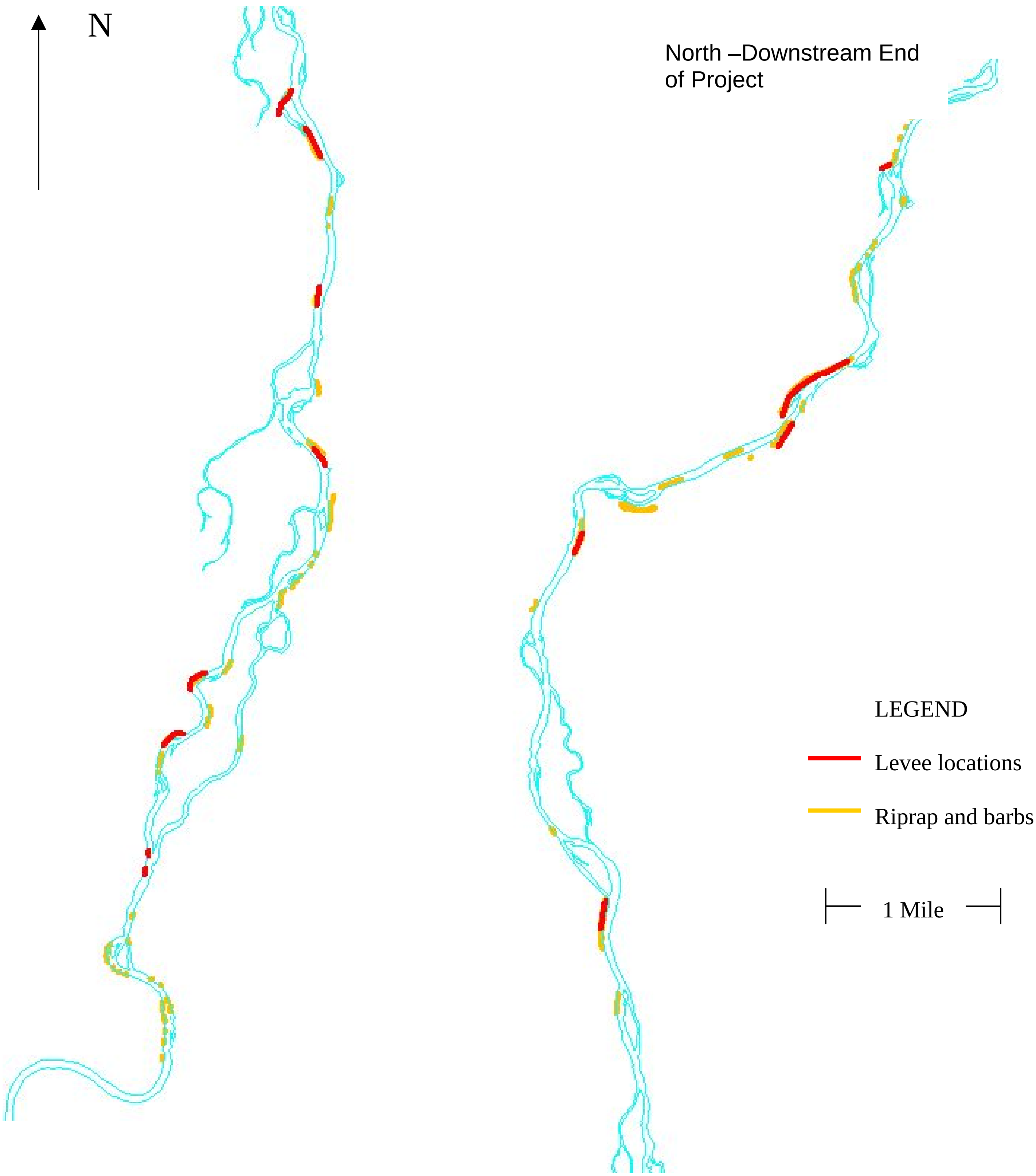

Figure 1-7 - Locations of bank protection and levees

Interviews conducted with local individuals describe a historic pattern of bank protection construction. One landowner constructs a barb or series of barbs to protect his property. The installation had little design basis and often had the unintended consequence of directing the River at the neighboring landowner on the opposite bank downstream. The neighbor on the opposite bank would, in-return, install bank protection to protect their property from the new attack. This anecdotal description of past bank protection construction is consistent with conditions observed at the project in which the existing bank protection appears piece meal and without attempt to fit the meander pattern upstream and downstream of the work. Few of the existing bank protection structures have the correct radius of curvature, wave amplitudes, *etc.,* figure 1-8 shows an example of an extremely tight radius of curvature and high velocity flow directed at opposite bank downstream. This pattern of reacting to river attack on one location without consideration of the larger picture has resulted in stability problems for adjacent reaches and fueled an ever-increasing amount of bank protection.

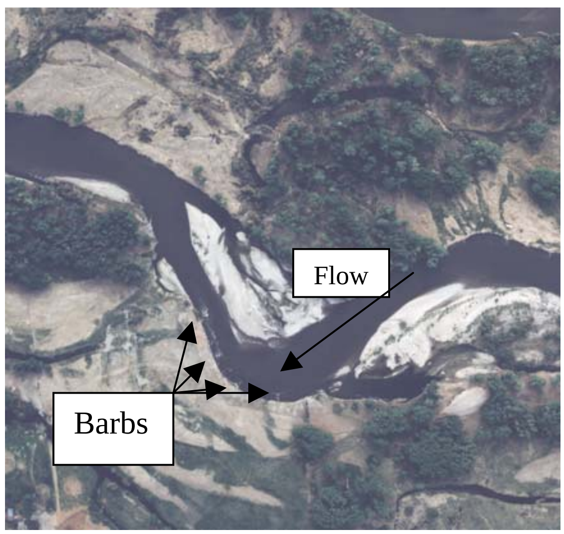

Figure 1-8 - Bank protection with tight radius

1.4 Habitat Issues for Main Channel

Despite the past history of mining, dredging, bank protection, *etc*., most of the river channel in the project reach has the normal appearance of a large, gravel bedded type of river. But, there are three habitat related issues that affect salmonids using the project reach.

The gravel banks of the active channel tend to be un-vegetated, and very uniform without undercuts, scalloping, or other habitat features as shown in figures 1-9 and 1-10. Additionally, there is little or no large woody debris. The lack of large woody debris and other features may not be the consequence of man's development in this area. Rather, it may reflect the tendency for the granular, non-cohesive bank material to lie on a uniform slope. Due to the nature of the peak flows of this basin (flood water surface increase ranging from 5.5 to 8 ft for the 1.5-year (yr) event (67 percent exceedance)) these flows tend to lift up a fallen tree and sweep it away downstream.

Figure 1-9 - Typical bank

Figure 1-10 - Typical bank continued

During the annual flood event, the uniform banks result in relatively swift flow along the bank and the lack of bank irregularity provides few quiet water areas. Consequently, the main channel provides little rearing/refugia for juvenile fish for the duration of the high water period. Abandoned channels that could potentially provide refugia during high water are often the areas where the bank protection or the levee construction has occurred, removing these opportunities for refugia and rearing. Removing levees and opening up secondary channels that provide slower water areas for rearing and refugia is one objective for this project.

Temperatures in the main channel during the summer and fall of 2002 had several days where average daily temperatures reached 18^{o}C (64.4^{o} F) (see figure 1-11) and 20-minute spikes of 23^{o}C (73.4^{o} F) (see figure 1-12). The local Idaho Fish and Game biologists have stated that the optimum water temperature for rearing Chinook fry is 11.7^{o}C to 15.6^{o}C (53^{o} F to 60^{o} F) and for rearing Steelhead fry is 12^{o}C to 18^{o}C (53.6^{o} F to 64.4^{o} F). The temperatures observed in 2002 are not lethal, but did have periods with temperatures above optimum.

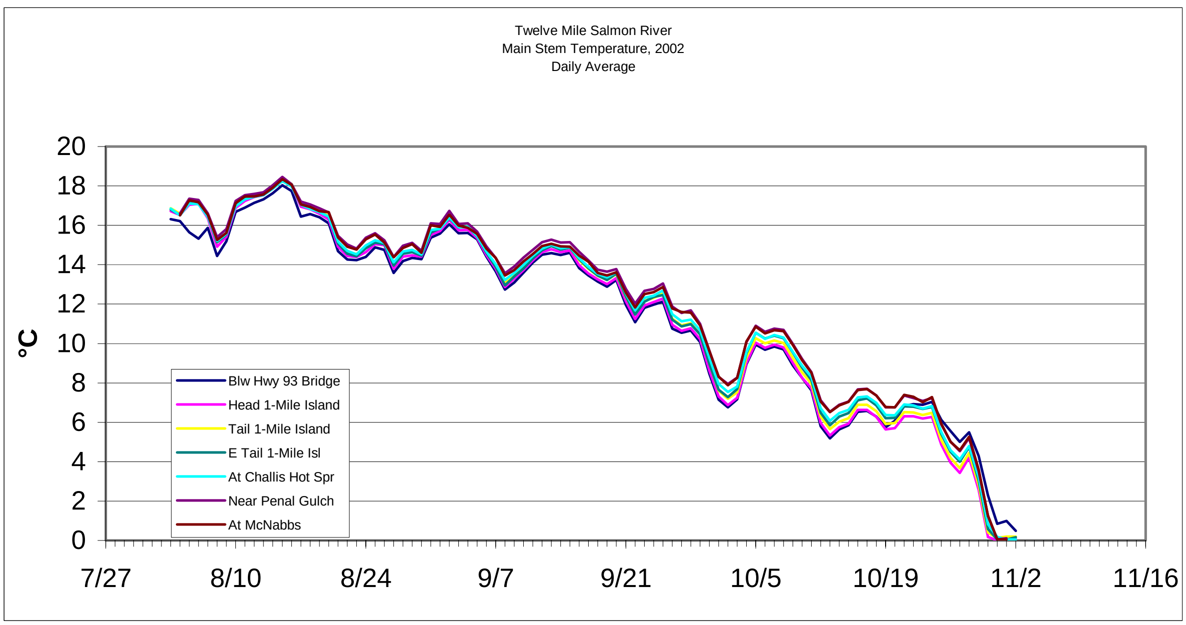

Figure 1-11 - Daily average temperatures for Salmon River

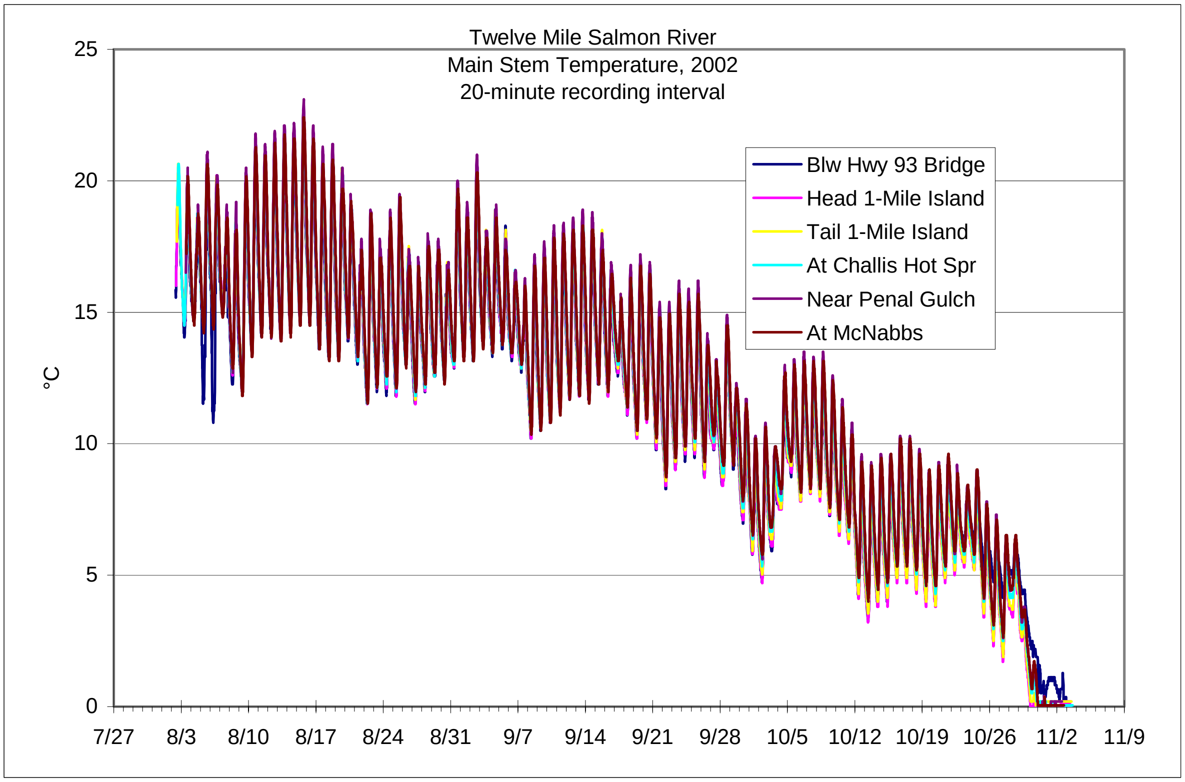

Figure 1-12 - 20-minute average temperature for Salmon River

Providing cooler water temperatures for rearing areas is an objective for this project. The project will remove fish passage barriers that block entrance to cool, spring-fed channels, and develop secondary channels with complete canopy cover. The developed secondary channels may be fed solely by water from the main channel or by a combination of springs and main channel water. The amount of temperature reduction to main channel fed by water in the secondary channel is uncertain, but at a minimum, shading of the water will be provided and this is expected to have some beneficial effects even in the event that water temperature reduction is minimal.

The final main channel issue discussed in this appendix is associated with the quality of spawning gravels in the main channel. The approximately 50-yr flood event (2 percent exceedance) of 1974 and the approximately 25-yr event (4 percent exceedance) of 1956 scoured banks and formed extensive gravel bars as shown in figure 1-13. The plentiful gravel supplied after these types of flood events would provide good substrate for spawning. Individuals who grew up in Challis and were familiar with Salmon spawning in the 1970s and 1980s describe extensive spawning with in the project reach until the mid-1980s. Today, few salmon spawn within the project area. The present riverbed within the project reach is observed to be medium to large cobbles with fines filling the voids of the coarser particles (imbrication). The existing substrate is generally coarser than the 4-in maximum size preferred for Salmon spawning. A typical photo of a pool tail-out area is shown in figure 1-14. The size of the bed material and presence of fines makes much of the riverbed less than ideal for spawning. Consequently, there is no spawning in most of the project because spawning adults are attracted to better sites outside the reach or compete for the few sites within the project having good spawning gravels. The riverbed substrate in most of the project reach may be so large that it does not mobilize during typical flood events. This may account for some of the spawning gravel quality issues previously described. The MIKE 11 model results (appendix I) were used to determine when the riverbed would mobilize based upon Shields Equation H-1.

$$\tau = \rho \cdot g \cdot R \cdot S$$ Equation H-1 (USACE 1994)

$\rho \cdot g$ = specific weight of water

R = hydraulic radius (MIKE 11 output for each section used in calculation)

S = hydraulic slope (average value for 12-mile reach used 0.0032)

The values calculated for Equation H-1 were substituted into Equation H-2 to calculate the critical particle diameter.

$$d_c = \frac{\tau}{\theta_c \cdot g \cdot (\rho_s - \rho)}$$ Equation H-2 (Simons and Senturk, 1977)

θ_c = critical shear factor (0.045 and 0.035 used in calculation)

ρ_s - ρ = specific gravity of substrate minus water

g = acceleration of gravity

Critical particle sizes were calculated for each cross section used in the MIKE 11 model for the 1.5-, 10-, and 50-yr events (67, 10, and 2 percent exceedance). These calculated critical particle sizes were compared with the river substrate sizes to evaluate when incipient motion is initiated.

Sampling was performed at several bars located within the project reach. In most locations, a surface armor layer was evident. The material below the armor layer was sampled, sieved, and gradation curves were developed (figure 1-15).

Figure 1-13 - 1977 photo after 1974 approximately 50-yr flood event
(2 percent exceedance)

Figure 1-14 - Coarse Riverbed

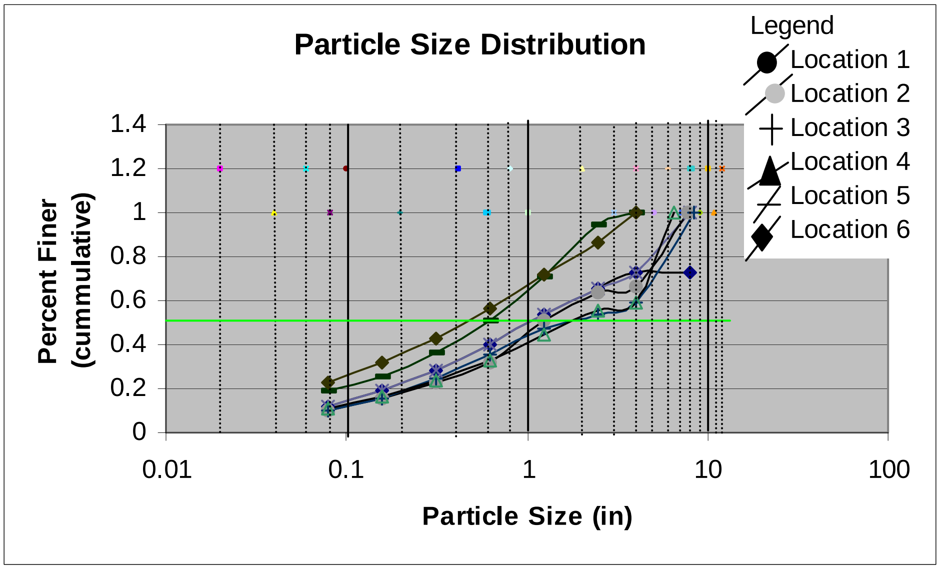

Figure 1-15 - Gradation of bar material below the armor layer

Due to the size of the material in the armor layer, sieving was not performed. Maximum sizes and average sizes of the armor layer were visually identified at the sample location and then individually measured as summarized in Table 1-1.

Location	Maximum (in/mm)	Average (in/mm)
1	13/330	4.2/107
2	7.7/196	5.5/140
3	12.3/312	6.3/160
4	9.1/231	4.8/122
5	7.8/198	4.8/122
6	8.5/216	4.8/122

Table 1-1 - Armor layer maximum and average sizes

The d85 for the sub-armor layer ranges from 2-inches (51 mm) to 6-inches (152 mm). The d85 for the armor layer is assumed to be approximately 6-inches (152 mm). Table 1-2 summarizes the number of cross sections for which the calculated critical particle diameter is larger than 6-inches (152 mm).

Critical Shear Factor	1.5-Yr Event (67% exceedance)	10-Yr Event (10% exceedance)	50-Yr Event (2% exceedance)
0.035	0	18%	30%
0.045	0	4%	7%

Note: Percent based on a total of 74 cross sections used in the MIKE 11 model.

Table 1-2 - Percent of cross sections having calculated critical particle sizes larger than the observed 6-inch diameter substrate

This analysis indicates that much of the bed is rarely mobilized. The major flood events appear to provide plentiful gravels for spawning (figure 1-13). Over time, the smaller gravels become less plentiful and an armor layer becomes pervasive. This armor layer does not mobilize during the moderate size events.

Figures 1-16 to 1-19 shows redd locations that were surveyed in September 2002 and shows the close correlation of spawning with areas of the River where active gravel sorting (current moves and deposits particles of different sizes and different specific gravities at different rates) is occurring.

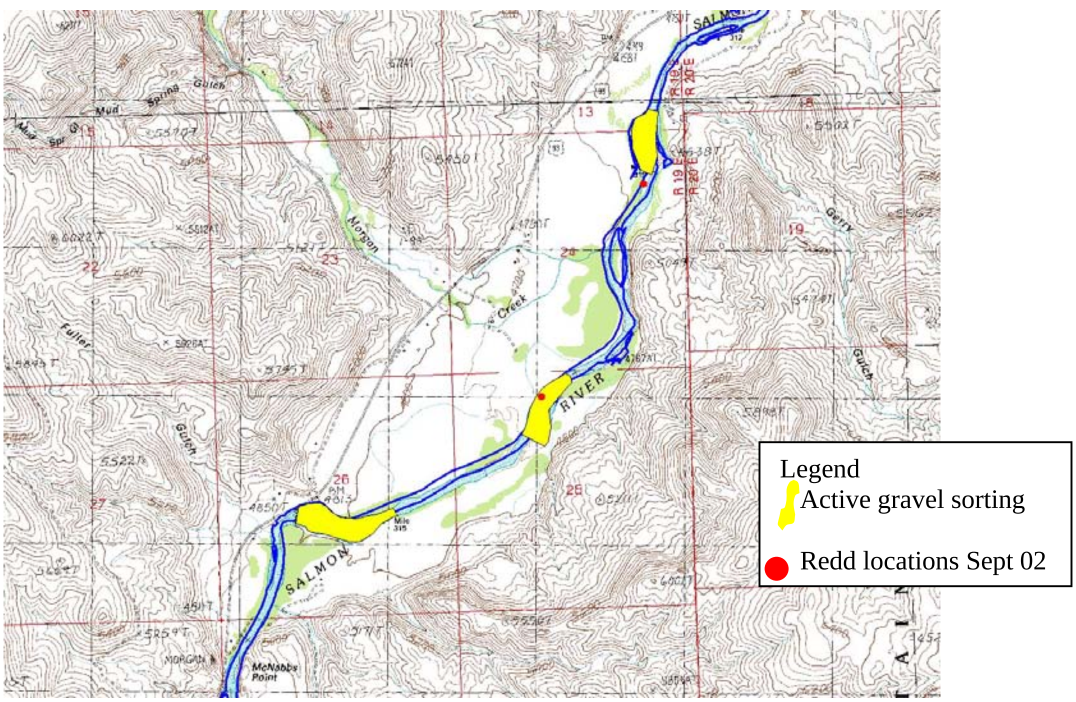

Figure 1-16 - North end of project, active gravel sorting and redd locations

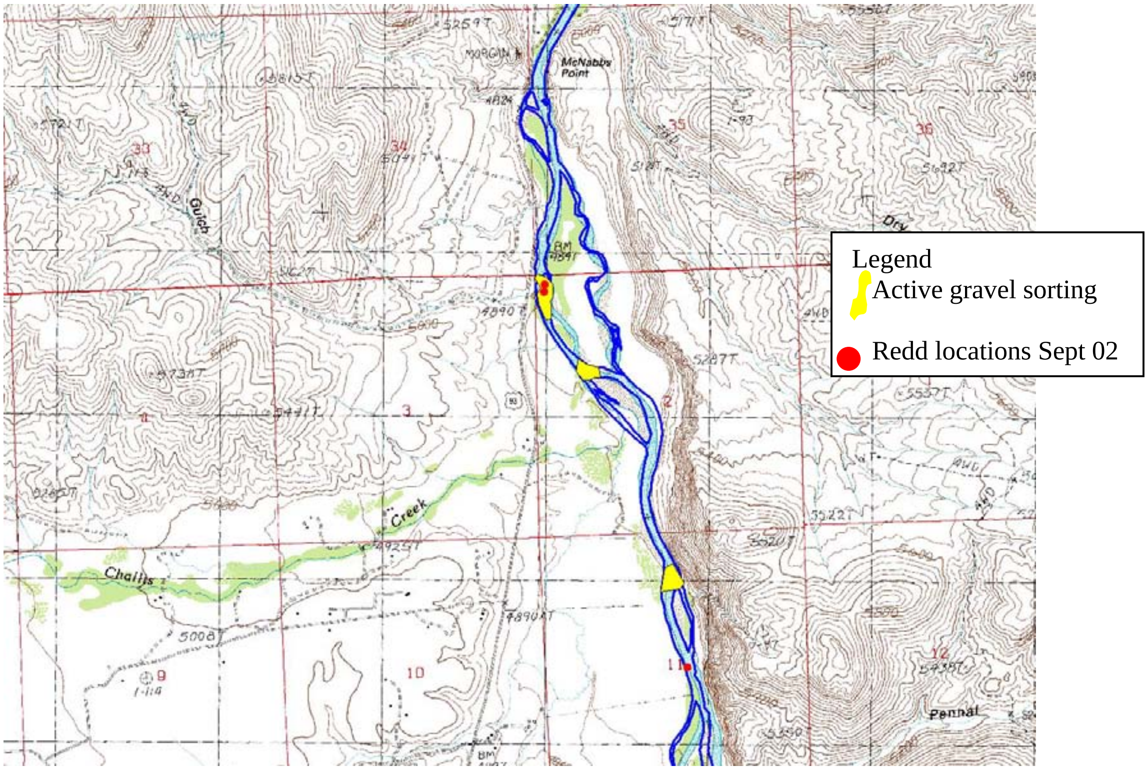

Figure 1-17 - Middle of project, active gravel sorting and redd locations

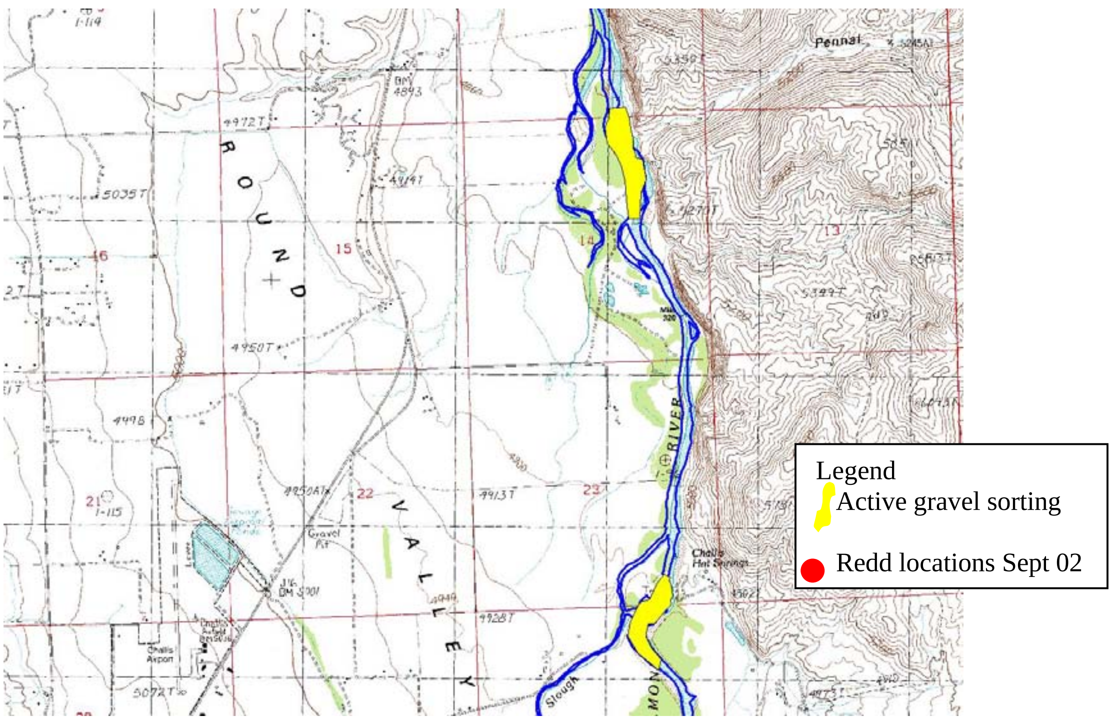

Figure 1-18 - Middle of project continued, active gravel sorting and redd locations

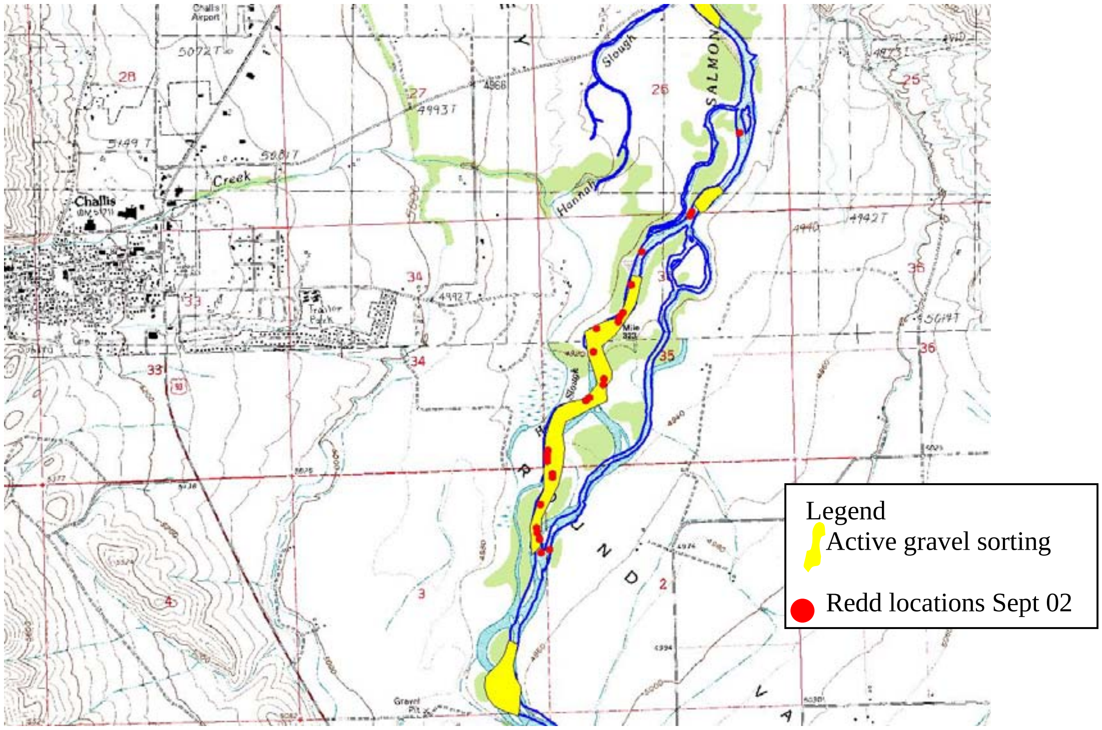

Figure 1-19 - South end of project, active gravel sorting and redd locations

The project reach has a channel slope that is borderline braiding (see appendix I for discussion of braiding). Some areas with pronounced braiding have bank heights that are less than the effective discharge (see appendix I for discussion of effective discharge). The clearest example is the river reach at One-Mile Island (near site 2). In reaches where the bank height is less than the effective discharge elevation the flow spreads out over the flood plain and sediment transport tends to decrease relative to other reaches with higher banks. This may create a condition where a borderline braiding reach becomes fully braiding. Once the characteristic braiding medial bars form, the braiding pattern tends to self-propagate because as the flow is directed around the medial bar (a bar near the center of the river which crowds the flow out towards the banks), it tends to attack the bank and generate more sediment that will in-turn, form new medial bars downstream. Consequently, low bank heights may be associated with braiding, bar formation, and gravel sorting. Because of the large bed material sizes found in most of the project, these areas of active gravel generation and sorting appear to provide desirable spawning bed areas. Removing or partially removing levees that increase bank height and cut-off high flow chutes is an objective for the project. Also, removing structures that train the river so that it no longer produces new sources of gravel is also an important objective for this project.
In summary, the three habitat issues previously described result in the following project objectives:

- Develop secondary channels and springs that will provide rearing areas for fry for refugia from the high flow periods

- Develop secondary channels and springs that provide cooler water temperatures
- Where adjacent private property is not threatened, levees and other river training structures will be removed to provide more spawning gravel sources.

2.0 DESIGN BASIS

2.1 General

The previous section identified several habitat issues for the Salmon River main channel. Making changes to the main channel that address some of these issues would involve removal of existing levees and bank protection and result in different flooding and alignment patterns. Most of the property adjacent to the Salmon River with in the project is privately owned and any changes to the River must be acceptable to the owners. Because of landowner sensitivity, a comprehensive plan for the river work would need to be developed that is based on predictions of future alignment changes and changes in flooding. Developing such a plan is beyond the funding limits of the Section 206 program authority. This design strives to compensate for the issues identified in the previous section and avoid the potential risk associated with direct work in the main channel by developing habitat off the main channel, or by performing partial removal of levees and bank protection on the main channel that will not result in significant alterations of current channel alignment and will not result in increased flooding of private land. Developing a comprehensive plan for the main channel may be pursued as a separate project under the General Investigation Authority.

2.2 Site 1 Dunfee Slough

2.2.1 General Description of Current Conditions. Site 1 is located on the left bank of the Salmon River approximately 1.7-miles downstream of the State Highway 93 Alternate bridge. The site includes a combination of relic channels (former main channel that has been abandoned by the river over time) and constructed channels. Much of the constructed portion was for aesthetic/recreation purposes. The constructed channel enters the site from the south and branches near the upstream end of the property and splits into two channels that run roughly north for approximately one mile before rejoining to form one channel again. A crude diversion structure divides the flow into these two branches. The west channel is entirely constructed while the east channel may have been a high flow channel that was modified by the construction of dams and the excavation to deepen to provide pools. A seasonal peak flow of approximately 10 cfs flows through the system provided primarily by irrigation water and some spring water. The spring flows are associated with irrigation of the terrace area above the site 1. There is little spring flow until after irrigation has begun. During winter, there is little or no flow through the channel, although groundwater ponds in some of the deeper pools. A significant portion of the site 1 has been cleared for pasture and is currently grazed. None of the riparian vegetation is in good condition and there is no shading vegetation along the existing channels.

2.2.2 Objectives. Objectives for this site include the following:

- Develop a secondary channel that:
  - Provides perennial flows (Design for a late summer daily average flow having a 95 percent confidence limit)
  - Reduces water temperatures if possible and provide shade as a minimum
  - Provides refugia for juveniles from the higher velocities of the main channel by providing reaches of low velocities (<2 ft/sec) during the 1.5-yr event (67 percent exceedance)
  - Provides feeding areas for juveniles consisting of low velocity reaches that don't require expending much energy to stay in place (< 2 ft/sec) but flows are sufficient to bring plentiful supply of food to the juveniles (>3 ft^3/sec)
  - Provides refugia pools for winter freezing of the channel and low velocity area during events that are large enough to result in velocities greater than 2 ft/sec in the secondary channel
  - Provides complex cover for juveniles consisting of undercut banks, woody debris, *etc.,* for evasion of predators
  - Provides a sediment trap at the upstream end to confine sediment to a convenient location for maintenance removal
- Re-establishes riparian vegetation
- Accommodate the following constraints:
  - Landowner will not allow secondary channel discharges that exceed 40 cfs for flood events up to bank full on the Salmon River main channel
  - Restrictions on the height of shrubs, forbs, and graminoids in the existing pasture area
  - Landowner wants to minimize the alteration of existing ponds and canals
  - Provide vehicle access across the perennial flow channel established by this project

2.2.3 Proposed Design for Achieving Objectives

2.2.3.1 Secondary channel intake. Ideally, a connection to the Salmon River main channel would provide perennial flows to the secondary channel at a location that could feed both existing canal branches. Unfortunately, potential areas that are sufficiently far upstream to feed both canals either are unstable because of caving/eroding banks, medial bars, *etc.,* or, lack a willing landowner that would participate in the project. The entrance to the secondary channel is located at the first reasonably stable location that has a landowner interested in participating in the project. This location is too far downstream to feed the west branch of the existing canals. Consequently, the west branch of the existing canals will only have water in them when the landowner runs irrigation water in that canal. Locating the entrance within an unstable area is not acceptable because of the quantity of sediment that the inlet would withdraw from the main channel and the associated maintenance that would be required to keep the secondary channel operating.

Bank full events on the Salmon River main channel would result in secondary channel discharges of several hundred cfs if the inlet were unregulated. Gates or other similar regulating devices would require that the project acquire a water right. Because of the length of time required to obtain a water right, potentially years, and uncertainty that a water right would be granted, a means of regulating the flow that would not require a water right will be used. Based on consultation with Idaho Department of Water Resources (Blau, 2002), using a culvert to reduce the flows will not require a water right. Unfortunately, a culvert that is small enough to reduce flow to the 40 cfs range will not meet fish passage requirement (NMFS, 1995; 1996; 2001) because the entrance is submerged by more than 1 ft by the fish passage design discharges (1 percent exceedance or 2 times the 50 percent exceedance). A culvert that would meet the fish passage design requirements would result in discharges exceeding 40 cfs for the bank full event on the main channel. The NMFS engineer suggested using a 4-ft-diameter culvert with a 1.5 x 1.5-ft orifice plate on the entrance. This orifice will regulate flows to below the 40 cfs limit requested by the landowner. The culvert entrance shown in figure 2-1 was coordinated with the NMFS engineer. Additionally, the edges of the orifice would be framed with 1-in thick molding to avoid cutting and injuring fish as they move through the orifice.

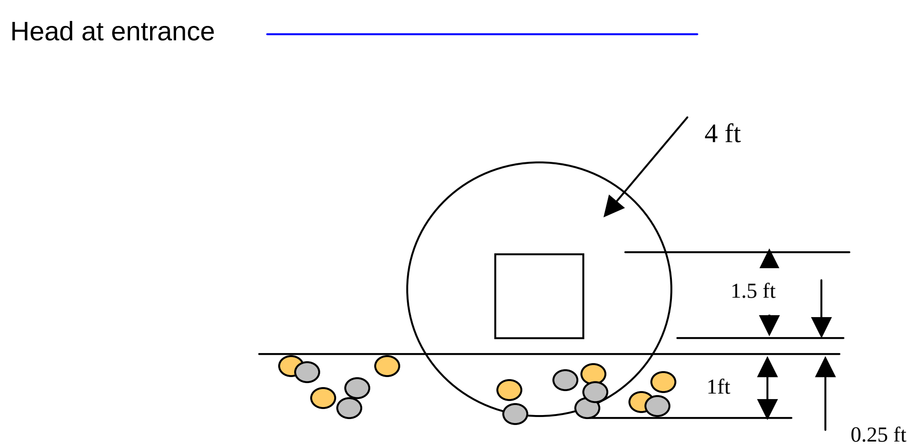

Figure 2-1- Culvert entrance with orifice

2.2.3.2 Secondary channel profile. A channel will connect to the main channel and feed water to the previously described culvert having an orifice plate located approximately 13 ft from the edge of the main channel. Beyond the culvert, a 150-ft-long new channel would connect to the existing canals. Some deepening of the existing canal is required for the upstream 1600 ft to assure fish passage and adequate flow during low flow periods. Additionally, the existing spillway located approximately 700 ft from the upstream entrance will be lowered to allow greater low flows. Beyond 1600 ft, the elevations and dimensions of the channels, pools, and spillways will not be significantly altered, because of landowner desire to minimize the amount of changes. Figure 2-2 shows a profile for the project and a water surface for the 1.5-yr event (67 percent exceedance). Since the present canal geometry is being retained, the 1.5-yr event (67 percent exceedance) was arbitrarily used to give some sense of the depths of flow. The MIKE 11 model of the main channel (described in appendix I) was used to determine water surface for the 1.5-yr event (67 percent exceedance) at the proposed entrance and exit of the site 1 secondary channel. The 1.5-yr (67 percent exceedance) discharge for the secondary channel was determined by adjusting the discharge until the HEC-RAS model water surface nearly matched the MIKE 11 model results at the entrance and exit and is approximately 23 cfs. The HEC-RAS model uses a culvert size of 1.67-ft-diameter round culvert with no blockage to model the culvert with the 1.5 x 1.5 orifice.

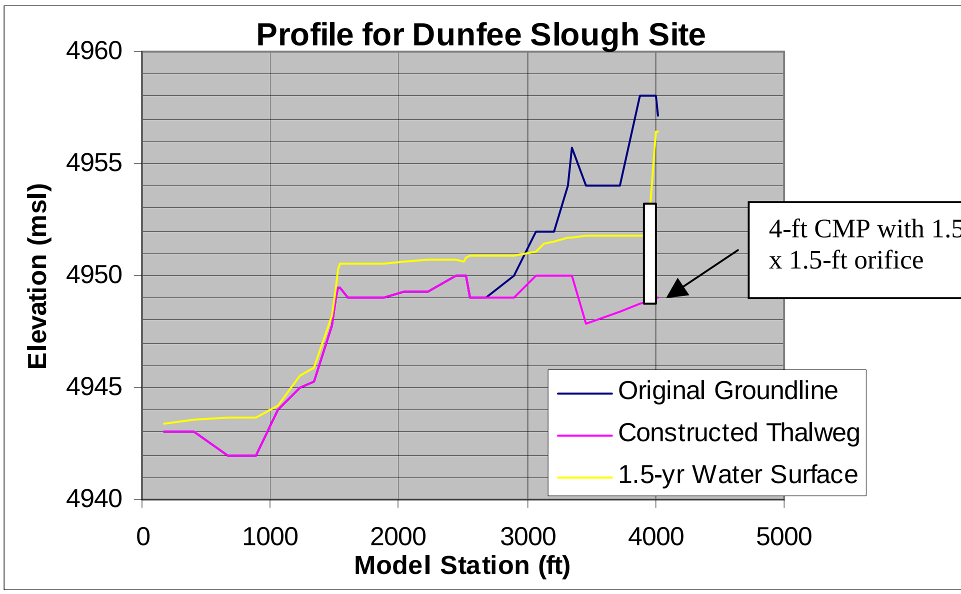

Figure 2-2 - Profile for Site 1 secondary channel

2.2.3.3 Base flows. Lowest flows in the Salmon River main channel occur during winter with average daily flow of approximately 640 cfs, and these flows are significantly lower than late summer flows of approximately 680 cfs as shown in figure 2-3. Designing the inlet thalweg for the lowest, winter flows may not be warranted because of the tendency for secondary channels to freeze during the winter. According to Idaho Fish and Game (Larkin 2001) most fish move out of the secondary channels before winter sets in. Consequently, there is little impact if flows in the main channel drop below the secondary channel inlet. Low flow for the secondary channel design will be based on the late summer 95 percent confidence flow of 680 cfs in the Salmon River main channel.

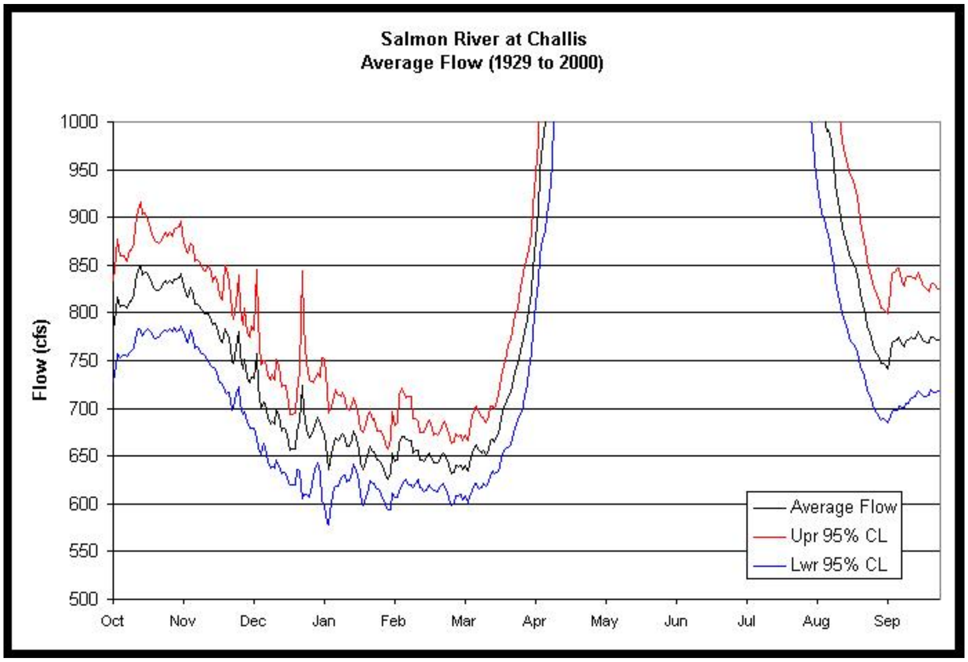

Figure 2-3 - Daily average flows for Salmon River gauge near Bayhorse

The MIKE 11 model of the Salmon River main channel (described in appendix I) was used to determine water surface for the 680 cfs discharge at the proposed entrance and exit of the site 1 secondary channel. The corresponding discharge for the secondary channel was determined by adjusting the discharge for the HEC-RAS model of the secondary channel until the HEC-RAS model water surface nearly matched the MIKE 11 model results at the entrance and exit. Depth of flow for the base flow discharge varied from less than 6-inches at some riffle/run locations to more than 3 ft deep in some pools and discharge was 5 to 6 cfs. Flows and depths could have been greater if the invert of the intake were set lower. But, there is a trade-off between having a lower invert with more flow and also more sediment and maintenance. The 5 or 6 cfs calculated in this analysis is based on setting the intake invert at approximately 0.45 ft above the main channel thalweg. Paragraph 2.2.5 discusses the issues of sediment and inlet elevation. During construction, some excavation of the existing channel bed will be required to form a more narrow and deeper channel that will provide a minimum depth of 6-inches for the base flow.

2.2.3.4 Stable channel and sediment deposition design issues. The secondary channel will withdraw significant proportions of bed load from the main channel (Shields and Abt 1989 and Linder 1952). The sediment deposition within the secondary channel will require maintenance to maintain flow in the channel. To the degree possible, the design will minimize the sediment withdraw so that maintenance costs are minimized. A primary strategy for minimizing sediment withdraw is to locate the intake within a stable reach of the main channel (minimizes sediment in the main channel). The withdrawal of bed load by the secondary channel can be further minimized by locating the intake on the outside of the bend, aligning the intake 90^{o} to the main channel, and elevating the invert of the intake above the thalweg of the main channel (Linder 1952). All of this, except for locating the intake on the outside of the bend, will be accommodated in the design for site 1. The invert of the intake will be approximately 0.45 ft above the thalweg of the main channel. Additionally, a sediment trap basin will be constructed beyond the culvert outlet. This trap will slow velocities in the channel and cause much of the sediment to drop out at a single location that is easier to maintain rather than spread the sediment throughout the secondary channel length. The first 12 ft of the channel will have a narrower and deeper section to keep shear stresses higher and facilitate moving any sediment that enters the channel through the culvert and then into the trap. The lower 2 ft of the channel section will be lined with large boulders to allow a near vertical slope in the lower channel section.

Despite the previously described sediment deposition reduction measures, the flow into the secondary channel may still be blocked by deposition that occurs in the main channel between the main channel thalweg and the secondary channel entrance. To avoid this, a channel will be excavated from the secondary channel entrance to the main channel thalweg, and the upstream edge of this excavation will be lined with large boulders to form a stone sill. The boulders will be set at an elevation that has the top of the boulder at 0.2 to 0.3 ft above the riverbed as shown in figures 2-4 and 2-5. The boulders slight projection above the riverbed should cause turbulence that will keep sediment scoured out from the entrance to the secondary channel. It is not practical to design a sill structure that would remain undamaged during a large flood event on the main channel. Consequently, the boulder sizes are arbitrarily set at approximately 3 ft diameter, and maintenance will be required to reestablish these boulders if they are moved out of position during a large flood event.

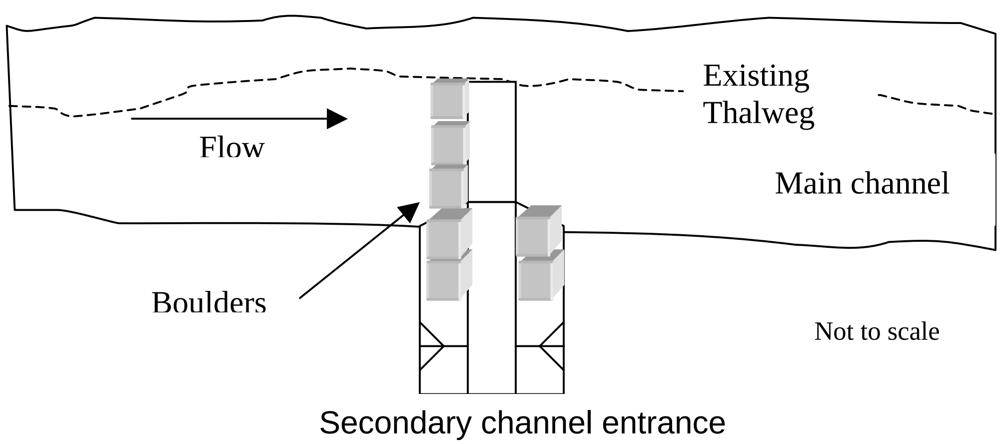

Figure 2-4 - Plan of secondary channel connection to main channel

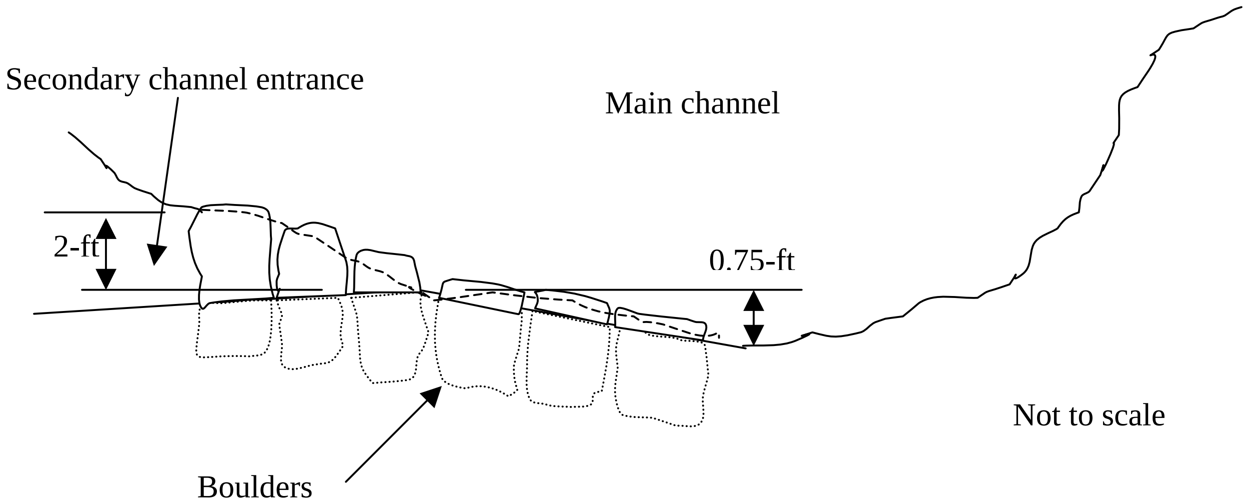

Figure 2-5 - Typical section of secondary channel connection to main channel

Velocities in the secondary channel range from a maximum of 3.65 ft/sec in the riffle/run reaches to 0.28 ft/sec at pool locations. Corresponding shear is .001 and 0.62 lbs/sf respectively for the 1.5-yr discharge. This range of velocities and shear stresses is less than allowable values indicated for vegetated banks (Fischenich, 2001). Velocities are 1.12 to 5.69 ft/sec and shear ranges from 0.02 to 1.06 lbs/sf for the 10-yr event (10 percent exceedance) and are less than allowable values indicated for vegetated banks.

2.2.3.5 Riparian Design. Riparian planting for site 1 consists of two types of plantings. A 35-ft corridor will be planted along both sides of the channels and a meadow/pasture area will be planted with "low-height" shrubs and grasses. The remainder of the area, not to be planted, will be allowed to re-establish riparian vegetation on its own by controlling grazing (fence property). The riparian corridor plantings adjacent to the channels will consist of the plants listed in Table 2-1 used by the U.S. Forest Service on their stream restoration projects in the Salmon River basin. The Forest Service experience with these plants indicates that they have a high survival rate and establish robust riparian communities.

Trees	Shrubs and Forbs
Alder (Alnus (incana, a.tenuifolla)	Willow (Salix, babbiana, boothll, exiqua, and geyeriana)
Birch (Betula, occidentalis)	Sedge (Carex, aquatilis and nebraskensis)
Cottonwood (Populus, trichocarpa)	
Dogwood (Cornus stolonifera)	

Table 2-1 - Plants for riparian planting

The trees will be planted as shoots with root mass that measures approximately 1.5 x 8-in except for the willows that will be planted from cuttings harvested from nearby areas. The trees will be planted at approximate densities of one per square yard over the corridor to be planted with the genus and species varying depending upon elevation above the water table. Willow live stakes will be harvested from the local area and planted in a line along the bank at a spacing of one per foot. Sedge will be planted as shoots with root mass that measures 1 x 4.75 inches. Sedge will be planted in groups with locations selected in-the field. Generally, 200 plants would be planted over a 1000-ft-length bank. All plants will be watered for 1 yr following planting and any plants that die, will be replanted during that first year. Weed control will also be performed during the first year.

The meadow/pasture area will be planted with trees as previously described, but because of owner restrictions on shrubs and grasses, the plants listed in Table 2-2 will be planted to provide a low-height understory.

Shrub	Grass
Fourwing saltbrush (atriplex canescens)	Sheep fescue (festuca ovina)
Winterfat (ceratoides lanata)	Durar hard fescue (festuca ovina duriuscula)
	Idaho fescue (festuca idahoensis)
	Smooth brome (bromus inermis)

Table 2-2 - Restricted height riparian planting

2.2.3.6 Fish Barrier. At two locations, the existing irrigation canals empty excess water into the proposed channel. If fish access the irrigation canals from the project channels, stranding could occur when the irrigation is shut off. Fish barrier structures will be installed to prevent fish access to the irrigation canals. A structure similar to figure 2-6 is proposed for the project based upon discussions with the NMFS's engineer.

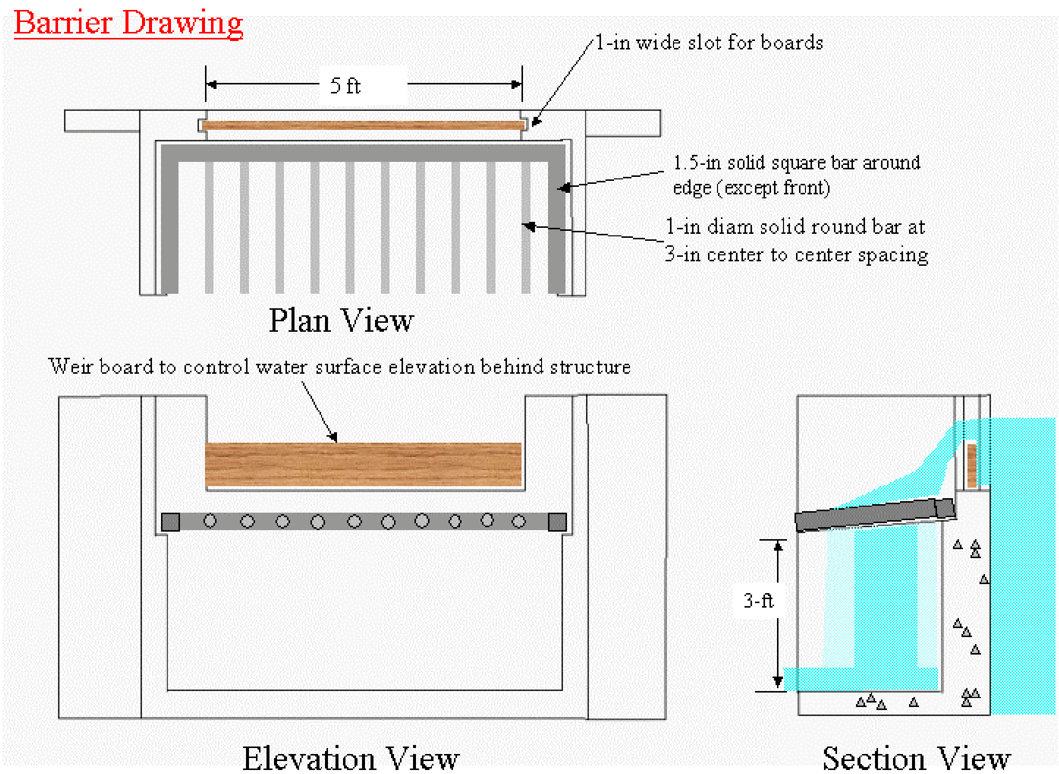

Figure 2-6 - Fish barrier

2.2.3.7 Precast 3-Sided Bridge. Presently, the flows in the existing channels are seasonal and can be controlled by the irrigation control gates. Following construction of the project, perennial flows will begin that prevent access to the east side of the property. The landowner requires some provision for access to the east side. The proposed design consists of a precast three-sided bridge as shown in figure 2-7. The bridge span is 8 ft long and width is 8 ft. The deck elevation is above the 1.5-yr event (67 percent exceedance).

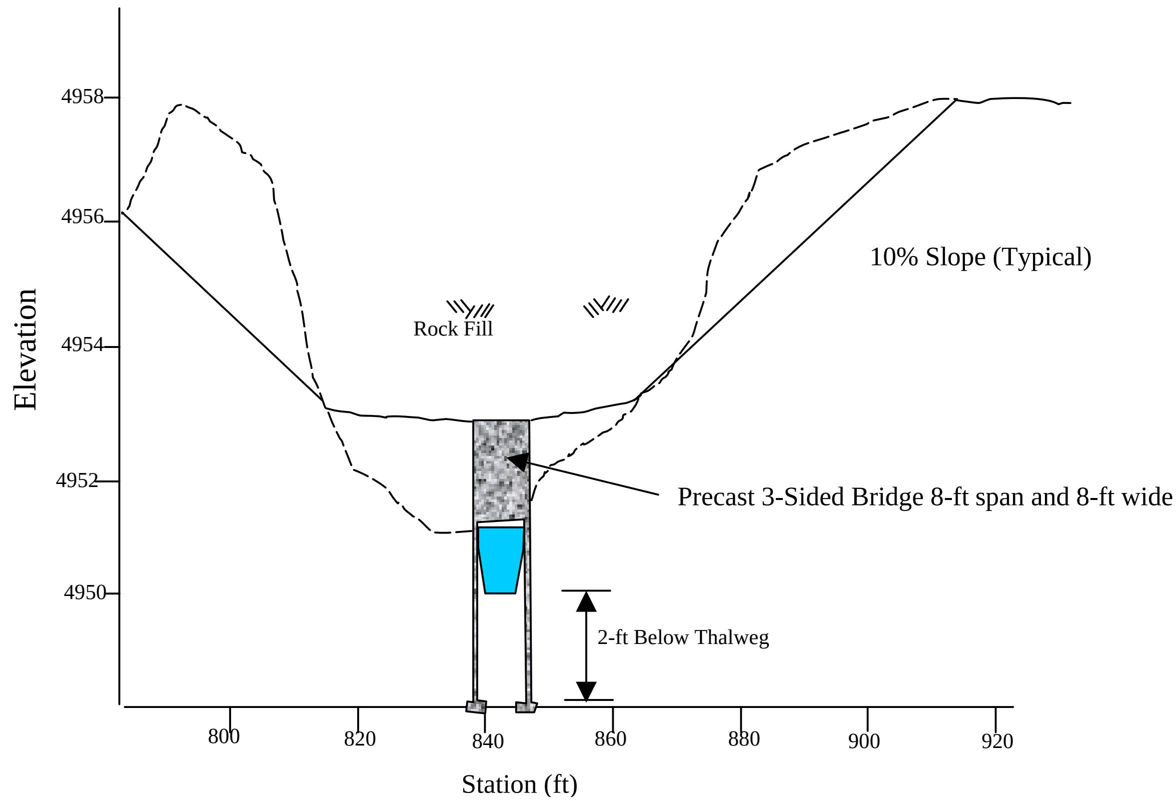

Figure 2-7. Cross section at bridge

2.3 Site 2 One Mile Island

2.3.1 General Description of Current Conditions. Site 2 is located on One-Mile Island and extends across the Salmon River main channel to include land on the west side of the Salmon River.

The portion of site 2 on the west side of the Salmon River includes the headwaters of the Hannah Slough. The Hannah Slough is considered by the Idaho Sate Fish and Game to be a critical rearing and spawning area for Steelhead. Snorkeling counts of Chinook juveniles range from 30 to 85 per 100 m^2 of channel in the lower end of Hannah Slough. There is little riparian vegetation left adjacent to Hannah Slough, for the portion of the slough within site 2, due to grazing.

The west side of the island has two locations where the main channel bank has been protected by barbs. These are between 400 and 600 ft in length. There are several locations of bank erosion on both the east and west banks of the island. The bank erosion results from a variety of factors. Grazing has removed much of the riparian vegetation from the island, and along with trampling, resulted in conditions that make banks more prone to erosion. Other factors include barb construction on the west bank of the Salmon River that results in flow impingement on the island. In some cases, the erosion occurs in the areas protected by existing barbs where the impinging flow has eroded the bank at locations between the barbs. Also, the east channel is readjusting to recent changes in discharge due to enlarging of the entrance to that channel.

2.3.2 Objectives. Objectives for this site include the following:

- Establish the riparian area around the Hannah Slough
- Re-establish the riparian area on One Mile Island
- Revegetate eroded, unstable banks

2.3.3 Proposed Design for Achieving Objectives. The re-establishment of the riparian vegetation on One Mile Island will be accomplished by fencing the flood plain and allowing the vegetation to naturally re-establish over time.

The eroded banks along the east bank of the Salmon River will be stabilized by willow layering. The eroded banks are located between existing barbs that provide some degree of protection from direct impingement by the river. The willow layers will consist of rows of willows having approximately 6 cuttings per foot. Rows will be spaced at approximately 1-ft intervals.

The eroded banks along the east channel area subject to direct impingement of flow. Logs placed at the toe, similar to an existing log structure shown in figure 2-8, will protect the bank from the high shear stresses at the toe. The existing log structure is located on the Salmon River near Challis and has functioned successfully for approximately 5 yrs. Each log will be anchored in place with boulders having a minimum diameter of 4 ft placed at 10-ft intervals along the length of the log. The slope above the log will be stabilized with willow layering as previously described.

Figure 2-8 - Existing log toe protection structure

The re-establishment of a riparian corridor immediately adjacent to Hannah Slough is a high priority and planting a 75-ft-wide zone on either side of the slough will be included in the project. The remainder of the area on the west side of the Salmon River will be allowed to re-establish riparian vegetation on its own by controlling grazing (fence property). The riparian plantings will consist of the plants listed in Table 2-1 used by the U.S. Forest Service on their stream restoration projects in the Salmon River basin. The planting will be as described in Paragraph 2.2.6.

2.4 Site 3 Hot Springs

2.4.1 General Description of Current Conditions. Site 3 is located approximately 4-1/2 miles downstream of the State Highway 93 Alternate bridge. The site is approximately 5,000 ft long by 1,500 ft wide. Much of the site has a uniform surface that is dissected by the Challis Hotspring Creek and its tributaries and, in the northwest portion of the site, also by several relic channels and high flow channels (channels that have formed in the area off of the main channel that carries flow only during flood conditions). Springs may be observed in relic channels depending upon the time of year and the point along the length of the channel. Site 3 has approximately 600 ft of levee and 2600 ft of riprap bank protection (riprap quantity overlaps with the levee quantity) and several high flow channels are cut-off by these structures. The southern portion of the site is grazed and/or planted and harvested for hay. The northern portion of the site is developed for recreation and includes camping, swimming pool, golf driving range, *etc.* The landowner will not agree to easements for property that results in removal of the existing levees and riprap to allow reconnection of most of these existing channels.

Most of the opportunities for restoration center around the Challis Hotsprings Creek that originates at the south boundary of the site as two separate spring tributaries. The Challis Hotsprings Creek enters the Salmon River main channel at the north boundary of the site. The Challis Hotsprings Creek is approximately 7000 ft in length and has a sandy substrate for most of its length. There is little or no shrub or tree development along the length of the spring due to current land use. The profile has few pools or riffles. The few deep pools that exist form behind structures, such as culverts, that impede the channel flow. Moss growing on the channel bed provides most of the cover within the channel. Geothermal flows join the spring at approximately 600 ft upstream of the point where the spring enters the Salmon River. At the approximate midpoint of the Challis Hotsprings Creek, a check dam creates an approximately 3-ft-high water fall. Fish passage is difficult beyond that point (see figure 2-9).

Figure 2-9 - Check dam Site 3 spring

Above the check dam is a pond (reservoir) (see figure 2-9) that was originally built in 1929 for hydropower and water storage. Over time, this pond filled in with sediment. In 1977 this pond was dredged and substantial quantities of sediment were removed. After the 1977 dredging, this sediment pond was 12 ft deep and approximately 104,000 square feet in area. Presently, the pond is filled to within 1 ft of the top indicating that approximately 42,000 cy of sediment have accumulated over a 15-yr period. The origin of the sediment is uncertain. The property owner indicates that an irrigation canal that flows into the Challis Hotsprings Creek approximately 400 ft upstream of the pond is the source of the sediment. The irrigation company denies that their canal discharges significant sediment to that property. The irrigation company has a small (approximately 15 ft by 20 ft) sediment trap upstream of the property that traps some sediment and the irrigation company removes accumulated sediment periodically. The irrigation company claims that the sediment is generated during flood events where sediment-laden run-off from the nearby gullies are intercepted by the canal and the flood sediment is transported to the sediment pond via the canal. Corps of Engineers personnel observed the irrigation canal prior to the start of the irrigation season and noted sand bars and bed formations indicating transport of sand sized material. An adjacent landowner stated that the irrigation flows are turbid when the Salmon River is at flood stage. Turbid river flows feed into the irrigation canal and this turbidity is carried throughout the canal system. This property owner states that the turbid flows persist for approximately one month. The quantity and source of transported material is difficult to judge with out significantly more effort and analysis. But, laboratory analysis of irrigation water samples collected by Idaho Department of Health and Welfare, Division of Environment near the end of the irrigation canal indicate that turbidity was measured as 4.0 NTU's (date of collection not known but appears to be during late summer) in 1977. Water quality samples collected by USACE near the end of the canal measured turbidity levels of 6.3 NTU's (by EPA 180.1), nitrite was not detected (by EPA 300.0), total phosphorus was not detected (by EPA 365.3), and total suspended solids were 10 mg/L (by EPA 160.2). The samples by USACE were collected on August 2, 2002 shortly after the irrigation flows were re-started following a 1-day shut down of the canal (would have slightly elevated turbidity relative to normal service). Based on the volume of sediment contained in the existing pond, the anecdotal history of the canal turbidity, and the laboratory data, it is assumed that the canal water is generally of good quality except for periods where significant sediment is transported and turbidity levels are relatively high.

Figure 2-10 - Existing pond

At approximately 4000 ft from the mouth, the spring splits into two tributaries. From this point to the upstream end of the tributaries, the water depth is generally less than 1 ft deep and in a few cases is only a couple of inches deep.

The Idaho Fish and Game counted 528 juvenile chinook salmon and 247 juvenile steelhead and trout in the late spring of July 2002 in the Challis Hotspring Creek. These counts are only for the portion of the channel downstream of the check dam. The landowner has reported seeing thousands of small fish in the upper part of the spring (above the check dam). But, within a short time after hatching, nearly all the juveniles are gone because of intense heron fishing. The spring, especially the upper portion, generally lacks crevices, woody debris, under-cut banks, *etc.,* that provide cover from predators.

Flows for the Challis Hotsprings Creek, below the confluence of the tributaries, are assumed to be relatively constant and were measured to be 6.7 cf/sec on March 17, 2000. Temperature of the spring water is approximately 54 ^oF throughout the summer. During the irrigation season, some relatively small quantity of irrigation return water enters the east tributary near the upstream end. This flow appears to be less than one cfs. The irrigation canal for the ranches in this area ends at site 3. Unused water from the irrigation canal combines with the spring water a short distance upstream of the pond. The temperature of the irrigation water varies and has a daily average temperature of 62^oF and 20 minute average spikes up to 77^oF during the summer. Water temperatures below the pond suffer from the combined effects of the higher temperature irrigation waters plus the solar gain from the large, shallow area of the pond. Figure 1-11 shows 20-minute average temperatures below the pond with spikes in temperature to 68^oF. Daily average water temperatures immediately below the pond are around 59^oF during the summer. The irrigation season begins April 1 and runs until mid-October or early November. The excess irrigation flows that may enter the Challis Hotsprings Creek from the canal can vary over a wide range and is summarized below based on observations of the irrigation canal chairman:

- 20 cfs (1000 miners inches (an irrigation unit of measure used in Idaho where 50 miners inches = 1 cfs)) for short duration peak flow associated with the interception of storm run-off and occurs once in 5 yrs
- 16 cfs (800 miners inches) for a duration of one day occurs once every 5 yrs
- 10 cfs (500 miners inches) for a duration of one day occurs twice each month of operation
- 4 cfs (200 miners inches) for a duration of two days occurs ten times each month of operation
- no flow for 5 days out of each month
- 1 cfs (50 miners inches) is assumed for remaining days
- Average flow assumed to be 2.4 cfs (119 miners inches)

It should be noted that these flows are very uncertain and wide variation from these values is possible.

A geothermal spring flows into the Challis Hotsprings Creek at approximately 600 ft above the confluence with the Salmon River. The geothermal spring has constant flows of approximately 2.7 cfs throughout the year with a temperature of 100 degrees Fahrenheit (^oF). Daily average water temperatures below the confluence with the geothermal spring are 67^oF during the summer. Fish seeking thermal refuge from the main channel may be discouraged from entering the cooler water of the upper spring because of the thermal barrier formed by the geothermal flows.

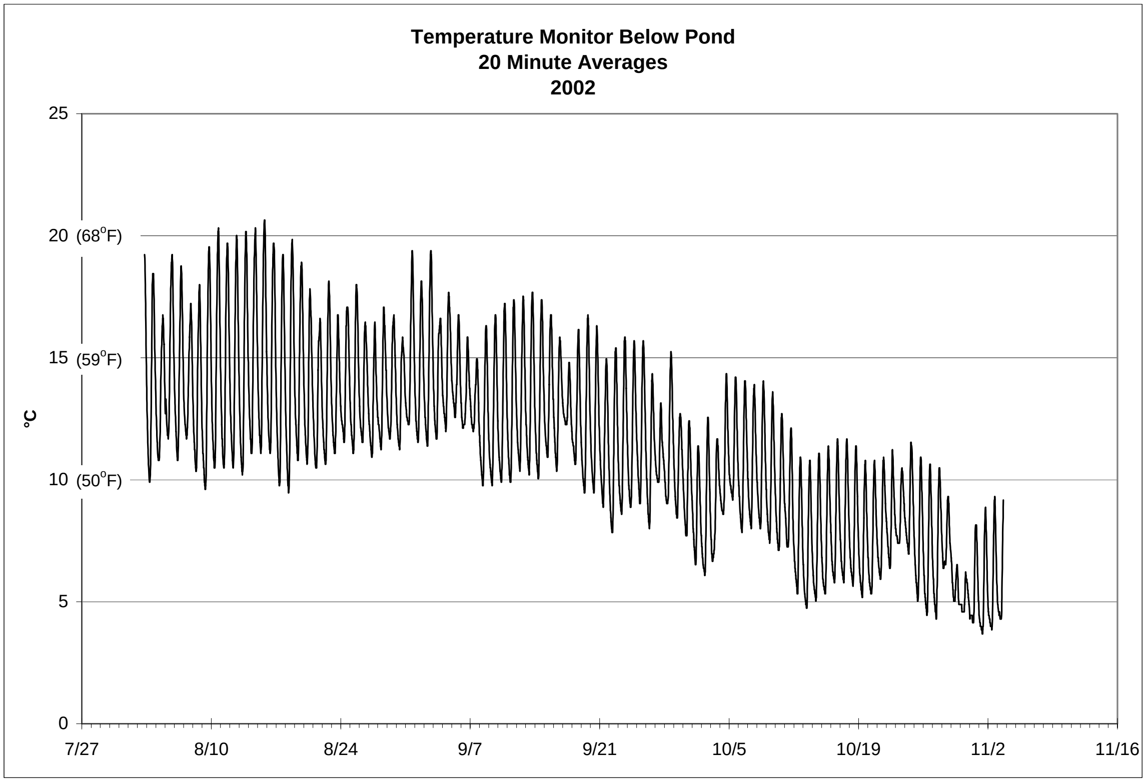

Figure 2-11 - Temperatures below pond (20 minute average)

An existing irrigation pump (approximately 1.5 hp pump) is located adjacent to the property owner's residence and withdraws water from the spring. The intake for this pump does not have a screen that meets NMFS' requirements.

2.4.2 Objectives. Objectives for this site are:

- Restore the Challis Hotspring Creek and provide conditions favorable for rearing:
  - Block passage up irrigation ditches
  - Provide NMFS compliant screen for irrigation pump
  - Remove fish passage barriers
  - Provide cover for juveniles for evasion of predators
  - Provide better water quality (including temperature)
  - Avoid discharging poor quality irrigation water to the Salmon River main channel
  - Provide refugia from main channel (low temperature water during summer and slow water velocities during annual peak event)
  - Provide a more diverse aquatic habitat such as pools, complex cover, and riffles
- Provide a robust and sustainable riparian area:
  - Ensure protection of corridor adjacent to spring
  - Promote upland riparian development to the degree possible

    - Re-configure the existing pond to provide a more diverse and productive system
- Accommodate the following constraints:
    - Property owner requires several pools with depths of 6 ft on the portion of reconstructed channel within the area of the existing pond
    - Property owner will not allow work downstream of the pond location
    - Access to the south half of the site is limited to one access road entrance location and can not utilize the existing access road that runs past the Stark home
    - Property owner has exiting structures within the ecosystem corridor that he requires to continue in-place and will require ability to do maintenance on these structures
    - Property owner will allow a 3-ft-diameter gate to divert excess irrigation flows into the channel. The diversion of irrigation flows into the channel will only be allowed when the irrigation water quality is good
    - Property owner will not allow alteration of the geothermal spring to avoid the potential of a thermal barrier near the mouth of Challis Hotsprings Creek

2.4.3 Proposed Design for Achieving Objectives

2.4.3.1 Develop upstream portion of Challis Hotsprings Creek. This section describes the proposed restoration work for the upper 4,000 ft of the Challis Hotsprings Creek and includes the east and west tributaries and extends to a point approximately 360 ft downstream of the confluence of the two tributaries to the start of the new channel construction (described further in section 2.4.3.2). Restoration within this reach includes a variety of actions intended to improve the habitat, improve fish passage, and block passage to irrigation ditches.

There are 2 existing culverts within this 4,000-ft reach. Both culverts present passage problems, such as submergence of the inlet. The existing culverts will be replaced with 60-in by 46-in pipe arches. All new pipe arches will be less than 20 ft long and installed per the following NMFS culvert criteria:

- Invert of the culvert will be 20 percent of the diameter (use 1 ft) below the bed of the channel
- Culvert will be installed level (on slope from entrance to exit)

An approximately 100-ft-long reach having a depth of only a couple of inches will be deepened to a minimum depth of 8-inches to provide fish passage.

At five locations, gravel fill will be placed across the channel so that the water pools to a depth of 3 ft upstream of the fill. On the downstream side, the fill will be sloped on a 1 vertical on 20 horizontal slope to form a riffle. The material placed into the fill will consist of gravel materials having between 10 and 20 percent passing the No. 200 sieve for the portion of the fill between the subgrade and a point 6-in below the surface of the fill. A 6-inch thick layer of gravel having a maximum size of 3 inches and having less than 10 percent passing the No. 200 sieve will be used on the fill surface. This feature is intended to provide an upstream pool that is sufficiently deep to protect the juvenile fish from heron predation. Also, the pools and riffles created by these features will provide more diversity.

At 6 locations, a bed of cobbles will be constructed to provide cover crevices for juvenile fish. The cobble beds will consist of a single layer of cobbles that span the channel width and are approximately 20 ft long. A 6-inch thick layer of gravel will be placed below the cobbles to prevent fine substrate material from migrating into the voids. The cobbles will be uniform in size and range from 6-in to 8-in in diameter.

An approximately 200-ft-long reach of the channel has near vertical banks. Within this reach, the banks will be excavated to form a 10-ft-wide bench that is approximately 6-in to 1 ft above the water surface. The slope will be excavated one vertical on 1.5 horizontal from the bench to the existing ground line. This feature is intended to provide a planting area that is well connected to the groundwater and stable slope that will not be an erosion problem in the future.

Fish passage into the existing irrigation ditch that enters this reach will be blocked with a barrier similar to figure 2-6.

The intended use for this technique is Water gaps are breaks in the fencing where cattle are allowed access to the stream for drinking water. Hardened fords are required in four locations to protect and establish riparian areas by excluding cattle from grazing where access to, or across, the stream is required by cattle and/or landowners.

Stream crossings and stock watering locations are constructed similar to figure 2-12 below. The streambed and adjacent bank area are excavated and layers of gravel fill and rock fill placed to provide a stable surface that will not rut, erode or be a source of turbidity when used. The rock fill layer consists of angular rocks, which interlock and provide a strong stable surface. Any voids and unevenness in the surface of the rock, which pose a hazard for cattle walking on the rock fill, are filled with gravel and the surface is compacted and finished to provide a uniform surface for cattle, as well as driving vehicles.

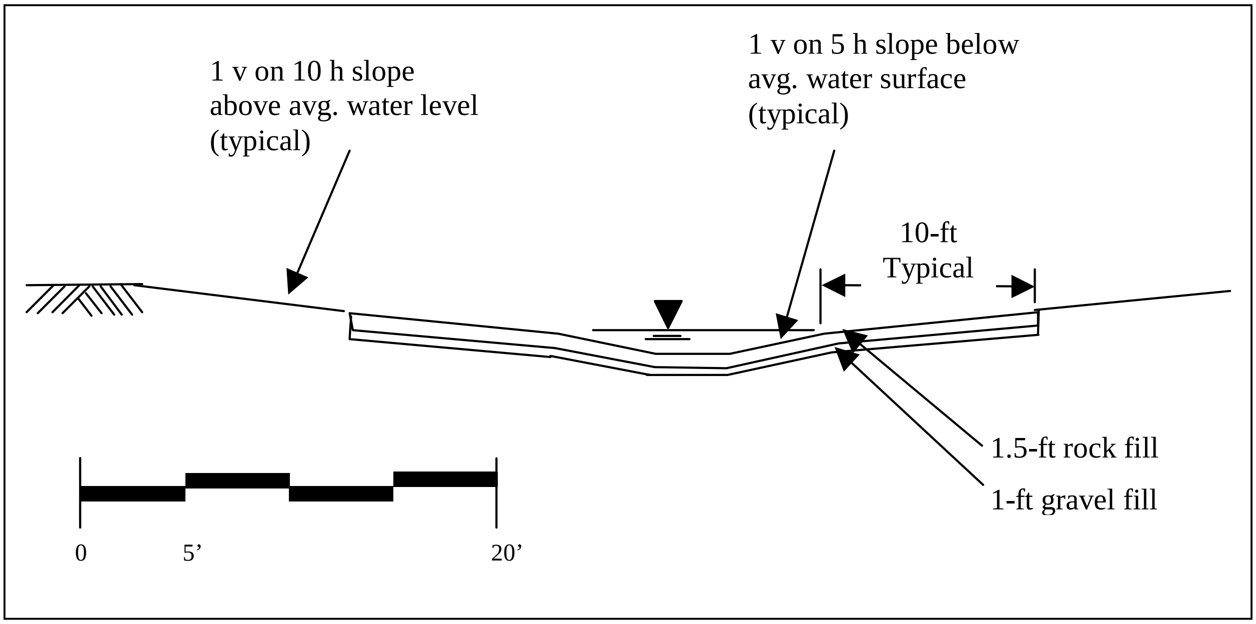

Figure 2-12 Hardened Ford and water gap typical section

Fencing is used in locations to exclude cattle from grazing in sensitive riparian areas. Breaks in the fencing are provided, together with hardened fords, to allow limited access to streams for water and crossing.

2.4.3.2 Abandon existing pond and create new channel. Beginning at approximately 360 ft downstream of the tributary confluence of the Challis Hotsprings Creek, a new channel of approximately 1,100 ft will be constructed. The construction of the new channel will include the removal of the existing culvert and road crossing located approximately 700 ft downstream of the tributary confluence and the removal of an existing check dam located approximately 1,800 ft downstream of the confluence. A uniformly sloped channel having a gradient of 0.0037 ft/ft is proposed. The alignment for the new channel is based upon approximate configuration prior to construction of the pond as remembered by the landowner. A regime basis for the alignment was not used because of the constant spring flow throughout the seasons and the uncertainty about the quantity of irrigation flow that may be periodically added. A relatively narrow channel (bottom width of 4 ft) was modeled using the spring discharge of 6.7 cfs to establish an approximate water surface for designing the bank height. It is anticipated that the wetlands water quality treatment facility (described in 2.4.3.4) will result in a higher groundwater table during the irrigation season and increases to the spring flows. The proposed bank height for the new channel at approximately 6-in to 12-in above the water surface computed for a flow of 6.7 cfs to contain the increased spring flow that may result from operation of the wetlands. A bank that is approximately 6-in higher than the water surface for a flow of 6.7 cfs will contain a flow of approximately 22 cfs. This range of bank height is believed to provide a riparian planting zone that is well connected to the groundwater table. In addition to increases to spring flows that result from the wetlands, irrigation flows may be diverted to this channel. Presently, excess irrigation water enters the spring at a point approximately 800 ft downstream of the tributary confluence. The wetlands design described in 2.4.3.4 includes a new canal to convey the irrigation flow to a new wetlands water quality treatment feature and would cross the existing channel in a flume supported on a constructed embankment. The proposed design also provides a gated diversion structure that allows a portion of the flow to the wetlands to be diverted into the new channel to augment the spring flows. If the irrigation flows that are diverted to the spring are large enough, the adjacent flood plain may become inundated. And, the addition of irrigation water of good quality could result in a more complex channel and a more diverse habitat. The amount, duration, and timing of the discharge will depend upon considerations of irrigation water quality, condition of the channel, condition of the riparian zone, life stage and habitat needs of the fish population, and other parameters. It is assumed that an adaptive management approach will be employed to divert irrigation flows into the channel and that the diversions will be adjusted over time to maximize the amount and quality of habitat and provide acceptable water temperatures.

The proposed profile for the new channel reach includes a series of deep (6 ft) pools. The pools will not form naturally in this channel for the range of flows anticipated. Pools will be constructed to provide habitat diversity and because of landowner requirements that are discussed further in 2.4.4 Constrains on Design. Boulders will be stacked to form one wall of each pool (located on the outside of the bend). The boulder wall will allow a steeper slope and a narrower channel. The narrower channel avoids the additional solar input that a wide, pool would have. Also, the boulders provide crevices for juvenile fish cover. Logs and rootwads will be incorporated into the pool depending upon the availability of those materials from salvage of adjacent areas.

The project does not change the existing channel or its water surface profile for the portion of the channel downstream of the new channel construction. The profile of the channel is shown in figure 2-13 from a location approximately 360 ft downstream of the tributary confluence to the mouth at the Salmon River.

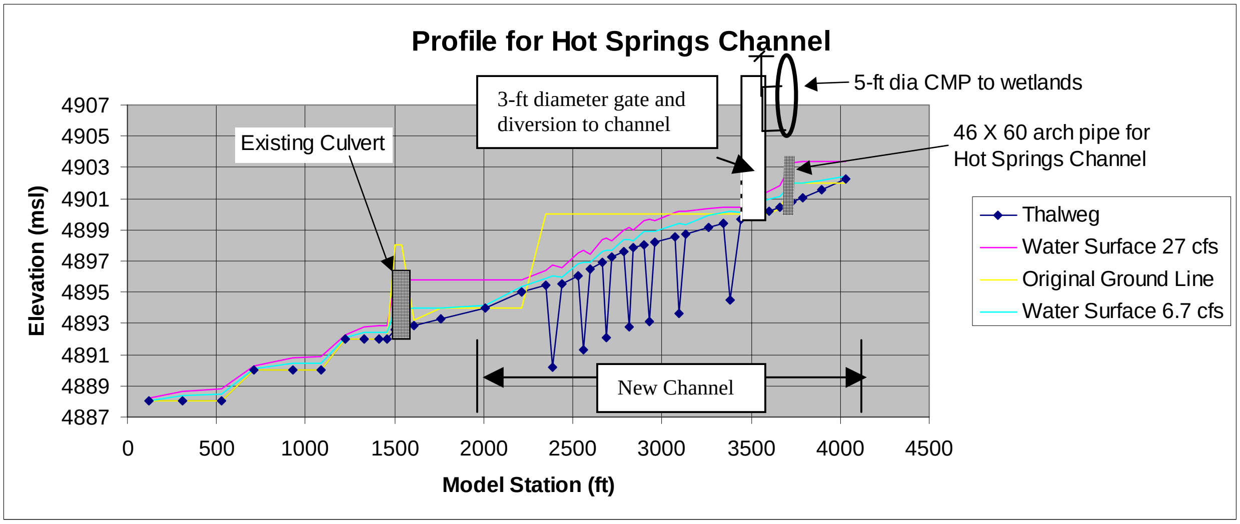

Figure 2-13 - Profile for Site 3

One new pipe arch that is approximately 40 ft long and 60 by 46 inches in size will be installed at the location of the irrigation flume crossing to provide for Challis Hotsprings Creek flow through the embankment supporting the flume. This pipe arch will be installed on a level slope and the invert placed 1 ft below the bed of the channel. Computer modeling based on the Challis Hotsprings Creek flow of 6.7 cfs (assumed to be relatively constant flow throughout the year) indicates that the depth of flow through the pipe arch at the flume crossing is approximately 0.65 ft and the velocity is approximately 2 ft/sec.

2.4.3.3 Wetlands design. As previously described in 2.4.1, the irrigation flows that currently enter the spring at approximately 800 ft downstream of the tributary confluence periodically have temperature and sediment water quality problems. The proposed project includes a flume to convey the irrigation flows over the spring and to wetlands designed for water quality treatment. The proposed design will remove the problem irrigation flows from the spring, create an environmentally beneficial wetlands, and raise the groundwater table so that the spring flows increase in nearby channels. It will also avoid discharging fine sediment to the Salmon River. The design will include a provision to discharge some of the excess irrigation flows to the spring, when the water quality of the irrigation water is acceptable. The quantity of discharge to the spring is based upon agreements with the landowner for a 3-ft-diameter gate that would allow diversion from the wetlands flume.

The wetlands and associated features are designed based upon EPA's Constructed Wetlands, Treatment of Municipal Waste Waters, EPA/625/R-99/010, September 1999. Excess irrigation flows were previously described in 2.4.1 and the maximum flow used for the wetlands design is 20 cfs multiplied by 1.875 factor of safety equals 37.5 cfs. All feeder canals and wetlands levee structures use a 2-ft freeboard height.

The irrigation ditch currently discharges to the spring at a point approximately 800 ft downstream of the confluence of the tributaries. A new canal will convey the irrigation flow over the spring channel and into a chamber designed to distribute flows uniformly over the width of the next chamber, the settling basin. The spring will flow under the irrigation canal via a 60-in by 46-in pipe arch culvert. At the spring crossing, the irrigation flows will enter a flume consisting of a 5-ft-diameter corrugated metal pipe. The flume will have a concrete headwall at the entrance. A pipe connecting to the flume will have a 36-in gate that allows flow to be diverted from the flume into a diversion structure to the spring. This gated diversion will allow the irrigation water to be managed in a flexible manner. The flume will be buried within the fill spanning the channel so that the top of the fill can serve as an access road over the channel. Levied banks are needed for much of the canal length and the levee will have a 10-ft-wide top and 1 vertical on 2 horizontal side slopes. The flume is supported on an embankment that will also serve as the access road to the project. Figure 2-14 shows the flume, embankment, and diversion to Challis Hotsprings Creek.

The flume and canal will feed the irrigation water to a flow distribution chamber that distributes the flow into the settling basin. The distribution chamber will be 395 ft wide (measured at the maximum water level), 25 ft long, and 4.73 ft deep (below the maximum water surface). Five weirs are planned for the outflow from the distribution chamber, each having a 5 ft width. The 5 weirs will have sufficient capacity to pass 37.5 cfs and still maintain a 2 ft free board. The head elevation above the weir required to pass the design maximum flow of 37.5 cfs is 0.75 ft. The weir flows were calculated using the following formula and the calculated head matches well with the water surface calculated in the HEC-RAS model:

$Q = (2/3)\ (C_1)\ b\ (2g)^{1/2}\ (H)^{3/2}$

- $C_1 = [0.6035 + 0.0813\ (H/Y) + 0.000295/Y][1+0.00361/H]^{3/2}$
- b = weir width – [(.1)(N)(H)] where N is 2 for contracted nap on both sides of nap
- g = acceleration of gravity
- H = head above weir

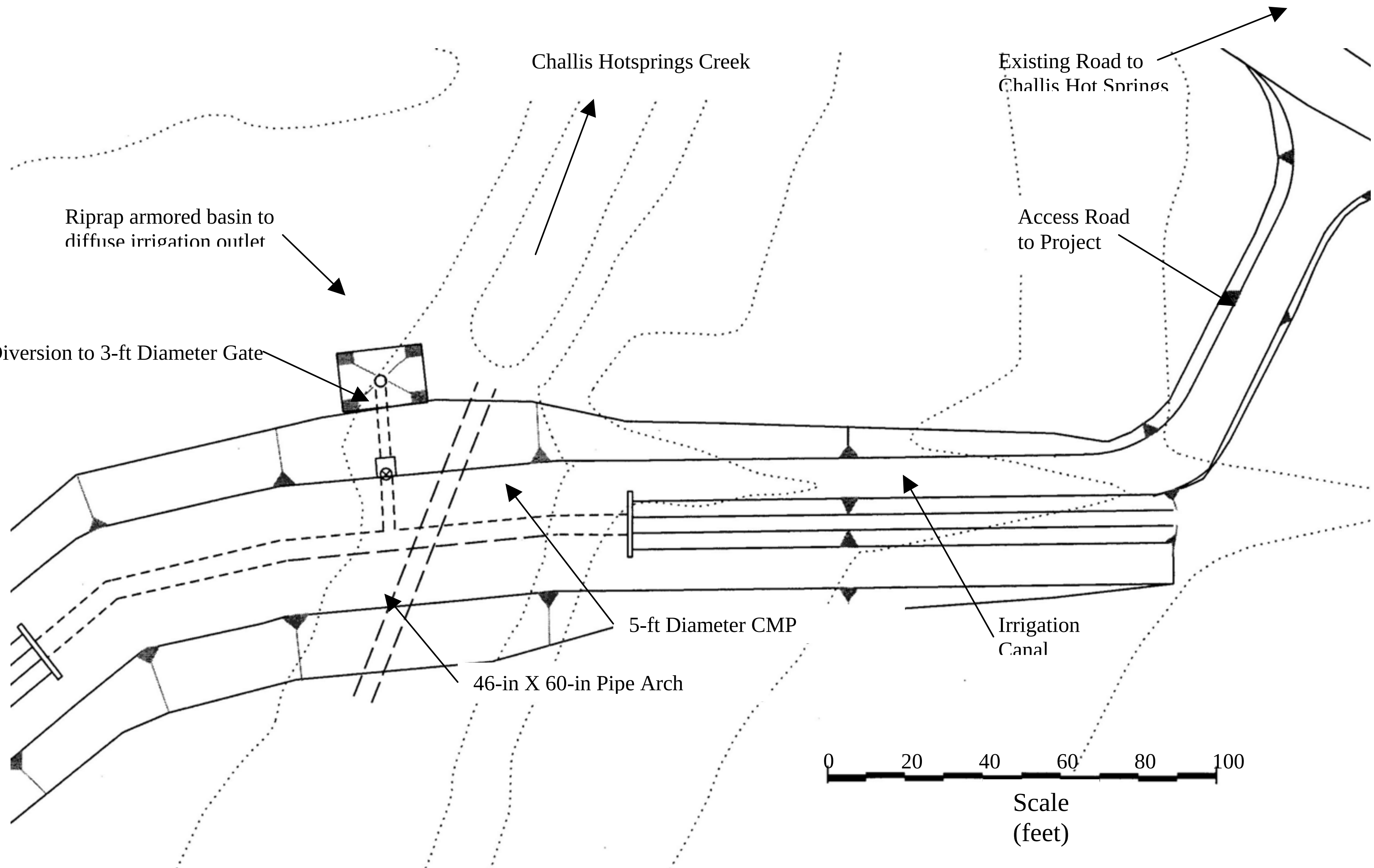

Figure 2-14 - Irrigation Flume at Challis Hotsprings Creek Crossing

The dimensions of the settling basin are based on the existing pond that appears to effectively remove large quantities of sediment. The proposed dimensions are 395 ft wide by 130 ft long. Outflow from the settling basin will be controlled by 5 weirs having sufficient capacity to pass is 37.5 cfs and maintain 2 ft of freeboard. EPA 1999 design guidance prescribes that the weirs be spaced at 10 to 15-meter intervals. The EPA guidance would require 13 weirs and would be operationally difficult to manage. Since the existing pond appears to effectively remove sediment without elaborate distribution of flow, only 5 weirs are proposed. The inlet end will be 5 ft below the maximum water surface and the outlet end would be 3 ft with the inlet being deeper to accommodate the greater rate of deposition at that location. This depth is sufficient to preclude establishment of emergent plants. The settling basin will require annual maintenance to remove accumulated sediment. Consequently, the design of the basin must include an access road. The head elevation above the weir required to pass the design maximum flow of 37.5 cfs is 0.75 ft using 5 weirs that are each 5 ft wide. The weir flows were calculated using the same formula described for the distribution chamber.

The objective for the wetland's treatment cell is to reduce cloudy (supracolloidal and colloidal) water that is discharged from the sedimentation basin. Wetlands that are constructed for treatment of municipal wastewater can reduce total suspended solids by means of particulate settling by gravity and by flocculation settling of the flocculation particles. Additionally, some removal occurs when particles adhere to the plants because of the slime film that forms on their surface. Municipal wastewaters treatment in wetlands typically shows sharp decreases in total suspended solids after one day of retention and moderate and relatively constant decrease with continued retention. The rate of decrease in suspended solids beyond the initial sharp decrease is 3.5 mg/l per day of retention (figure 4.2 EPA, 1999). This data is based on wastewater that is significantly different from the irrigation water being treated for the proposed project. The EPA data is for water having more organically rich solids with low specific gravity as compared with the inorganic particles with higher specific gravity expected for the irrigation water being treated for this project. It is expected that for the irrigation water being treated at site 3, there will be less flocculation settling and more particulate settling by gravity and adherence to the films on the plants as compared with the municipal wastewater considered in EPA, 1999. The design consists of a three-stage system with an initial stage having emergent vegetation where most of the flocculation and sedimentation will occur, an aerobic stage within an open water compartment having submerged plants, and a final stage with emergent vegetation that polishes the suspended particulates. The three stages are contained within a single compartment measuring 694 by 395 ft and the individual stages are formed by controlling the elevation of the pond bottom to form the treatment stage areas. The EPA 1999 design guidance is based upon providing approximately two days of retention for each stage (six days total). This would require an approximate area of 13 acres calculated from equation H-3.

$t=(V_w)(\epsilon)/Q$ Equation H-3 (EPA 1999, eq. 4-4)

Vw = (A)(h)
A = wetland area
h = average water depth (2.76 ft)
ϵ = wetland porosity use 0.8
Q = 2.4 cf/sec (daily average flow)

Rearranging the formula can provide the approximate required area.

Some decrease in the discharge due to evaporation and percolation will occur. The local Agricultural Extension office recommended an evaporation rate of 1/4 inch per day. This relatively minor loss is omitted from the calculation. Percolation is anticipated to be large initially and to decrease over time as fine material accumulates and seals the bed of the wetlands. No percolation loss is assumed in the calculation. The area at site 3 that is available for the wetlands is limited to approximately 274,130 sf (6.3 acres). Consequently the design will be constrained to the space available and the quality achieved will be some decrease less than the full retention time recommended by EPA, 1999. Approximate retention time for the space available and average flows is approximately 3 days. The wetland plants and depths for the three stages are shown below:

- Stage 1 – 1.97 ft to 2.95 ft Typha or Scirpus
- Stage 2 – 3.94 ft to 4.92 ft Potamogeton, Elodea
- Stage 3 – 1.97 ft to 2.95 ft Typha or Scirpus

The wetlands treatment cell will have a 2-ft freeboard above the maximum water surface at the 37.5 cfs flow event. Vegetative mat buildup occurs at a rate of three to five inches over a 15-yr period. Removal of the accumulated mat will be required at intervals of approximately 10 yrs to avoid loss of free board. Out flow from the wetlands cell will consist of 5 weirs 5 ft wide and having sufficient capacity to pass 37.5 cfs and still maintain a 2-ft freeboard. Depth near the inlet end for the stage 1 basin will be deeper than the outlet end to accommodate the greater rate of deposition at that location. The head elevation above the weir required to pass the design maximum flow of 37.5 cfs is 0.75 ft using 5 weirs that are each 5-ft wide. The weir equation used is the same shown for the settling basin design. The weirs located at the wetlands treatment cell discharge shall be equipped with fish barriers similar to figure 2-6.

The outflow from the wetlands treatment cell will be collected in a chamber 395 ft wide and 15 ft long. The collection chamber will have a check dam at either end so that discharges can be routed north towards existing channels and ditches in that vicinity, or south to discharge in the Salmon River. The discharge to the Salmon River will be continuously sloped to avoid stranding fish when the irrigation flows are interrupted. The collection chamber and canal will have 2 ft of freeboard above the maximum water surface. The outlet canal is approximately 800 ft long when it connects to the secondary channel and has a slope of approximately 0.003 ft. When the irrigation flows are shut off, the constant slope of the canal should facilitate migration of any fish out of the canal. Additionally, the wetlands can be managed so that stranding fish in the outlet canal is avoided. The diversion of flows to the spring can be managed in a way that slowly reduces flows to the wetlands so that an abrupt shut of irrigation water is avoided. Also, as the water level in the outlet canal drops, surveys will be conducted to identify any pools where fish could potently be stranded.

The proposed profile for the flume, canal to the wetlands, wetlands, and outlet canal is shown on figure 2-15.

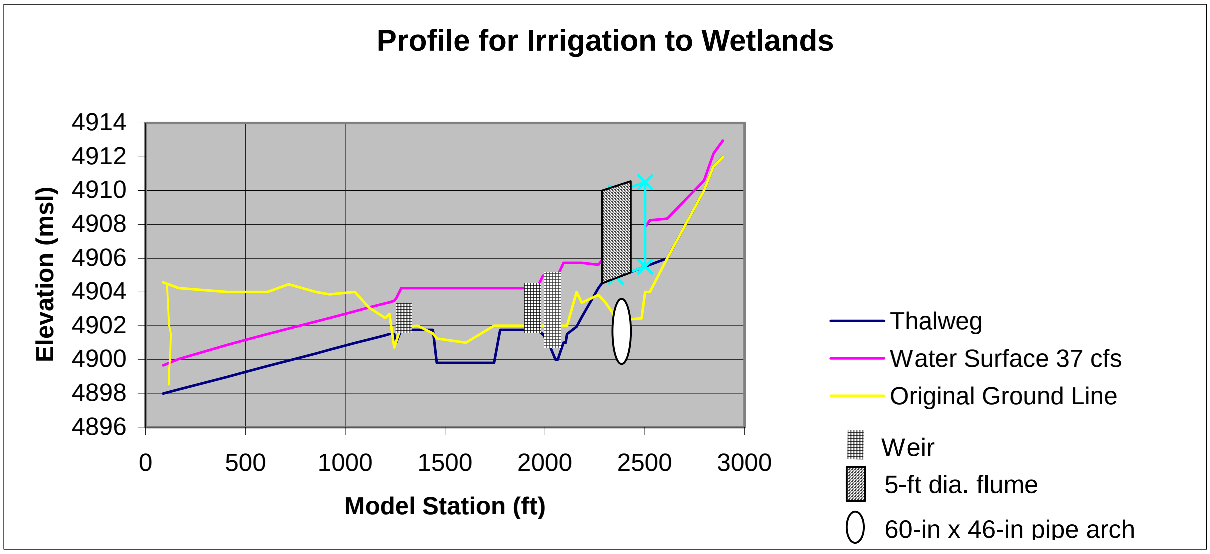

Figure 2-15 - Profile for canal and wetlands

The wetlands will raise the groundwater table and cause an increase in spring flows in the nearby channels. Piping and loss of fines along high permeability channels in the foundation is a potential concern. The project construction includes a follow-on phase of inspection and follow-up construction that would occur after initial construction is completed and the wetland is filled with water. An inspection of nearby existing channels will be conducted to identify any new springs and locations of potential piping. These locations will be treated with a filter blanket that will prevent piping.

Figure 2-16 shows a typical levee section for the distribution chamber, sediment basin, and wetlands treatment cell. The levee interior slope will be 1 vertical on 2 horizontal slope. The outer slope will be 1 vertical on 3 horizontal. The slope and levee width may be adjusted to dispose of excess material from required excavation if needed. Generally, the ground line on the south side of the wetlands is higher than the water surface within the wetlands, and the ground line on the north is lower than the water surface. At locations where the water surface within the wetlands is expected to be higher than the existing groundling, the toe of the outer slope will have a filter section constructed into the toe to avoid piping. This filter toe will extend through any foundation layers of fine-grained materials to underlying gravels. The levee construction will include stripping the topsoil and any low strength zones (such as low density fine-grained materials) from the ground surface below the levee footprint to provide a sound foundation for the levee.

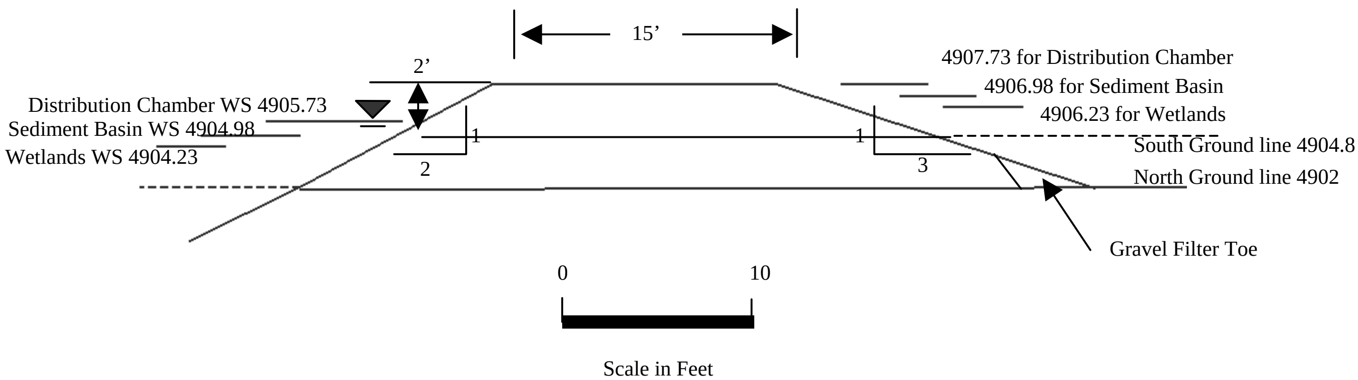

Figure 2-16 - Typical section wetlands levee

2.4.3.4 Stable channel design issues. The existing portion of the channel is stable with no indications of bed or bank erosion except a 250-ft-long reach having high, steep (2 vertical on 1 horizontal) banks. These banks will be re-sloped to provide a bench for riparian planting and have a 1 vertical on 2 horizontal slope from the back of the bench to the top of the bank.

The velocities within the new constructed channel range from 1.15 to 3.37 fps and average shear stress ranges from 0.05 to 0.68 lbs/sf for the 6.7 fps discharge. Adjusting the shear for the outside of bends using Equation H-4 results in a maximum shear stress of 1.34 lbs/sf. This is within the limit for natural vegetation, and ranges from shear resistance values of 0.1 to 2.5 lbs/sf.

$$\tau_{max} = 2.65\,\tau_{avg}\,(r/W)^{-0.5}\,. \qquad \text{Equation H-4 (Fischenich, 2001).}$$

τ_{avg} = average shear for main channel in lbs/sf
r = radius of curvature of a bend (39 ft for site 3 sharpest bend)
W = channel width (10 ft for main channel)

The velocities within the canal feeding the wetlands range from 2.6 to 6.9 fps and armoring the canal slopes with riprap will be required. The riprap design is based upon Equation H-5.

$$D_{30} = S_f C_S C_V C_T d \left[\left(\frac{\gamma_w}{\gamma_s - \gamma_w} \right)^{\frac{1}{2}} \frac{V_{SS}}{\sqrt{K_1 g d}} \right]^{2.5}$$ Equation H-5 (USACE, EM1110-2-1601)

D_{30} = riprap size of which 30 percent is finer by weight
S_f = safety factor (1.1)
C_S = stability coefficient for incipient failure (0.375 for angular rock)
C_v = vertical velocity distribution coefficient (1 for straight channels since velocity is much lower in curved portion of channel)
C_T = thickness coefficient (for D_{85}/D_{15} = 2.1 and N = 1) is 1
d = local depth of flow (1.74 ft)
γ_W = unit weight of water (62.4 lbs/cf)
γ_S = unit weight of rock (165 lbs/cf)
V_{SS} = local depth-averaged velocity (6.9 max average velocity within reach an V_{SS}/V_{avg} value of 1 is used for a V_{SS} of 6.9 fps)
g = 32.2 ft/sec^2
$K_1 = \{1-(\sin^2\theta / \text{sine}^2\varphi)\}^{0.5}$
θ = bank angle with the horizontal (33.7 degrees)
φ = angle of repose of the riprap (1 v on 1 h)

The calculated riprap D_{30} is 0.57 ft. Riprap layer thickness is calculated to be 1.1 ft (based on $1.5D_{50}$ x N). The riprap will cover the canal bed. This riprap blanket would extend from the beginning of the wetlands canal and continue for 700 ft (except as interrupted for the flume).

2.4.3.5 Riparian Design. The riparian planting locations are shown on plates 10 and 11 of the Detailed Project Report for the Stark and the Hammond property. The width of the planted area is 75 ft and begins at the top of the channel bank for the Challis Hotsprings Creek. The planning width is greater in the area of the pond.

The existing pond area will be re-contoured to provide more productive wetlands. Construction of wide, shallow emergent vegetation areas could have adverse temperature effects on the cool spring flows if these areas are directly connected to the spring. Rather, the proposed design constructs open water and emergent wetland areas that are located away from the edge of the spring. These remote located wetlands would be fed by groundwater. Consequently, the finished grade of the ground line for the wetlands would be 1 to 2 ft below the groundwater surface at the time of construction to insure that these wetlands would continue to be inundated by groundwater. This area includes uplands areas that would be planted with alder, birch, cottonwood, and dogwood. The lower elevation areas would be planted with willow and sedge. The re-contouring to produce uplands and wetlands will be similar to figure 2-17.

Figure 2-17 - Re-contouring and riparian vegetation example for pond area

Some of the land on the Stark property, particularly the bank adjacent to the Salmon River, is approximately 4 ft above the water table and the soil tends to be alkaline. Developing and sustaining a robust riparian area in this situation may be difficult without irrigation. Consequently, the sponsor may consider an option in managing this riparian area that will provide for irrigation. The easement does not allow activities that harm the project objectives. But, the sponsor can allow activities that are consistent with the project objectives to benefit salmonid species and are considered to cause no harm. The Grazing Management Plan (GMP) establishes a process for determining the condition of the riparian area and for evaluating when grazing results have caused harm. The GMP defines the process for overall management, decision-making about grazing limits, and public record requirements. It also describes quantitative survey procedures and establishes the objectives for the riparian areas to benefit salmonid species. See appendix D for the GMP. Potentially, the sponsor may negotiate an arrangement with the landowner for irrigation of the riparian area in exchange for some level of grazing that does not harm the riparian vegetation. The grazing may be considered for portions of the riparian zone outside of the fenced corridor, no grazing will be allowed within the fenced corridor.

The landowner has offered some of the existing, 2- to 10-yr old trees located elsewhere on the property for use in the project's riparian corridor planting. The construction contract will include provisions for transplanting these larger trees as individually identified by the landowner.

2.4.4 Constraints on Design. The creation of new channel and installation of habitat features is limited to specific reaches and includes features (such as 6 ft deep pools) because of specific requirements by the landowner. Reconfiguration of the channel in the vicinity of the Hot Springs Resort buildings is not acceptable to the landowner.

The landowner has several existing buildings and utilities within the easement corridor and will need to work in the channel and the easement corridor on occasion to maintain these structures. For example, there is an existing gravity pipeline from the house to the sewage lagoon that crosses the channel and this pipeline may require maintenance at some time in the future.

2.5 Site 4 Pennal Gulch

2.5.1 General Description of Current Conditions. Site 4 is located at the end of long road (approximately 3 miles from the State Highway 93 to the end of the road) that provides hunting and fishing access to the River bank across from Pennal Gulch (locally known as Sportsman's Access). The area is characterized by a series of channels that are dry at times during the year or may carry irrigation flows and these channels roughly parallel the current main channel across an area that is from 500 to 1,000 ft wide and is several thousand feet long from the point where the relic channels diverge from the current channel location to the point where they rejoin the current channel. The majority of site 4 is on Bureau of Land Management property. The downstream end has private ownership. One owner may participate in the project, but, the owner of the 2,000-ft-long section of privately owned land at the very end of the site will not participate in the project. There is some uncertain whether the Bureau of Land Management, the State of Idaho, or a private party owns the upstream 1,300 ft of the site. The channels that cross the site consist of relic channels abandoned by the channel when the main channel shifted position and high flow channels. Most of these channels are now cut-off by a series of levees but may carry spring water or irrigation water at times during the year. At the upstream end of the site, an approximately 1,000-ft-long levee channelizes the Salmon River against the hillside to the east. This levee cuts-off what once was the main channel for the River. A wetland has formed in the old channel on the landside of the levee. At approximately 700 ft downstream of the first levee, a second levee cuts-off a second channel and is 250 ft long.

The channel behind the first levee is approximately 6,000 ft long and has many branches and junctions with other channels and other high flow channels. At approximately 1,300 ft from the levee, a channel enters from the west side carrying spring water and irrigation flows. Combined irrigation and spring flows observed during the summer are approximately 10 cfs. Spring flows observed during the winter are approximately 4 cfs. Below this junction, the channel is blocked by a series of beaver dams. The beaver dams divert a portion of the flows from the main channel into nearby channels. The channel capacity and interconnection with adjacent channels is transitory because of the beaver dams.

The channel cut-off by the second levee does not have perennial flow, but high flow channels periodically feed water to this channel at several locations along its length. This channel has two locations where the high flows have scoured vertical banks. These two locations are each 250 – 300 ft long and the bank heights are 4 – 5 ft with the bank material being fine-grained material. The topsoil within the floodplain area is generally thin or entirely gone. Some limited amount of grazing of the floodplain occurs.

2.5.2 Objectives. Objectives for this site include the following:

- Develop a secondary channel providing:
  - A late summer daily average flow having a 95 percent confidence limit of not being interrupted
  - A connection to the Salmon River that avoids, to the degree possible, private property
  - A connection to the Salmon River that avoids, to the degree possible, disturbance of the existing wetlands
  - A hydrograph that, to the degree possible, reflects the natural hydrograph of the Salmon River
  - Refugia for juveniles from the higher velocities of the main channel by providing low velocities (<2-ft/sec) for 30 percent of the total length during the 1.5-yr event (67 percent exceedance) and 20 percent of the total length during the 10-yr event (10 percent exceedance)
  - Feeding areas for juveniles consisting of low velocity reaches that don't require expending much energy to stay in place (< 2 ft/sec) but flows are sufficient to bring plentiful supply of food to the juveniles
  - Refugia pools for winter freezing of the channel
  - Complex cover for juveniles consisting of undercut banks, woody debris, *etc.,* for evasion of predators
  - Reduced water temperatures if possible and provide shade as a minimum
  - A sediment trap at the upstream end to confine sediment to a convenient location for maintenance removal
- Provide a robust and sustainable riparian zone:
  - Reconnect high flow channels that will provide floodplain inundation and opportunity for developing more diversity
  - Protect the riparian area from grazing
- Accommodate the following constraints:
  - Avoid erosion or flood related damage on privately owned property
  - Adjacent landowners have established boundary limits that affect riparian corridor widths
  - The landowner requires that the boundary fence have water gaps for stock watering where the project crosses privately owned land

2.5.3 Proposed Design for Achieving Objectives

2.5.3.1 Channel profile, section, and alignment. The existing levee at the upstream end of the project will be breached to provide perennial flow connection to the Salmon River. The entrance will have a 4-ft-diameter culvert and orifice similar to the one described for site 1. A culvert with orifice is needed to limit peak discharges because of the private ownership of the land.

A short length of channel would connect to the Salmon River and the culvert. Downstream of the culvert, a sediment trap and a new channel would be constructed for approximately 1,300 ft leading to a road crossing. At this road crossing, a 4-ft-diameter culvert would be installed per NMFS 2001 requirements. This culvert will accommodate summertime flows. But, annual peak discharges will exceed the capacity of this culvert. A high flow channel and hardened section of road will be provided for the peak flows. The channel construction continues for approximately 750 ft at which point the proposed channel profile matches the existing channel thalweg. Beyond this point, the existing channel section will not be changed.

A 75 to 100-ft long hardened section would be added to the access road to provide for over bank flow when flood flows exceed the capacity of the culvert. This hardened section would consist of rock fill material that is compacted to be tightly interlocked. The surface of the rock will be choked with gravel to provide a smooth surface. At the downstream edge of the roadway, a trench will be excavated and backfilled with rock fill to prevent head cutting that may undermine the rock fill.

The alignment for the new channel construction follows a narrow corridor between private property boundary to the southwest (assumed boundary based on Custer County records) and the main body of the wetlands to the northeast.

The profile for the site 4 secondary channel is shown on figure 2-18. The proposed profile generally requires 2 - 4-ft excavation below the existing ground line for the upstream 2,000 ft. Approximately 600 ft of levee will also be required to provide a channel section with bank that are at least as high as the 1.5- to 3-yr water surface. Some amount of bank height is required to provide separation from the wetlands that is expected to have high water temperatures during the summer. Additionally, the levee would provide a planting surface that when it matures, would provide a canopy over the channel. Establishing the top of levee at the 1.5- to 3-yr water surface should be sufficiently elevated to allow establishment of the cottonwood and similar trees desired for the canopy, but not so high that the wetland and adjacent floodplain can't frequently be inundated.

The MIKE 11 model of the main channel (described in appendix B) was used to determine water surface for the 1.5-yr event (67 percent exceedance) at the proposed entrance and exit of the site 1 secondary channel. The 1.5-yr (67 percent exceedance) discharge for the secondary channel was determined by adjusting the discharge until the HEC-RAS model water surface nearly matched the MIKE 11 model results at the entrance and exit and is approximately 19 cfs. The HEC-RAS model uses a culvert size of 1.67 ft diameter with no blockage to model the culvert with the 1.5 x 1.5 orifice. The model uses a culvert size of 3.67 ft to model 4-ft-diameter culvert with the invert 1 ft below the channel thalweg. The smaller culvert sizes used in the model provide equivalent open areas to the larger culverts proposed for installation (either equivalent to the culvert orifice open area or equivalent to the area above 1-ft blockage of the culvert bottom). The ineffective flow area settings used in the model were generally conservatively set, especially in the downstream 5,000 ft of the channel. These conservative ineffective flow settings keep water in a single, main channel so that the computed water surface elevation and velocities would be conservative in regards to indicating potential effects on the downstream private property.

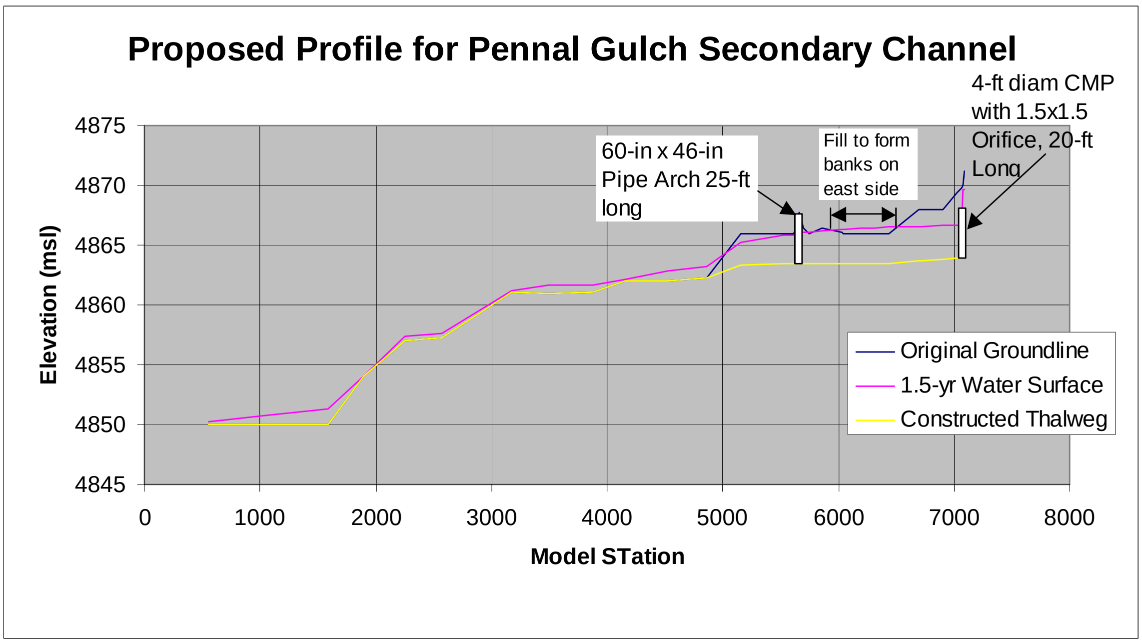

Figure 2-18 - Profile for Site 4

2.5.3.2 Base flows. Base flow for the secondary channel for site 4 was calculated in a manner similar to the one described in Paragraph 2.2.4. The design considers the trade-off between maximizing the low flows against sediment deposition and maintenance. Consequently, the secondary channel inlet is set approximately 1 ft higher than the thalweg of the Salmon River. Depth of flow in the new constructed portion of the channel (upstream 2,000 ft) ranges from 1.27-1.49 ft. Depths of flow in the channel will be influenced by beaver dam activity and will vary over time as changes in those dams occur.

2.5.3.3 Stable channel design issues. Velocities in the secondary channel range from 0.26 to 4.77 fps for the 1.5-yr event (67 percent exceedance). Most of the velocities are 1 to 2 fps. Velocities range from .29 to 5.21 fps for the 10-yr event (10 percent exceedance). Most of these velocities are between 1 and 2 fps. The single high velocity is located within the area affected by beaver dam activity. The velocities will not result in significant erosion of the channel. However, beaver dam activity is expected to have large impacts to the future channel section and alignment.

2.5.3.4 Riparian Design. One of the existing levees (the more downstream one of the two) will be lowered to allow overtopping for events larger than the 1.5- to 3-yr event (67 percent exceedance to 33 percent exceedance) (approximately 3 ft of lowering) for approximately 100 ft and a 48-inch-diameter culvert with an orifice similar to figure H-20 will be installed. Where the levee is lowered, that lowered surface will be hardened to resist the overtopping flows. The hardening will be similar to the description in 2.5.3.1. Because of the elevation of the ground downstream of the levee, the culvert will not flow except during the high water period. The intent of these actions is to allow more floodplain connection that will allow complex patterns of high flow channels and deposition that vary over time. Through this variation in flooding, a more complex and diverse riparian area may develop.

The design includes fencing of the project boundary to exclude all grazing of the riparian area. Water gaps/hardened fords as described in Section 2.4.3.1 will be required in two locations where the fence crosses land that is privately owned.

Riparian vegetation similar to that described in 2.2.3.5 will be planted on the proposed levee section.

2.5.3.5 Habitat Design. For the proposed new channel, the shear stresses developed during the 1.5-yr event (67 percent exceedance) are not expected to be great enough to develop many habitat features. And, with the sediment inflow, it may be difficult to provide/preserve pool type habitat on the site 5 secondary channel. Barb and sill structures will be constructed at 3 locations on the secondary channel to create scour pools downstream of these structures (Shields, *et al,* 1995). The structures consist of a barb projecting from one bank that is approximately 1/3 of the channel width and crowds the flow towards the opposite bank. The barb will form an angle of 23 degrees with the bank and the root of the barb will be embedded a minimum of 5 ft into the bank to avoid end-around scour. The barb will slope from the 1.5-yr (67 percent exceedance) water surface at the bank, to the thalweg elevation at the tip. The toe of the opposite bank is protected with a line of large boulders forming a sill. The upstream and downstream ends of the sill will be embedded a minimum of 5 ft into the bank to avoid end-around. Both the barb and the sill will be founded 4 ft below the thalweg. The combination of the barb and sill increases the water velocity and turbulence through the structure and results in the formation of a scour pool immediately downstream. The size of the existing gravels in the subsurface may be sufficiently large to inhibit formation of the scour pool for many years. Consequently, the scour pool will be formed at the time of construction and the turbulence and shear created by the barb and sill structure may help prevent deposition and filling of the pool.

At field selected locations, logs and rootwads salvaged from adjacent areas will be anchored into the bank to provide cover structures.

As previously described in 2.5.3.3, most of the velocities for the secondary channel are less than 2 fps and the channel will provide refugia during high flows in the Salmon River. Additionally, the existing spring flows will provide open water reaches during winter periods when the channels supplied only by river water freeze.

The constructed portion of the channel will have a bank full width of approximately 12 ft. This will allow development of a canopy over the channel when the riparian vegetation matures. The degree of reduction in the water temperature that would result is uncertain. But, at a minimum, the shade provided would have a beneficial effect on the fish being able to tolerate the higher water temperatures in the late summer.

2.5.4 Constraints on Design. There is an existing sportsman's access at site 4. Restoration of site 4 will need to preserve this public access with only brief interruptions. The secondary channel alignment crosses the access road to the river. A 46 x 60-in pipe arch will allow access over the channel during low flows. But, during peak flows, the culvert will not accommodate the discharge and the remainder of the flow will be routed over the road through a high-flow channel. Flow over the road through the high flow channel will cutoff the access to the ramp. A 75- to 100-ft-long hardened section would be added to the access road to provide for over bank flow when flood flows exceed the capacity of the culvert. This hardened section would consist of rock fill material that is compacted to be tightly interlocked. The surface of the rock will be choked with gravel to provide a smooth surface. At the downstream edge of the roadway, a trench will be excavated and backfilled with rock fill to prevent head cutting that may undermine the rock fill.

2.6 Site 5 State Highway 93 Alternate Bridge

2.6.1 General Description of Current Conditions. Site 5 is located primarily on Bureau of Land Management and Idaho State Department of Lands property. Consequently, the private landowner concerns that drove the designs for some of the other sites do not apply to this site. The upstream end of the site is slightly levied adjacent to the Salmon River. The majority of the site shows evidence of past borrow operations. Pits and mounds are prevalent. There are several high flow channels that cross the site. None of the channels are continuous due to the previous borrow operations. The site has an existing boat launch ramp and a parking area. The site has also been used extensively by off-road vehicles and trails and vehicle rutting are prevalent. The Highway 93 Alternative bounds the southeast side of the site.

2.6.2 Objectives. Objectives for this site include the following:

- Develop a secondary channel providing:
  - A late summer daily average flow having a 95 percent confidence limit of not being interrupted
  - A hydrograph that reflects the natural hydrograph of the Salmon River
  - An unconstrained and dynamic discharge
  - Refugia for juveniles from the higher velocities of the main channel by providing low velocities (<2 ft/sec) for 30 percent of the total length during the 1.5-yr event (67 percent exceedance) and 20 percent of the total length during the 10-yr event (10 percent exceedance)
  - Feeding areas for juveniles consisting of low velocity reaches that don't require expending much energy to stay in place (<2 ft/sec) but flows are sufficient to bring plentiful supply of food to the juveniles
  - Refugia pools for winter freezing of the channel
  - Complex cover for juveniles consisting of undercut banks, woody debris, *etc.,* for evasion of predators
  - Reduced water temperatures if possible and provide shade as a minimum
  - A sediment trap at the upstream end to confine sediment to a convenient location for maintenance removal
- Provide a robust and sustainable riparian zone:
  - Natural pattern of inundation of the flood plain
  - Locates the riparian corridor in proximity to the water table
- Accommodate the following constraints:
  - Protect the existing highway embankment from potential flood damage associated with the new channel
  - Allows public access to the existing boat launch ramp
  - Allows public recreation within the site (walking trails, *etc*.)
  - Minimizes the sediment deposition problems and reduces long term maintenance
  - The BLM has specified the location of fence lines for controlling off-road vehicle use of the site and has specified vehicle-parking areas.

2.6.3 Proposed Design for Achieving Objectives

2.6.3.1 Channel profile, section, and alignment. The channel section, alignment, and profile were developed through an iterative process of assuming a discharge, calculating regime channel width and plan dimension, then using a hydraulic model to determine water surface and flow for the trial section, plan and profile, and repeating the regime calculations and modeling steps until the flows are reasonably balanced. Additionally, stable channel design was considered and is discussed further in Paragraph 2.6.3.3. The final channel alignment will be coordinated with the BLM Hydrologist and Fish Biologist and involve adjustments of the proposed alignment to take advantage of shade from mature vegetation, topographic features that lend themselves to a natural channel, and other issues related to field conditions. The channel dimensions were calculated from the equations below:

$W = 3.68\ Q_b^{0.5}$ Equation H-6 (Soar, *et al*, 2001)

(Bank full width in meters empirically derived relation based on North American rivers)

$L = 12.34\ W$ Equation H-7 (Soar, *et al*, 2001)

(wavelength in meters)

$r = 2.25\ W$ Equation H-8 (Soar, *et al*, 2001)

(radius of curvature in meters)

The return interval for the secondary channel design was set at 1.5 yrs. Most of the naturally occurring secondary channels within the project reach are old abandoned channels and their section geometry is not necessarily the result of present day flow regimes. The selection of 1.5-yr return period for the bank full design was assumed to fit reasonably well with patterns of inundation that the riparian vegetation would respond well to (1.5- to 3-yr event (67 to 33 percent exceedance) inundation allows good flood plain connection) and also confines fish to the channel for events up to the 1.5 yr (67 percent exceedance). For events greater than 1.5 yrs (67 percent exceedance), the water surface will overtop the channel banks at certain locations and this may result in some stranding. The MIKE 11 model of the main channel (described in appendix B) was used to determine water surface for the 1.5-yr event (67 percent exceedance) at the proposed entrance and exit of the site 5 secondary channel. The 1.5-yr (67 percent exceedance) discharge for a trial section and profile for the secondary channel was determined by adjusting the discharge until the HEC-RAS model water surface nearly matched the MIKE 11 model results at the entrance and exit. The 1.5-yr (67 percent exceedance) discharge determined by HEC-RAS was then used to calculate a new width and plan geometry from the regime equations. Results are summarized below:

1.5-yr (67 percent exceedance) discharge = 144 cfs (4 cubic meters per second)
Bankfull width = 24 ft (7.36 meters)
r = 54 ft (16.56 meters)
Wave Length = 298 ft (91 meters)
Slope = 0.0003 (entrance to road crossing, profile constrained by road crossing)
= 0.002 (road crossing to exit)

At bends, the outside bank may experience super elevation above the water surface calculated by the HEC-RAS model. Super elevation is calculated from equation H-9 from EM 1110-2-1601.

$\triangle y = C ((V^2W))/(gr)$ Equation H-9 (EM 1110-2-1601)
C = 0.5 for trapezoidal channels with tranquil flow
V = Mean channel velocity (for 1.5-yr event = 2.45 ft/sec typical)
W = Channel width (24 ft)
g = acceleration of gravity (32.2 ft/sec^2)
r = radius of channel (54 ft typical)
$\triangle$y = 0.04 ft

The calculated super elevation is negligible and will be ignored in the bank height design.

The channel profile is shown in figure 2-19.

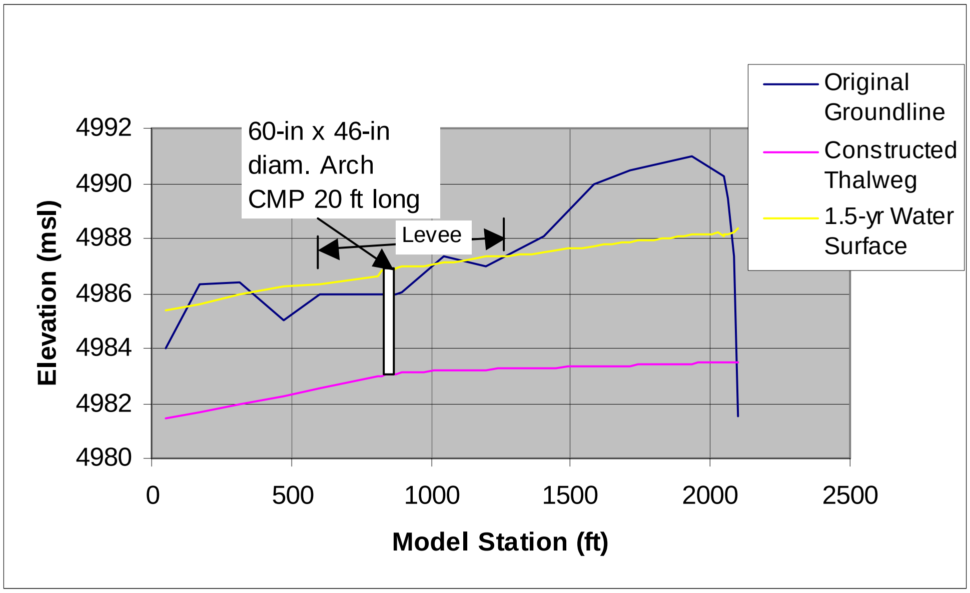

Figure 2-19 - Profile for Site 5

The proposed channel crosses an area of old borrow pits and building banks (levees) will be required through this reach to maintain a bank full channel section. At the road crossing, a 46-in by 60-in arched pipe is planned. The invert of the culvert will be set 1 ft below the bed of the channel in accordance with NMFS 2001. The HEC-RAS model uses a culvert size of 3.67 ft for the arched pipe and the model calculation of culvert discharge is based upon an unblocked, round culvert. The culvert size used in the model has an equivalent area to the open portion of the proposed culvert (the 60 x 46-in pipe arch with 1 ft of blockage has 10.3 sf and the 3.5 culvert with no blockage has 9.62 sf). The model's calculated discharge for the culvert appears to match with hand calculated culvert discharges for the 1.5-yr event (67 percent exceedance) and matches less well for the 10-yr event (10 percent exceedance).

2.6.3.2 Base flows. Base flow for the secondary channel for site 5 was calculated in a manner similar to the one described in Paragraph 2.2.4. The iterative process of balancing MIKE 11 water surfaces for the main channel with HEC-RAS water surfaces for the secondary channel resulted in a base flow having a depth of 1.12 to 1.24 ft and discharge of approximately 6 cfs with a channel bottom of 4 ft. Flows and depths could have been greater if the invert of the intake were set lower. But, there is a trade-off between having a lower invert with more flow and also more sediment and maintenance. The 6 cfs and approximately 1 ft of depth calculated in this analysis are based on setting the intake invert at approximately 0.75 ft above the main channel thalweg. Paragraph 2.6.4 discusses the issues of sediment and inlet elevation.

2.6.3.3 Stable channel and sediment deposition design issues. The sediment deposition design is similar to the discussion in Paragraph 2.2.2. The site 5 intake is located within a very stable reach. Air photographs of this reach show little or no movement of this portion of the channel since 1977. The withdrawal of bed load by the secondary channel will also be minimized by aligning the intake 90^o to the main channel, and elevating the invert of the intake above the thalweg of the main channel (Linder 1952). The invert of the intake will be approximately 0.75 ft above the thalweg of the main channel. Additionally, a sediment trap basin will be constructed 50 ft beyond the entrance. This trap will slow velocities in the channel and cause much of the sediment to drop out at a single location that is easier to maintain rather than spread the sediment throughout the secondary channel length. The first 50 ft of the channel will have a narrower and deeper section to keep shear stresses higher and facilitate moving any sediment that enters the channel into the trap. The lower 2 ft of the channel section will be lined with large boulders to allow a near vertical slope in the lower channel section. A boulder sill intake similar to figures H-21 and H-22 will be provided for the site 5 intake.

Velocities in the secondary channel range from 1.78 to 4.56 fps and average shear stress ranges from .08 to .38 lbs/sf for the 1.5-yr discharge. This range of velocities and shear stresses is less than allowable values indicated for vegetated banks (Fischenich, 2001) based upon maximum shear stress calculated for the outside of the bend using equation H-4 and the indicated channel dimensions.

r = radius of curvature of a bend (54 ft for site 5)
W = channel width (24 ft for main channel)

For the 10-yr event (10 percent exceedance), the average shear stress ranges from .05 to 1.59 for the main channel with the first 50 ft of the channel accounting for the high shear stress values. Beyond the first 50 ft, the highest average shear stress for the main channel is 0.95 lbs/sf. Adjusting this value for the shear on the outside bend results in a maximum shear of 1.7 lbs/sf. This value is within the limit for natural vegetation, and ranges from shear resistance values of 0.1 to 2.5 lbs/sf. At a level of shear stress of 1.7 lbs/sf, some localized erosion is anticipated but would not be extensive.

2.6.3.4 Riparian Design. The riparian planting consists of a 75-ft-wide corridor at the locations indicated on plate 14 of the Detailed Project Report. The plant types and spacing are the same as described in Paragraph 2.2.6. At locations where the profile for the channel results in a bank height that is more than 4 ft above the 1.5-yr water surface, a 5-ft-wide bench will be excavated along the bank to allow planting closer to the water table. The bench will be excavated at approximately the 1.5-yr water surface elevation.

2.6.3.5 Habitat Design. The unregulated inlet and variable pattern of annual peak discharge is anticipated to develop an aquatic and riparian corridor that changes over time. The shear stress anticipated for a 10-yr event or larger may provide some localized scour, develop undercut banks, and recruit large woody debris at isolated locations of limited extent. Additionally, the existing topography has many pits from past borrow operations and old channels. These channels and pits will be closer to the water table and provide a more diverse riparian community. In some cases, the low areas will develop wetlands.

The shear stresses developed during the 1.5-yr event (67 percent exceedance) are not expected to be great enough to develop many habitat features. And, with the sediment inflow, it may be difficult to provide/preserve pool type habitat on the site 5 secondary channel. Barb and sill structures will be constructed at 4 locations on the secondary channel to create scour pools downstream of these structures similar to the ones describe in 2.5.3.5.

A pool located off the channel will be constructed for refugia during peak flow events. The pool will be constructed to be 6 ft deep at low flows to provide refugia during winter. Locating the pool on the main channel would potentially allow the pool to fill with sediment. Alternatively, if the pool is located off the channel but supplied by a branch from the channel, there might be too little water left in the main channel during the late summer flows. Consequently, the pool will be located off of the main channel and be supplied by a french drain that brings water from a point on the secondary channel that is upstream of the pool. The french drain is located adjacent to the channel for a length of approximately 20 ft. The core of the french drain would consist of screened cobbles or rock. A gravel filter zone would prevent piping of fines into the core material that could result in clogging of the drain. The french drain would be protected behind a rock armor layer covering the channel bank at the location of the french drain. The profile for the french drain and pool is shown in figure 2-20. During the summer, the rate of inflow from the french drain may not be sufficient to maintain water quality. But, the water quality should not be a problem for the periods when refugia are needed. Assuming a pool measuring approximately 25- by 15 ft and 6 ft deep, the pool volume would be changed every 4 days as calculated in Equation H-10. If the pool were frozen over by 2 ft of ice, the pool volume would change every 2.5 days. This is considered acceptable for winter when the fish metabolism rates are low.

$q = kiA$ Equation H-10 (Sowers and Sowers 1970)

k = Δh/L (Assume head difference is difference between the base flow water surface in the channel at the entrance to the french drain and the channel water surface at the pool exit to the channel. Also, the head loss is primarily across the sand filter zone assumed to be 6-in thick)

i = 0.02 ft/minute (The value for sand filter and other materials used in construction of the french drain are higher than 0.02, but this value (for fine sand) accounts possible deposition of finer material over time)

A = 30 sf (assumes 20 ft length along side of channel and section height of 1.5 ft)

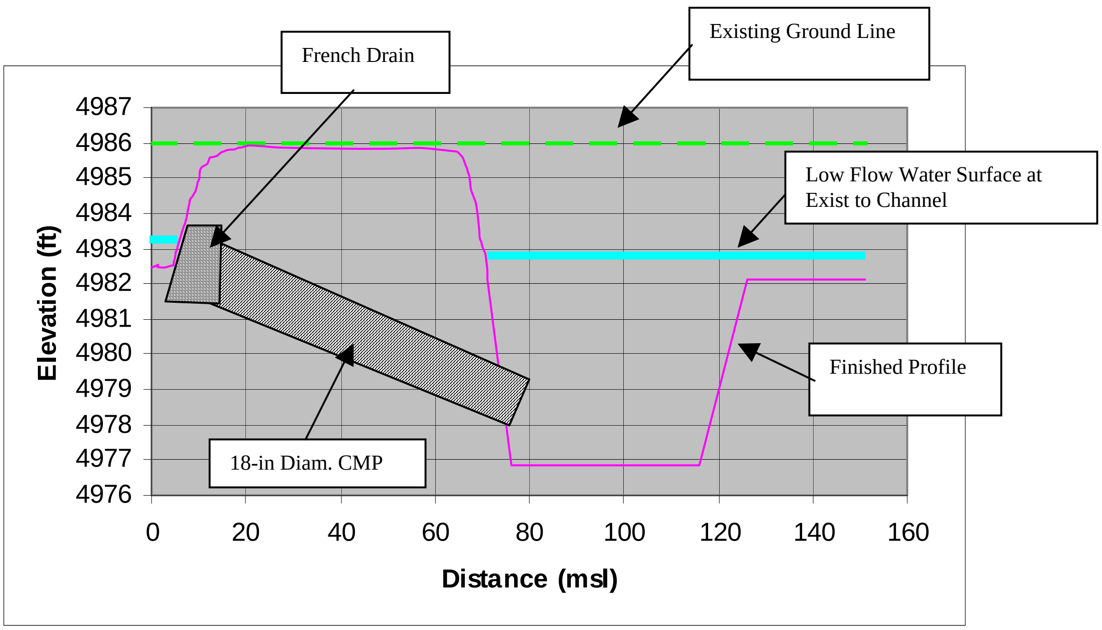

Figure 2-20 - Profile french drain and winter refugia pool

Velocities in the secondary channel range from 1.78 to 4.56 fps with most of the channel having average velocities greater than 2 fps for the 1.5-yr event (67 percent exceedance). Approximately 765 ft of the channel length has over-bank flow during the 1.5-yr event (67 percent exceedance) and velocities in the over bank portion are estimated to be 2 fps or less based upon HEC-RAS model results. Similar results are observed for the 10-yr event (10 percent exceedance). The edges of the channel and the over-bank flow portion will provide refugia areas of low velocity (less than 2 fps) for more than 30 percent of the channel's length.

During low flows, the velocities range from 0.79 to 1.48 fps. The entire length of the channel has low enough velocity to minimize swimming energy expenditure and the velocities are sufficient to bring food to the fish.

The proposed channel width is 24 ft wide. The planned riparian planting should provide a canopy that completely spans the channel when the plantings become mature. The canopy will reduce solar input to the channel and may have some beneficial temperature effects. The degree of temperature reduction during the low flow periods is uncertain. As a minimum, the canopy shading will improve the survival during the high water temperature periods.

2.6.4 Constraints on Design. There is an existing boat launching ramp at site 5. Restoration of site 5 will need to preserve public access to this ramp with only brief interruptions. The secondary channel alignment crosses the access road to the ramp. A 46 x 60-in pipe arch and high flow overflow hardened section, as described in Section 3.5.4, will be required.

The proposed secondary channel alignment is in close proximity to the existing Highway 93 embankment for approximately 400 ft. The highway will be protected from erosion by constructing 5 barbs (at approximately 100 ft spacing) that extend 35 ft from the embankment toe. Barbs are typically long, narrow (relative to their length) rock structures that project from the bank into the stream to deflect flow away from the bank. The barb will be embedded 4 ft below the ground line and tie into the embankment 4 ft to prevent undermining by scour. The barb will slope up from the ground line at the tip of the barb to a height of 4 ft at the root (tie in to the embankment).

The site 5 is presently used by four wheeled all terrain vehicles and off road motor cycles. A new fence will prevent these vehicles from accessing the riparian areas. The Bureau of Land Management (BLM) owns the property and has stipulated that the fence will be a jack fence. Additionally, the BLM stipulates that some recreation uses, including use of walking trails, must continue. Consequently, the fence for vehicle control will allow pedestrian access from the existing parking lot.

3.0 Material Sources and Spoil Areas

3.1 Material Sources

Filter zone materials, gravel fill materials with specific gradation requirements, and cobble bed materials may be provided by commercial sources at Challis. There are no presently operating sources for riprap and boulders. Rock material for county road construction and riprap for bank protection have been obtained from a variety of quarry areas in the past. But, these quarries are not presently producing rock material. Procuring rock from these quarries will require that the construction contractor (or his subcontractor) mobilize the necessary equipment and make arrangements with the landowners.

3.2 Spoil Areas

Site 1 will have excess soil material generated from required excavation. An on-site spoil area is planned for site 1.

Site 2 will not generate significant quantities of excess material.

Site 3 requires extensive excavation. But, the required fill, particularly for construction of the wetlands levees, should balance the excavation and fill quantities. If there is excess material, that material can be incorporated into the wetland levees to provide a wider levee section.

Site 4 will generate excess soil material. An off-site spoil area will be included in the project to receive excess material from this site, or any of the other sites. The spoil area is located within an existing gravel borrow pit. Some smoothing and dressing of the finished spoil area surface will be required to satisfy the landowner.

Site 5 will generate excess soil material that will be disposed of within existing borrow pits on-site.

4.0 REFERENCES

Blau, 2002, personal communication

Emmett, William. 1975. *The Channels and Waters of the Upper Salmon River Area, Idaho*, Geological Survey Professional Paper 870-A, 1975, U.S. Department of the Interior. Not referenced.

Environmental Protection Agency. 1999. *Constructed Wetlands, Treatment of Municipal Waste Waters*, EPA/625/R-99/010.

Fischenich, Craig. 2001. *Stability Thresholds for Stream Restoration Material*, USAE Research and Development Center, Environmental Laboratory, ERDC TN-EMRRP-SR-29.

King, King, Scott N. 2002. *The Effective Discharge Concept In Gravel-Bed Stream Restoration: The Twelve Mile Reach Of The Salmon River At Challis*, Idaho, A Thesis Submitted In Partial Fulfillment Of The Requirements For The Degree Of Master Of Science With A Major In Civil Engineering In The College Of Graduate Studies University Of Idaho.

Larkin, Mike, July 2001, personal communication.

Linder, C. P. 1952. *Diversions from Alluvial Streams*, American Society of Civil Engineers, Transactions, Proceedings-Separate No. 112 paper 2546.

National Marine Fisheries Service. 1995. Juvenile Fish Screen Criteria. Environmental and Technical Services Division, Portland, Oregon. Rev February 16, 1995. http://www.nwr.noaa.gov/1hydrop/nmfscrit1.htm (18 Aug 2003).

___. 1996. J*uvenile Fish Screen Criteria for Pump Intakes*. Environmental and Technical Services Division, Portland, Oregon. Rev May 9, 1996. http://www.nwr.noaa.gov/1hydrop/pumpcrit1.htm (18 Aug 2003).

____. 2001. *Guidelines for Salmonid Passage at Stream Crossings*. Southwest Region.

Simons and Senturk, 1977, Simons, Daryl B., and Senturk, Fuat, Sediment Transport Technology, Water Resources Publication, Fort Collins, Colorado.

Shields, F. Douglas, and Abt, Steven R., 1989, "Sediment Deposition in Cutoff Meander Bends and Implications for Effective Management," Regulated Rivers: Research and Management, Vol. 4, p 381-396.

Shields, F. Douglas, and Cooper, C. M. Jr., and Testa, Samuel III. 1995. *Towards Greener Riprap: Environmental Considerations from Microscale to Macroscale*. Published in *River, Coastal and Shoreline Protection: Erosion Control Using Riprap and Armourstone*, John Wiley & Sons Ltd.

Soar, *et al.*, 2001, Soar, Philip J. and Thorne, Colin R. 2001. *Channel Restoration Design for Meandering Rivers*, Coastal and Hydraulics Laboratory, U.S. Army Corps of Engineers, ERDC/CHL CR-01-1, 260.

Sowers and Sowers. 1970. Sowers, George B. and Sowers, George F. *Introductory Soil Mechanics and Foundation*, Macmillan Publishing Co., Inc. 1970.

U.S. Army Corps of Engineers. 1994. Engineer Manual 1110-2-1418, *Channel Stability Assessment for Flood Control Projects*.