Final Report

Henry M. Jackson Hydroelectric Project (FERC No. 2157)

Relicensing Study Plan No. 20

Fish Passage Feasibility at the Sultan River Diversion Dam

Phase 2 Assessment

Prepared for

Public Utility District No. 1 of Snohomish County

April 2009

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EXECUTIVE SUMMARY

The City of Everett's municipal water Diversion Dam at RM 9.7 on the Sultan River is within the Project boundary of the Henry M. Jackson Hydroelectric Project (FERC No. 2157). The Diversion Dam and previous dams in the same general vicinity have blocked upstream fish passage to about 6 miles of river habitat since the early 1900s. During the license amendment process to add hydroelectric facilities and create the Jackson Project in the early 1980s the fisheries agencies decided to not prescribe fish passage at the Diversion Dam based on the prospect of greater salmonid production in the lower Sultan River with implementation of the Project's fisheries mitigation plan, which included instream flow requirements, water temperature controls, conservative powerhouse down ramping rates, and reduced peak flows during the salmon egg incubation period. In addition, it was recognized that historical salmon production in the accessible portion of the reach above the Diversion Dam was probably very limited because of the highly unstable gravel beds during the frequent peak flow events. Steelhead trout would have been more likely than salmon to have successfully spawned and reared in this reach.

As part of the relicensing activities for the Project, several stakeholders requested that the feasibility of providing fish passage at the Diversion Dam be re-evaluated. This request was prompted partly because the Project now provides substantial flow control in the bypass reach thus increasing the potential for salmon production, and partly because Puget Sound fall Chinook salmon and Puget Sound steelhead trout are now listed as threatened species under the federal Endangered Species Act.

Specific objectives of the Fish Passage Feasibility Assessment include:

1. Identify upstream fishway alternatives for the Diversion Dam site
2. Provide initial estimates of costs for fishway alternatives
3. Estimate the benefits of providing fish passage in terms of potential production of Chinook salmon, coho salmon, and steelhead trout, and
4. Identify potential indirect Project effects and costs associated with establishing anadromous fish production above the Diversion Dam.

The anadromous fish species subject to the fish passage feasibility assessment include steelhead trout, Chinook salmon, and coho salmon. Pink and chum salmon spawn only in the lower river well downstream of the Diversion Dam.

Fishway Alternatives

The Sultan River Diversion Dam at RM 9.7 is a concrete ogee-crest gravity structure measuring 25 feet high. The primary components include a 120 ft-wide overflow spillway and an adjacent 25-ft-wide sluiceway.

Two options were identified for fishway alternatives at the Diversion Dam. One option would be to construct a fishway that would accommodate the full 20-ft operating head of the dam in its current configuration. The second option would be to lower the water level behind the dam to the minimum that can be controlled with the current sluiceway gate. This would produce an effective head of only 8-9 ft. However, any type of fishway constructed in the existing sluiceway would reduce the ability to sluice accumulated gravel out of the forebay near the water intake trash racks and pass the large woody debris that becomes mobile during high flow events. These concerns, especially for gravel sluicing, may preclude the lowered-head option.

For the full-head option, a conventional vertical slot fishway could be constructed on the right bank of the dam at an estimated cost of $3.6 million. For the lowered-head option, either a vertical slot or a pool-and-chute fishway would be feasible. Either of these lower-head designs would cost approximately $2.16 million.

Fish Production Potential in Bypass

The river channel in the Sultan River between Culmback Dam and the Diversion Dam (bypass reach) is largely confined within a narrow bedrock canyon with a moderately high gradient. Stream flows in the bypass reach consist of low-level discharges from Culmback Dam, which are typically 20 cfs, plus limited accretion between Culmback Dam and the Diversion Dam. There are no major tributaries entering the bypass reach.

Estimates of adult anadromous fish production potential for the bypass reach by method are as follows:

Chinook salmon:	Based on spawning substrate availability = 58 adults
	Based on fry rearing habitat availability = 118 adults
	Based on WUA spawning habitat at 30 cfs = 40 adults
	Based on WUA spawning habitat at 100 cfs = 150 adults
Coho salmon:	Based on rearing habitat availability = 735 adults.
Steelhead trout:	Based on rearing habitat availability = 52 adults
	Based on WUA rearing habitat at 30 cfs = 15 adults
	Based on WUA rearing habitat at 100 cfs = 35 adults

These estimates reflect approximate average marine survival rates experienced in the last two decades, which have been relatively low compared to those in previous decades. If marine survival rates increase in the future so will the estimated adult production for the bypass. Of the several methods used to estimate bypass production potential for fall Chinook salmon and steelhead trout, the WUA approach likely provides the most reasonable estimates because it relies on the most detailed description of site-specific and species-specific habitat and is based on extrapolating (via habitat scaling) 17 years of known production from in the lower river.

The production estimates provided in this report do not quantitatively account for several site-specific factors that could significantly diminish the production potential from the bypass reach and, in fact, could make it biologically infeasible to achieve sustainable runs of salmon and/or steelhead in the reach. These factors include:

1. Fish passage impediment at the Marsh Creek cascade below the Diversion Dam
2. The adverse effects of cold water in the bypass reach on salmonid growth, smolt development, and egg incubation
3. The limited amount of winter habitat for coho salmon in the bypass reach

These three factors are summarized below.

Marsh Creek Cascade

Based on several lines of evidence used to evaluate fish passage at the site in 2007 it was concluded that the Marsh Creek cascade at RM 7.6 is a near-complete upstream migration barrier to Chinook and coho salmon and steelhead trout (Ruggerone 2008). If the Marsh Creek cascade remains a partial barrier as it does now, or if it the site worsens with new landslides, there would be little justification to pursue fish passage at the Diversion Dam located about 2 miles above this site.

Water Temperature

The fish production estimates presented in this report for the bypass reach did not consider the effects of water temperature regime. However, water temperatures in the upper bypass reach tend to be very cold due to the bottom discharge of water from Culmback Dam. With average water temperatures in the upper bypass rarely exceeding 6°C even in the warmest late-summer period, the growth of juvenile salmonids in the upper half of the bypass would be extremely slow. Under such conditions it likely that most juvenile salmonids would tend to avoid using the upper half of the bypass or be stimulated to migrate downstream in search of better growth opportunities. Clear evidence of this can be seen in the current distribution of resident rainbow trout in the bypass.

In addition to growth impairment, the cold water would be expected to impair smolt development during the critical early spring period for Chinook and coho salmon. Furthermore, the cold water conditions would be expected to produce significant delays in fry emergence for all three species.

The issue of water temperature, especially in conjunction with alternative instream flows to be evaluated for this reach, raises considerable uncertainty as to the biological feasibility of fish passage at the Diversion Dam unless water temperatures can be conditioned to be more suitable for fish production. This temperature issue as well as the concern over fish passage impairment at the Marsh Creek cascade will need to be incorporated into the final decision on fish passage at the Diversion Dam.

Winter Coho Habitat

Numerous studies have shown that the availability of winter habitat can often be the primary limiting factor for coho salmon production. The Sultan River bypass reach contains little if any of the features typically defining suitable winter habitat for coho salmon. Therefore, it is likely that most juvenile coho that might rear there in the summer would move downstream out of the bypass reach during the autumn in search of suitable over-wintering habitat. Considerable losses of historical coho salmon winter habitat have been documented for the Snohomish basin. If winter habitat availability in the lower Snohomish basin is a primary limiting factor for coho production, the increased summer production possible for the Sultan bypass reach may not result in an increase in overall coho production in the Snohomish system.

Indirect Effects

The presence of anadromous fish in the bypass reach would trigger the need to consider alternative instream flows, which likely would be higher than current flows. However, greater discharges from Culmback Dam would only exacerbate the cold water concerns by extending the cold water further downstream. Therefore, the fish production that might be gained by providing additional physical space for fish with increased flows may be offset by expanding the length of stream with water of unsuitable temperatures. In addition, an increase in instream flow requirements would increase the extent of late-summer drawdown in Spada Lake, which, in turn, would limit the ability of the Project to control water temperatures in the lower river especially on dry years.

The notion of providing anadromous fish passage at the Diversion Dam initially might appear as though it could benefit anadromous fish production in the Sultan River; however, other consequences associated with such an action could compromise the ability of the Project to maintain the current successful fish enhancement measures now in place for the river below the Diversion Dam. While it is beyond the scope of this report to assess these consequences in detail, it will be necessary at some point to evaluate the interactions among these linked consequences in order to consider any new potential protection, mitigation, and enhancement measures that would truly benefit the net production of anadromous fish in the Sultan River while being within the feasibility constraints of the Project.

1.0 STUDY OBJECTIVES AND DESCRIPTION

The Henry M. Jackson Hydroelectric Project (FERC No. 2157) on the Sultan River consists of Culmback Dam at RM 16.3, a Diversion Dam at RM 9.7, and a powerhouse at RM 4.3. The Diversion Dam was originally built in 1930 to divert water to the City of Everett for municipal and industrial uses. Historically, anadromous fish were able to access the watershed to the point of a natural barrier at the approximate location of Culmback Dam (CH2M HILL 2005). However, fish passage has been blocked by the Diversion Dam and by previous dams in the same general vicinity since the early 1900s. The issue of fish passage was reviewed by the joint fisheries agencies in the early 1980's in conjunction with the Stage II development of the Jackson Hydroelectric Project (Project). At the time, it was determined that salmon production in the Sultan River would be greater in the river system without passage because of the Project's ability to provide enhancement measures in the lower river. This conclusion was not reached for steelhead, however, and the Project's mitigation for that species currently is via hatchery supplementation.

As part of the relicensing activities for the Project, several stakeholders requested that the feasibility of providing fish passage at the Diversion Dam be re-evaluated. The fact that Puget Sound fall Chinook salmon and Puget Sound steelhead trout are now listed as threatened species under the federal Endangered Species Act is added to the reconsideration of fish passage at the dam. In consultation with stakeholders the Licensee developed a study plan (SP 20) for Fish Passage Assessment that consists of three phases:

1. Phase 1. Passage Assessment at Marsh Creek Landslide (RM 7.6)
2. Phase 2. Determination of Feasibility of Diversion Dam Fish Passage
3. Phase 3. Evaluation of Fish Passage Alternatives at Diversion Dam (RM 9.7)

The purpose of this report is only to address Phase 2 of the study plan. Phase 1, the assessment of passage at the Marsh Creek landslide, was conducted in 2007 with a final report completed in January 2008 (Ruggerone 2008). Phase 3, which will consist primarily of conceptual designs and cost estimates for alternative fish passage facilities, will be initiated after completion of the Phase 2 assessment if fish passage is deemed feasible and desirable.

Specific objectives of Phase 2 of the Fish Passage Feasibility Assessment include:

1. Identify upstream fishway alternatives for the Diversion Dam site
2. Provide initial cost estimates for fishway alternatives
3. Estimate the benefits of providing fish passage in terms of potential production of Chinook salmon, coho salmon, and steelhead trout
4. Identify potential indirect Project effects and costs associated with establishing anadromous fish production above the Diversion Dam.

The anadromous species subject to the fish passage feasibility assessment include steelhead trout, Chinook salmon, and coho salmon. Although the Sultan River also supports large runs of chum and pink salmon, they have never been observed upstream of RM 7.6. They spawn primarily in the lower 3-mile alluvial section of the river.

2.0 BACKGROUND INFORMATION

2.1 Historical Perspective

The City of Everett's water supply Diversion Dam, which was initially built in 1916 and rebuilt in 1930, currently blocks upstream fish passage at RM 9.7 in the Sultan River. Prior to construction of these dams, Chinook salmon, coho salmon, and steelhead trout were able to access about 6 miles of the river upstream of the Diversion Dam site. To compensate for the lack of fish passage at the Diversion Dam, the City entered into an agreement with the State of Washington in 1957 that provided funding used to construct a salmon hatchery on nearby May Creek and a steelhead trout rearing facility (Reiter Ponds) on a tributary to the Skykomish River near Gold Bar.

Because of the highly unstable gravel beds in the river above the Diversion Dam, sustainable salmon production was probably quite limited in the accessible portion of this reach (Eicher 1981a). However, because steelhead trout often seek higher gradient reaches and spawn in the spring after the winter flood season, they would have been more likely than salmon to have successfully spawned in this reach. Also, steelhead trout, by virtue of their superior swimming and leaping abilities, likely penetrated farther upstream into the 6.8-mile reach than Chinook or coho salmon.

The Jackson Hydroelectric Project was licensed in 1961. However, the project was built in two stages. Stage I only consisted of the construction of the original Culmback Dam to provide needed water storage capacity for the City of Everett. The addition of hydroelectric generating facilities (Stage II) was not completed until 1984. Restoring anadromous fish production above the Diversion Dam was considered at length by the Joint Agencies during Stage II planning from 1978 to 1981. The effort culminated in a Settlement Agreement in 1983, wherein the Joint Agencies accepted measures to enhance salmon production in the lower Sultan River downstream of the Diversion Dam, rather than restoring anadromous fish access to the reach above the dam. This outcome relied on several factors discussed below:

1. The 6.4-mile reach above the Diversion Dam has a relatively high gradient (averaging 90 feet per mile) and is in a steep-walled canyon. As a result, the channel contains mostly bedrock and large-sized bed material with few areas of suitable spawning gravel.
2. Before construction of Stage II, spawning gravel areas in the canyon experienced frequent scour events. Flows exceeding 2,500 cfs caused considerable gravel movement and some higher flows scoured down to bedrock (Miller et al. 1984). Under natural conditions, peak flows exceeded 5,000 cfs about 5 times yearly (Eicher 1981a) and 10,000 cfs in 8 out of 10 years based on stream gaging since 1912. Because these high flows occurred during the salmon egg incubation period, historical salmon production in this reach was probably very limited when access was possible prior to the construction of the earliest diversion dam in 1916.

3. After completion of Culmback Dam in 1965, water temperatures in the reach above the Diversion Dam became too cold for productive salmon and trout growth (Eicher 1981b). Although the Project has a multi-level withdrawal outlet from the reservoir for controlling temperature of water routed through the power tunnel and discharged at the Diversion Dam and powerhouse, it is not possible to control temperature of water discharged at the base of Culmback Dam.
4. A provision for upstream fish passage for salmon and steelhead would have suggested a need for higher instream flows in the reach above the Diversion Dam. Those increased discharges from Culmback Dam would continue to flow to the river mouth and contribute to unfavorable water temperatures from March through October for salmonid rearing and egg incubation in the most productive downstream reaches.
5. A requirement for higher instream flows above the Diversion Dam for salmonid habitat would have reduced potential power production enough to make the hydroelectric project infeasible.

In summary, the Joint Agencies in 1981 decided to not prescribe fish passage at the Diversion Dam based on the prospect of greater salmonid production in the lower Sultan River with implementation of the Project's fisheries mitigation plan. That decision also recognized that a requirement for higher instream flows above the diversion dam would make the Project economically infeasible and thus unable to provide the agency-preferred enhancement measures.

2.2 Description of Diversion Dam and Operations

The Sultan River Diversion Dam at RM 9.7 is a concrete ogee-crest gravity structure measuring 25 feet high (Figure 2-1). The primary structure consists of a 120 ft wide overflow spillway and an adjacent 25 ft wide sluiceway (Figure 2-2). The center 8 feet of the sluiceway gate has been notched to create an overflow weir that can accommodate up to 280 cfs. Under normal operations all flows <280 cfs are passed through the sluice gate weir where it discharges onto a concrete apron leading to the tailwater pool. Flows in excess of 280 cfs pass uncontrolled over the ogee spillway. Because of the flow control provided by the upstream Culmback Dam, flows at the Diversion Dam rarely exceed the 280 cfs needed to force spillage at the ogee more than once a year (Table 2-1).

Figure 2-1 Photograph of Sultan River Diversion Dam at RM 9.7

Table 2-1. Monthly exceedance flows (cfs) below the Sultan River Diversion Dam (USGS Gage No. 12137800. Data from 1983 to 2003).

Month	90% Exceedance	50% Exceedance	10% Exceedance
January	145	187	223
February	165	205	263
March	193	212	272
April	188	208	247
May	180	207	226
June	140	167	191
July	110	124	153
August	97	119	144
September	132	154	186
October	170	190	260
November	120	178	940
December	114	153	266

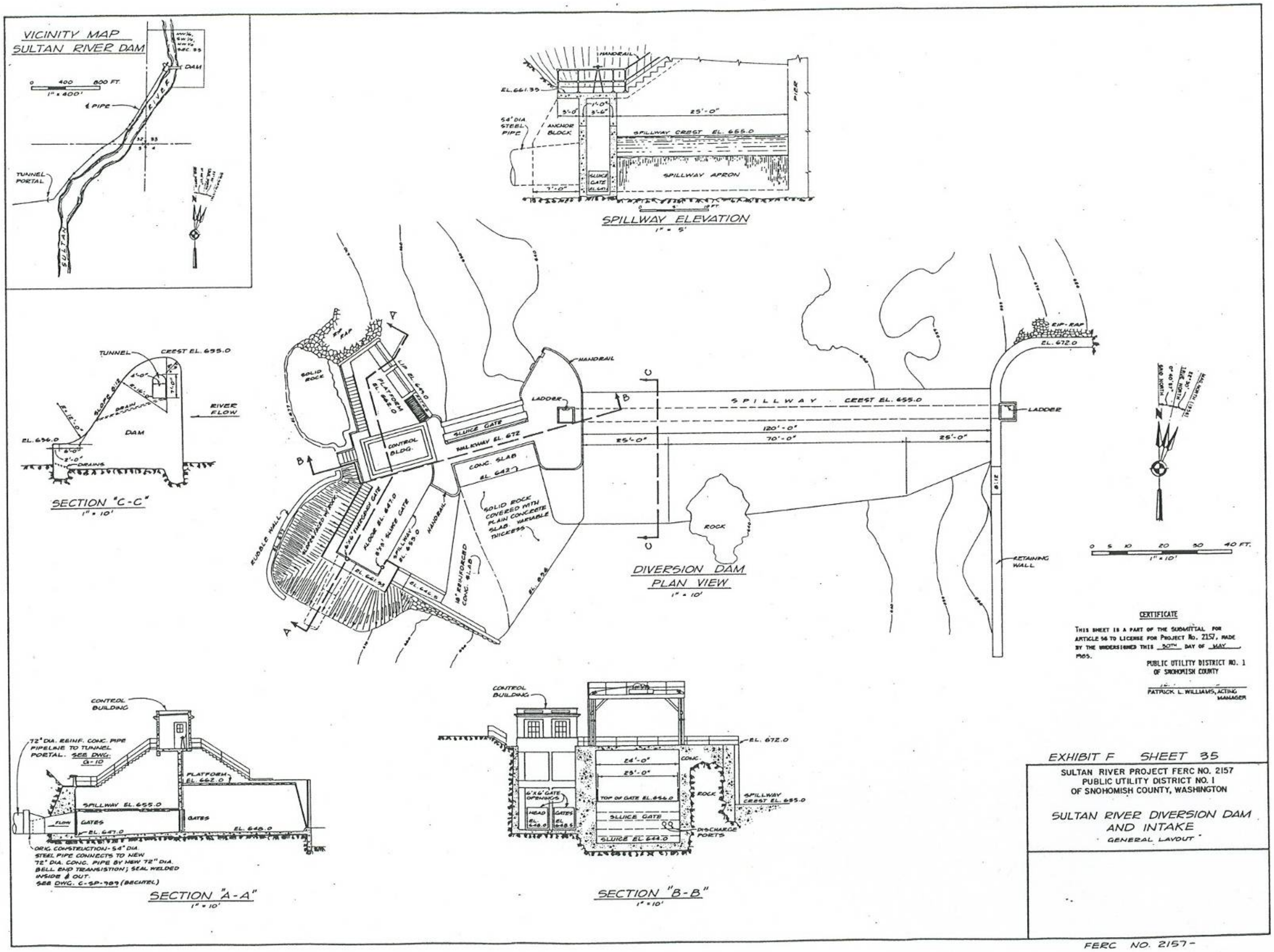

Figure 2-2. Design features of Sultan River Diversion Dam.

Under most flow conditions observed at the dam the head differential between the forebay and tailwater is approximately 20 feet. It is also possible by raising the sluiceway gate to lower the forebay water level to the elevation of the concrete sluiceway apron crest, thereby effectively reducing the head to approximately 8 to 9 feet under normal operating flows.

The Diversion Dam was originally used to divert water from the Sultan River, then route it through a pipeline and tunnel westward to Lake Chaplain for municipal water supply storage. In 1965 Culmback Dam was constructed about 7 miles upstream of the Diversion Dam to create Spada Lake and provide the City of Everett with much needed reliable water supply storage. Water was still diverted at the Diversion Dam as in the past. However, upon completion of the Stage II hydroelectric facilities in 1984 (which included raising Culmback Dam, constructing a powerhouse at RM 4.3, and building a pipeline from the powerhouse to Lake Chaplain) the function of the Diversion Dam changed considerably. Prior to completion of Stage II water for Lake Chaplain was diverted directly from the river. Now with the hydroelectric facilities in place, water for Lake Chaplain is passed through the powerhouse and from there routed by pipeline to the shore of the lake. Most of this return water is diverted into Lake Chaplain to supply the City of Everett. The remaining water in this pipeline is returned to the Sultan River at the Diversion Dam to assure that the instream flow requirements are met below that point. This water passes eastward through the same tunnel and pipeline that previously routed water westward from the river to Lake Chaplain (Figure 2-3).

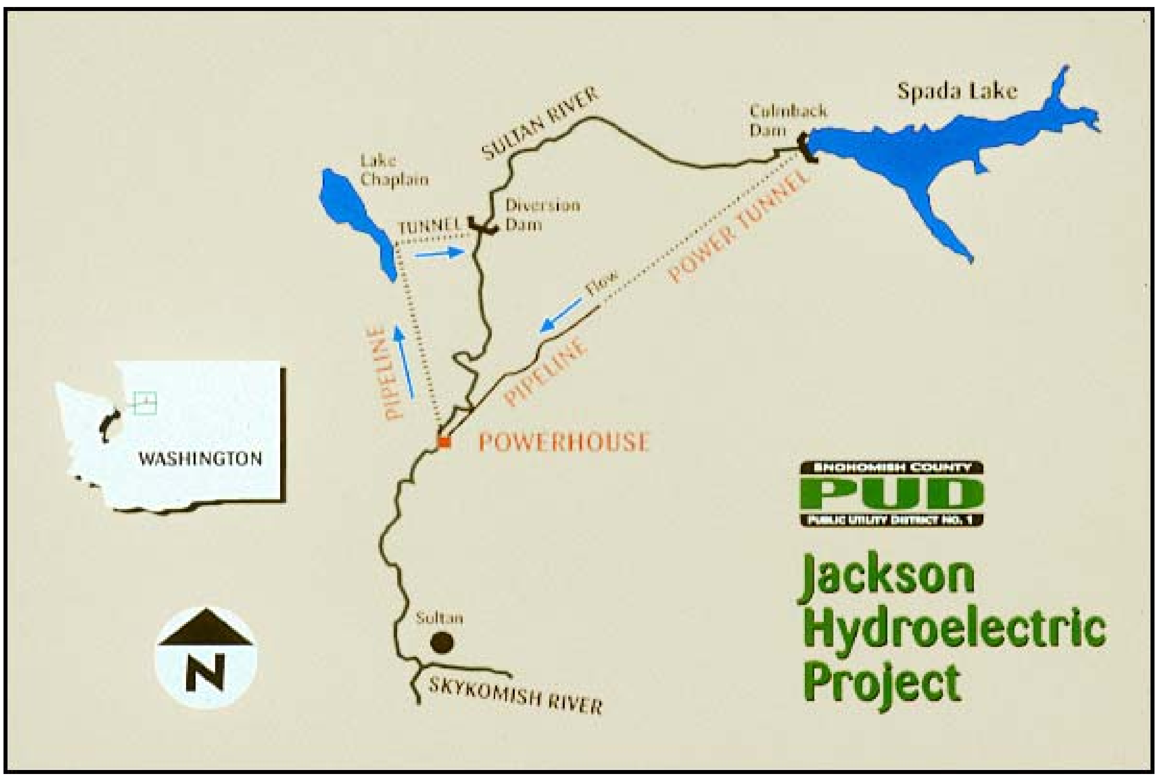

Figure 2-3. Jackson Project Facilities Map and Flow Diagram under Normal Operating Conditions.

Occasionally, the Diversion Dam is still used discretionally in its original design to divert water from the river to Lake Chaplain. This occurs on average only a few days per year during major storm events when there is sufficient inflow in the bypass reach to meet the instream flow requirements below the Diversion Dam and the City's water requirements. Also, it is critical for maintaining the City's water supply that the Diversion Dam remains in place and is functional to divert water in case the Jackson facilities associated with the power conduit, powerhouse, or Lake Chaplain return pipeline require shutdown for inspection or maintenance for more than a few days.

2.3 Description of Bypass Reach Habitat

The river channel in the Sultan River between Culmback Dam and the Diversion Dam (bypass reach) is largely confined within a narrow bedrock canyon. Channel gradients range from 0.7 to 13.7 percent and average 1.6 percent (Figure 2-4). Near RM 16.0, which is about 0.5 mile below the Culmback Dam site, the channel gradient increases dramatically, averaging 7.1 percent (over a distance of 1,700 feet), and reaching 13.7 percent over a distance of 146 feet at one location. Therefore, RM 16.0 likely represents the upstream limit of fish passage (Ruggerone 2006).

The steep gradients and confined channel in the bypass result in a high-energy system characterized by numerous cascades, riffles, and deep pools. Boulders (53.7 percent), bedrock (30.6 percent), rubble (13.2 percent), cobble (1.5 percent), and coarse gravels (1.0 percent) are the dominant substrates in the bypass (PAD 2005).

In comparison to the downstream reaches, the bypass reach most resembles the reach between the powerhouse and the Diversion Dam (RM 4.3 -9.7) both in terms of habitat

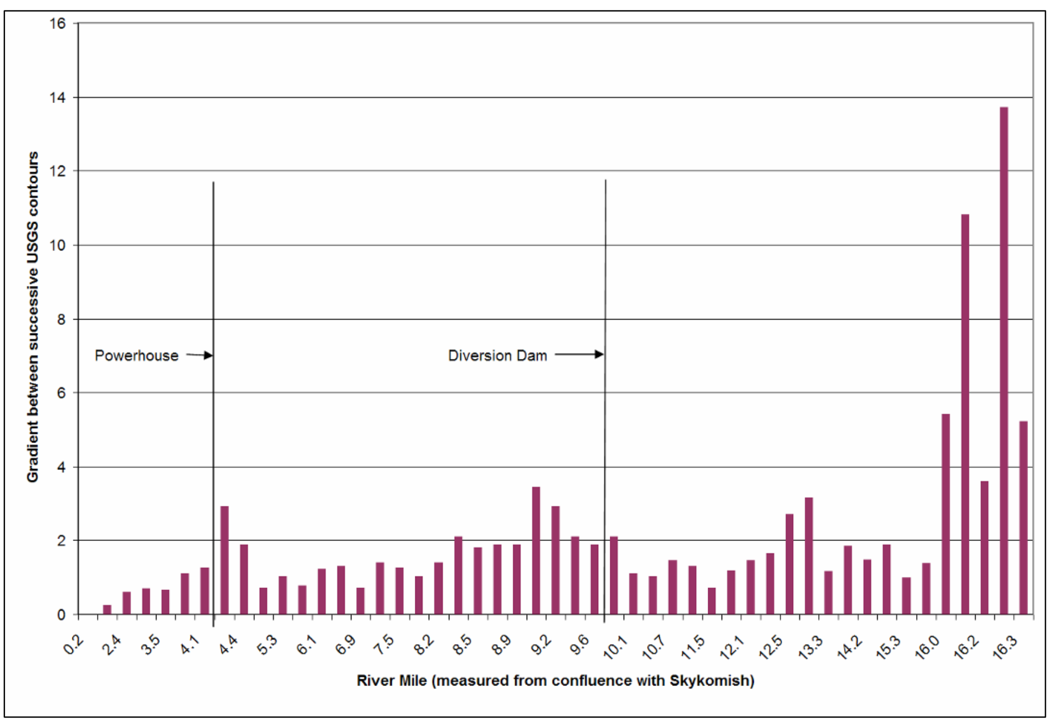

Figure 2-4. Sultan River Gradient Profile.

types (Table 2-2) and substrate composition (Table 2-3**)**. Bar edge habitat, which is important habitat for salmon fry, is most abundant in the lower reach no. 1 (34 percent) and reach no. 2 (18 percent) and least abundant in the bypass reach no. 3 (6 percent) (see Study Plan-18 Final Report, Stillwater Sciences 2008). A series of photographs of the bypass reach taken in the summer of 2007 are shown in the Study Plan 18 Final Report available at: http://www.snopud.com/water/relicensing/relicensingdocs/studyrpts. Stream flows in the bypass reach consist of low-level discharges from Culmback Dam, which are typically 20 cfs, plus surface runoff between Culmback Dam and the Diversion Dam. There are no major tributaries entering the bypass reach, but side flows can be substantial at times. At other times side flows are negligible. Estimated monthly side flows entering the bypass reach simulated by Snohomish PUD are shown in Table 2-4.

Table 2-2. Percent total surface area by main channel riverine habitat type, by reach in the Sultan River downstream of Culmback Dam.

		Percent of Each Habitat Type				
Reach	River Mile	Pool	Riffle – Low Gradient	Riffle – High Gradient	Glide	Cascade
1	0.0 to 4.3	7.5	30.8	9.9	49.9	1.9
2	4.3 to 9.7	42.8	27.6	10.6	12.7	6.2
3	9.7 to 16.5	45.1	17.6	11.4	20.9	5.0

Data source: Stillwater Sciences 2007 (Study 18)

Table 2-3. Percent visible substrate type by reach in the Sultan River, mouth to Culmback Dam.

Reach	River Mile	Percent Coarse Gravel (1 to 3-inch dia)	Percent Cobble (3 to 6-inch dia)	Percent Rubble (6 to 12-inch dia)	Percent Boulder (12-inch dia)	Percent Bedrock
1A	0.0 to 2.7	28.6	50.0	14.3	7.1	0.0
1B	2.7 to 4.3	0.0	3.1	15.0	62.7	19.0
2	4.3 to 9.7	2.3	3.7	15.0	43.3	33.7
3	9.7 to 16.5	1.0	1.5	13.2	53.7	30.6
All	Average	5.9	10.5	14.0	43.6	24.7

Source: Snohomish County PUD and City of Everett 2005 (PAD)

Table 2-4. Simulated stream flows entering the Sultan River Bypass between Culmback Dam (RM 16.5) and the Diversion Dam (RM 9.7). Does not include releases from Culmback Dam. (USGS Gage No. 12137800. Data from 1983 to 2003).

Month	Median	Mean	Minimum	Maximum
January	56	95	0	1,122
February	47	81	0	1,288
March	53	71	0	1,052
April	67	83	0	503
May	57	65	0	235
June	37	44	0	296
July	15	19	0	284
August	6	9	0	90
September	6	14	0	302
October	21	48	0	776
November	67	118	4	1,393
December	44	83	2	1,100
Data Source: Snohomish County PUD				

3.0 METHODS

3.1 Fishway Alternatives

This phase of the study consists of a screening- level assessment of alternative fishway designs for the Diversion Dam based upon the experience of fisheries engineers at similar sites coupled with an evaluation of site conditions potentially affecting the feasibility of some alternatives. Such site conditions include range of river flows, hydraulic dam height, spillway configuration, geology, and abutment features. Additional input and opinion regarding fishway alternatives was obtained from fisheries engineers and biologists from stakeholder groups during a site visit on September 12, 2007.

For each alternative we provide a brief physical description of the facility, an order-of-magnitude cost estimate, a list of pros and cons, and other pertinent comments regarding the technology's feasibility and potential acceptability for the site. Some technologies that clearly are not acceptable for the site are simply noted. No site-specific drawings are provided in this phase, but generic sketches and/or photographs from other sites are included.

3.2 Anadromous Fish Production Estimates

3.2.1 Overview of Approach

Fish production potential is estimated for fall Chinook salmon, coho salmon, and steelhead trout. Determining production potential for these species above the Diversion Dam requires an understanding of the potential limiting factors in fresh water. Summer rearing habitat often is considered the limiting factor for those species that spend at least one year in fresh water. These include coho (1 yr) and steelhead (typically 2 years), and to some extent fall Chinook populations in the Snohomish system, where about 5 percent of the juveniles remain in the riverine system for one year (Snohomish Basin Salmon Recovery Forum 2005). For these species winter rearing/refuge habitat also can be a limiting factor, but typically the juveniles will migrate out of their summer rearing areas in the fall and seek suitable winter habitat in downstream areas such as off-channel ponds (especially coho), deep pools and small tributaries (steelhead), and estuaries (Chinook).

For fall Chinook, availability of good spawning habitat and safe incubation conditions (minimal scour and embededness) are typically considered the major population-limiting factors in freshwater. Peak winter flow that can scour eggs out of the spawning gravels is an important limitation on these salmon populations. As a result, fall Chinook tend to spawn in lower gradient reaches or in areas such as side channels that provide greater protection from high flows. It has long been recognized for Chinook spawning that some areas or reaches of a stream are more heavily utilized year after year than other areas and thus serve to functionally control the spatial structure of the population within the river system. These locations have been defined as core habitat areas (Martin, Benda, and Shreffler 2004). Criteria for a core habitat in rivers are associated with features that are 1) temporally persistent, 2) biologically suitable, 3) located within or adjacent to a migratory corridor and accessible most of the time. These areas favor habitat occupation and high survival. For example, a specific habitat feature that is geomorphically persistent, forms a large spawning area, and is located on the migratory corridor is more likely to consistently contribute to population production than is a habitat that is associated with a more ephemeral feature and is located a long distance from other habitats with core characteristics. Recognition of this core area concept is important in evaluation the effective Chinook salmon production potential that might be achieved if fish passage was provided at the Diversion Dam on the Sultan River.

In most cases salmonid production potential is estimated in terms of juvenile or smolt numbers per area or length of stream. Production also can be estimated for adult fish, such as number of returning spawners plus harvest, but such estimates require consideration (assumptions) of survival factors outside of their source stream, such as in the downstream migration corridor, estuary, ocean, and harvest. Still, it is common to apply a smolt-to-adult return (SAR) survival assumption to a number of smolts while recognizing that the SAR can be highly variable from year-to-year or stream-to-stream. Use of a SAR assumption is most supportable in streams having good spawning escapement and harvest rate estimates that can be used to provide a “reality check” on the SAR. In the case of the Sultan River excellent adult spawner escapement data and harvest rate assumptions are available for fall Chinook salmon and steelhead trout, but not for coho salmon.

Two general approaches are used to estimate fish production potential for the Sultan River bypass reach:

Habitat based approach: This approach uses a measurement of the amount of habitat available to a limiting life stage of the species of interest and calculates production (usually juveniles or smolts) per unit of habitat using available formula. This approach is used most often for coho salmon and steelhead trout.

Comparative-based approach: This approach consists of reviewing current adult production in the lower Sultan River and scaling that production to the bypass reach based a comparison of habitat conditions between the two reaches. This approach works well for Sultan River Chinook and steelhead because excellent spawner data are available for these two species. For scaling, different measures of habitat can be used such as a simple stream length, surface area of defined spawning or rearing habitat, or quantified “weighted usable area of habitat” (WUA) as determined by PHABSIM modeling.

Fish production estimates derived from any approach can be subject to significant uncertainties based on site-specific conditions other than the simple habitat variables assumed in the calculations. There are several such qualifiers for the Sultan River bypass reach. These include partial migration barriers (e.g. Marsh Creek cascade), water temperature, and winter conditions. Each of these factors is discussed as they pertain to the estimates of production potential for each species. In addition, we have not considered the effect that alternative instream flows in the bypass might have on production potential except in the estimating approach where Chinook and steelhead production is tied to WUA. In most cases, production potential estimates are based on variables (e.g. stream length and width) that are not expected to vary significantly with flows within a reasonable range.

Specific methods used to estimate anadromous fish production potential above the Diversion Dam are described below for each species.

3.2.2 Coho Salmon

Adult coho salmon escapement estimates are not available for the Sultan River. Therefore, a habitat-based approach was used to estimate production.

Several commonly used methods have been developed for application in Washington and Oregon to estimate coho smolt production. Washington Department of Fisheries published one of the most commonly used methods (Zillges 1977), which assumes a smolt potential of 0.50 smolt/m^2 of surface area for streams less than 5.5 m wide and 2.3 smolts/m of linear length for larger streams. The rearing potential for larger streams was based on studies conducted on the Big Qualicum River in British Columbia by Lister and Walker (1966). Baranski (1989) estimated smolt production for 10 Puget Sound streams based on smolt trap counts. His estimates were generally lower than those of Zillges, ranging from 0.08 to 0.26 smolts/m^2 with an average of 0.18/m^2. He found the highest density, 0.23 smolt/m^2, in streams of moderate gradient of 1-2 percent. All of the streams studied by Baranski were relatively small compared to the Sultan River.

Several studies have applied habitat features to estimate coho smolt production. Beechie et al. (1994) considered pools, riffles, ponds, and side channels, with the highest density (0.425 smolt/m^2) in pools. Nickelson (1998) also found much higher coho densities in pools, and subsequently defined 8 types of pools for which to estimate coho densities in Oregon coastal streams. He also estimated coho smolt production on the basis of winter habitat where highest coho production occurred in off-channel alcoves and beaver ponds. Both of these methods were based on studies of small streams and thus are not applicable to the Sultan River.

The review by Beechie et al. (1994) noted that there is only limited information available on coho production in larger streams. They cite the 2.3 smolt/m in Zillges (1977) and provide estimates from WDF unpublished data for the Bogachiel River (0.30 smolt/m) and the Skagit River in winter (0.34 smolt/m). They subsequently concluded that 0.60 smolt/m was appropriate for the Skagit River.

The Sultan River is not believed to support a high density of coho salmon compared to other streams in the Snohomish basin based on results of limited spawning surveys (CH2M HILL 2005). However, the river probably can support higher rearing densities than the mainstem Skagit River. Therefore, we conclude that an average of the Beechie et al. value applied to the Skagit River (0.60/m) and the Zillges large-stream value (2.3/m) would be most appropriate for the Sultan River bypass. This results in a smolt density estimate of 1.45 smolt/m of accessible stream length.

3.2.3 Fall Chinook Salmon

There are several habitat-based methods available for estimating production of stream-type Chinook salmon, i.e. those that rear for one year in freshwater. However, most fall Chinook in the Sultan River express an ocean-type life history, meaning that the juveniles typically rear in fresh water for only a few months. For fall Chinook, general habitat-based methods have not been found to be useful or accurate. The amount of available spawning habitat or emergent fry habitat has sometimes been used, but what is defined as suitable (e.g. WUA) may not actually be usable or preferred by the fish when considering the importance of core areas factors, as discussed previously In Section 3.2.1.

For the Sultan River bypass we concluded that a realistic means to estimate fall Chinook production is to use a comparative-based approach with the available spawning survey data from the lower river scaled with spawning habitat defined in terms of available gravel/cobble substrate or as WUA. Also, as a means of considering rearing habitat, we scaled comparative adult production on the basis of salmonid fry habitat as represented by bar edge habitat. Bar edge habitat, which is defined as gravel bars along stream margins, was quantified in SP 18 (Stillwater Sciences 2008) because if its importance as rearing habitat for emergent juvenile salmon during the spring and early summer. These two habitat scaling methods provide production estimates in terms of adult escapement. Reasonably good estimates of yearly harvest rates for Snohomish basin Chinook are available (Snohomish Basin Salmon Recovery Forum 2005) that were applied to the escapement data to yield total (catch plus escapement) estimates.

As with other salmon species, historical use by Chinook of the now-defined bypass reach was probably limited by poor spawning success due to the frequency of high gravel-scouring flows and a limited gravel supply. However, because these adverse conditions have largely been eliminated by the current Project operations, our estimated Chinook production is based on the assumption that future flows in the bypass will be maintained at below-scour levels at the same frequency as now provided by the Project.

3.2.4 Steelhead Trout

The most widely used method for estimating steelhead production in western Washington is Gibbons et al. (1985) developed for the Washington Department of Wildlife. This WDW Steelhead Methodology is similar to the habitat-based methods used for coho salmon except it estimates parr production rather than smolt production. Converting parr estimates to smolt estimates requires an assumption about overwinter survival. For this we assumed an overwinter survival of 50%, which is within the range observed in the literature (Everest et al. 1985, Kiefer and Lockhart 1995, Ward and Slaney 1988, Chilcote et al. 1984). The Steelhead Methodology is well suited for estimating steelhead production in the Sultan River because it allows adjustments for moderate sized rivers like the Sultan and can be applied to different stream gradient zones. The methodology was based on steelhead parr density estimates made at 18 stream sites with stream flows ranging from 41cfs to 620 cfs. The parr utilization rates (parr/100 m^2) by gradient zone on mainstem rivers are shown in Table 3-1.

Table 3-1. Gradient zones and steelhead parr utilization rates (parr/100 m^2) used to calculate potential parr production for mainstems of western Washington rivers.

Gradient Zone	Gradient per Cent	Steelhead Parr per 100 m^2
1	0.00-0.25	1.05
2	0.26-0.5	2.07
3	0.51-1.0	4.10
4	1.1-3.0	6.68
5	3.1-5.0	6.68
6	5.1-7.0	--
7	7.0	--
Source: Gibbons et al. 1985		

In addition to a straightforward habitat-based estimate of steelhead production in the bypass, we also used a comparative-based approach to validate the bypass estimates. This was done by estimating steelhead smolt production for the lower river and assuming a reasonably supportable smolt-to-adult survival rate to see if the results of the Steelhead Methodology agree well with the actual adult return data.

4.0 RESULTS AND DISCUSSION

4.1 Upstream Fishway Alternatives

4.1.1 Alternatives Considered Unacceptable for Site

Fishway designs are generally categorized as 1) pool-and-weir, 2) vertical slot, 3) baffle, or 4) locks/lifts (Clay 1995). For the Sultan River Diversion Dam a fish lock/lift system would not be appropriate. Also, a baffle-type fishway, such as a Denil or Alaska steep-pass, would not likely be acceptable to the agencies with fishway prescription authority. These baffle design fishways are used typically for temporary situations, such as during dam or fishway construction, or at steep sites where limited access precludes construction of a more conventional fishway.

In terms of site constraints, the left (east) side of the dam would not accommodate the construction of any fishway. There would be no reasonable construction or maintenance access to this side of the dam, and there would be no room to accommodate a conventional fishway. Also, the bank is essentially a cliff that would become unstable and unsafe with any construction activity. In addition, this side of the dam and tailwater is not conducive to the attraction of migrating fish. As currently operated under most flow conditions, all of the discharge occurs along the right bank of the dam, and a natural fish holding pool occurs there as well.

Two optional approaches were identified for fishway alternatives at the Diversion Dam. One option would be to construct a fishway that would accommodate the full 20-ft operating head of the dam in its current configuration. The second option would be to lower the water level behind the dam to the minimum that can be controlled with the current sluiceway gate. This would produce an effective head of only 8-9 ft. Construction of a smaller fishway would be less costly and could provide easier passage for fish as well. A decision to lower the water level behind the dam to accommodate a smaller fishway would have to consider the possibility that the water level may have to be raised following shutdown of the powerhouse in order to route water to Lake Chaplain. During such events the fishway would not pass fish. This lowered forebay approach also would need to deal with the energy dissipation and false attraction flow associated with water coming from the Lake Chaplain pipeline/tunnel. Furthermore, and perhaps most importantly, any type of fishway constructed in the existing sluiceway would reduce the ability to 1) sluice accumulated gravel out of the forebay near the water intake trash racks and 2) pass the large woody debris that becomes mobile during infrequent but certain high flow events.

Fishway alternatives for the full-head and lowered-head options are discussed below.

4.1.2 Full-Head Alternative

The Diversion Dam under its full-head (20-ft) configuration would be conducive from constructing a conventional pool-and-weir or vertical slot fishway on the right bank. Both types of fishway designs would have similar footprints and cost. Most recent fishways constructed for anadromous salmonids have been of the vertical slot design. Therefore, our discussion will focus on a vertical slot fishway, while noting that a pool-and-weir type is still an alternative until a further determination is made by the prescription agencies. An example photograph of a vertical slot fishway is shown in Figure 4-1.

A vertical slot fishway with an assumed 1:10 slope would be approximately 200 feet long. This type of fishway would require 30 to 40 cfs for the fishway itself and potentially another 80 cfs for attraction water. The attraction water system is normally a requirement where upstream migrating fish have competing spillway or powerhouse flows to deal with. An attraction water system may not be needed in this case due to the low flows coming from the sluiceway most of the time. Normally, the fishway is expected to be operable between the 5% and 95% flows on the daily flow duration curve during the fish migration season. These design river flows have not been determined as yet for this project pending input from the fisheries agencies on the unusual man-made nature of the hydrograph at the Diversion Dam.


Figure 4-1. Example Photograph of a Vertical Slot Fishway.

The fish entrance be located adjacent to the existing pool at the base of the sluiceway apron (see Figure 2-1). Current discharges through this sluiceway are ideally located to provide attraction flow to the fishway entrance; however, they may also cause false attraction. This issue would need to be resolved with experienced fish passage engineers during the design phase. At this phase of study we have assumed that an attraction water system is to be included in the project. To accommodate the fishway length, the pools would first lead the fish downstream and then double back in the upstream direction towards the fishway exit.

The fishway exit (upstream) would need to be tied into the current portal discharge area. Because water in the portal area normally flows in the opposite direction from what would be needed for the fishway, a divider wall would be constructed in the portal area to separate the flows. Fish would exit into the forebay at a location near the current trash racks. While there may be some tendency for fall back at this location during high flow events, it is considered to be technically infeasible to route the fishway exit further upstream in the forebay due to the steep terrain and existing water supply infrastructure.

4.1.3 Lowered-Head Alternatives

Two alternative fishway designs have been identified for the lowered-head option. One would be a conventional vertical slot fishway built into one side of the current sluiceway. Assuming that the fishway is approximately 12 feet wide it would take up about half of the sluiceway width. Water in excess of the fishway need would discharge into the tailwater pool adjacent to the downstream entrance of the fishway, thus providing ideal attraction flow conditions. The fishway would be approximately 80 feet long with no turns assuming a 1:10 slope. Because a vertical slot fishway operates within a relatively narrow range of flow, hydraulic control facilities (e.g. gates) will need to be included in the design of the fishway exit (upstream). It is likely that the existing sluiceway and gates will need to be rebuilt to accommodate the fishway and to maintain the required discharge controls at the dam.

The second alternative fishway design identified for the lowered-head option is a pool-and-chute fishway. This fishway is a type of pool-and–weir fishway but the weirs are triangular shaped (Figure 4-2**)**. It was developed to provide effective fish passage over a large range of flows and upstream water levels without requiring auxiliary flows in the

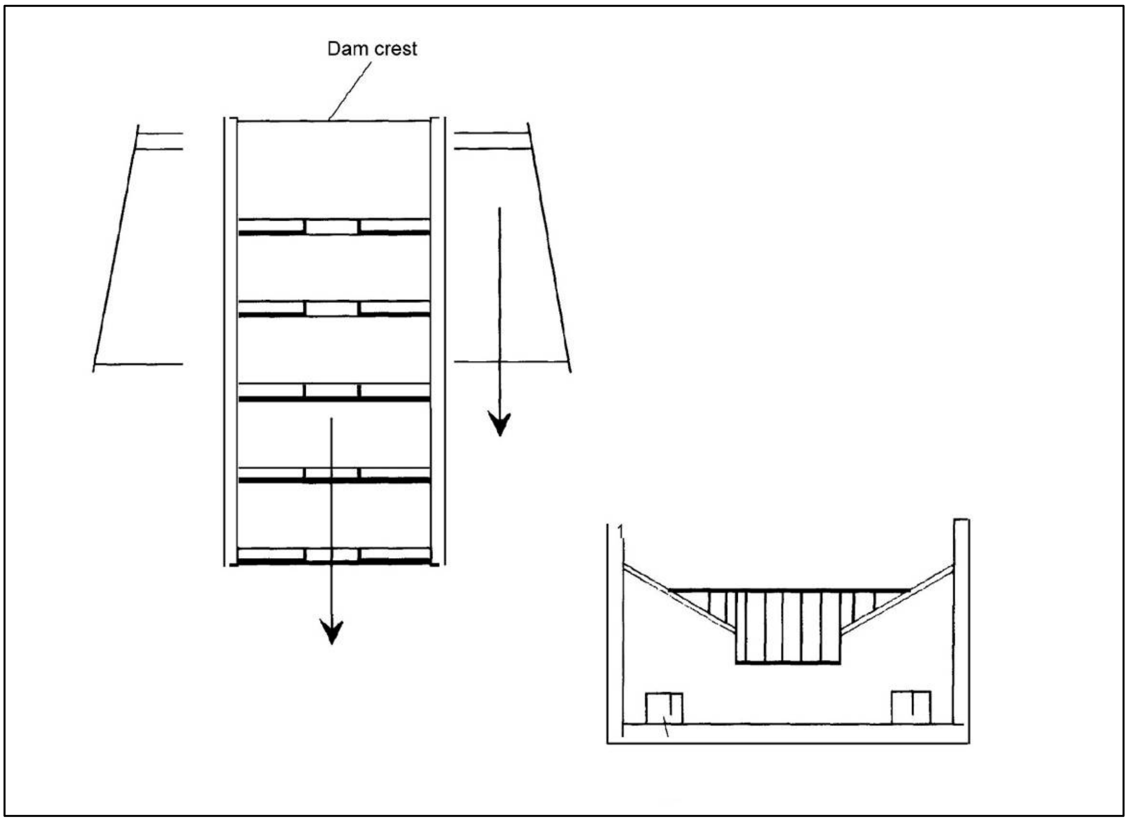

Figure 4-2. Design Sketch of a Pool-and-Chute Fishway.

downstream section or any control device regulating the flow pattern. At low flows the fishway operates like a classic fishway with plunging flow. At higher flows good fish passage conditions are maintained along the edges of the pools (containing submerged orifices) while the high velocity streaming flows forms in the center of the fishway. Fish have a choice of passing through the submerged orifices along the pool edges or through the center weir. The slope of the fishway can be as high as 20 percent but are typically less. This fishway alternative also would be built into the existing (modified) sluiceway at the Diversion Dam.

The amount of resting area for migrating fish in a pool-and-chute fishway is limited especially at higher flows. Therefore, their application has been limited to low-head sites up to 8 or 9 feet. Examples of pool-and-chute fishways are provided in Figure 4-3.

4.1.4 Comparison of Fishway Alternatives (Pros and Cons)

The pros and cons comparing the three general types of fishways are presented in Table 4-1. The option of lowering the head differential of the dam clearly has a cost advantage over a full-head option regardless of design type merely because of the need for a smaller facility. A shorter fishway built into the existing sluiceway also would provide easier passage for fish with less potential for delay.

4.1.5 Cost Estimates and Constructability

4.1.5.1 Cost

The estimated cost of a full-head (20 ft) vertical slot fishway at the Diversion Dam is $180,000/ft (2008 dollars) for a total of $3.6 million. This estimate represents total cost, which includes construction, construction contingency (20%), engineering design (10%), legal and administrative (5%), and services during construction (10%). Operational and maintenance costs are not included but would be expected to be minimal. If any fish counting facilities or fish handling requirements are included with the fishway, the associated additional costs would need to be incorporated.

For the low-head alternatives, we assumed that the cost per foot used above would have to be increased by 50 percent to include the significant modifications to the sluiceway. Costs would be similar for either the vertical slot or pool-and-chute fishway at this location. Assuming an 8-ft head and $270,000/ft, the total cost estimate of either low-head alternative is $2.16 million.

4.1.5.2 Constructability

Construction of a full-head fishway would require considerable earth removal on the right bank between the tailwater pool and the portal area. It is possible that the location contains some bedrock. Special precautions also would be needed during construction to ensure the integrity and continued operational need of the existing tunnel and portal basin.

Figure 4-3. Example Photographs of Pool-and-Chute Fishways.

Table 4-1. Fishway pros and cons.

Fishway Type	Pros	Cons
Pool and Weir	1. Proven technology / longest track record 2. Resting area in each pool	1. Operates within narrow flow range 2. Need for flow control mechanism/sections 3. Requires considerable space 4. Submerged orifices easily clogged 5. Fish passage is only along the bottom (through orifices) 6. Typically need attraction flow to help fish find entrance 7. Requires slope of 10% or less
Vertical Slot	1. Most common/contemporary type in NW (and world) 2. Tolerate major variations in upstream and downstream water elevations 3. Allow fish passage at any depth 4. Provide resting areas in each pool	1. Operates within narrow flow range 2. Need for flow control mechanism/sections 3. Upstream water entrance subject to debris clogging 4. Typically need attraction flow to help fish find the entrance 5. Requires slope of 10% or less 6. Construction of a full-head fishway at Sultan Diversion Dam site would require considerable excavation with potential bedrock problems
Pool-and-Chute	1. Handles wide range of flows (~6X) so suited for sites with little or no flow control 2. Self cleaning – readily passes debris and gravel 3. Improved attraction flow (provides its own) compared to alternatives 4. Can be designed for up to 20% slope 5. Two passage options: submerged orifices (pool) or notch weir (chute) 6. Diverse passage routes for adults and juveniles 7. Relatively simple and less costly to construct	1. Relatively new technology with shorter track record 2. Design criteria only recently developed and tested under limited conditions 3. Only minimal resting area in pools so height limit (to date) of 8 ft (without intermediate resting pools) 4. Scour potential at outlet 5. Installation in the existing sluiceway may impede ability to sluice sediment buildup in front of water intake area

For the low-head alternatives, the primary construction challenge will be working within the constraints of the existing sluiceway. Much, and perhaps all, of the concrete apron would need to be replaced. The fishway exit would need to be designed and constructed such that the function of the sluice gate is not impaired. It is possible that a fishway built into the sluiceway would seriously affect the ability of the system to remove gravel buildups, thereby precluding any such low-head fishway alternative. Further investigation of this concern would be needed if Phase 3 is conducted.

4.2 Fish Production Estimates

4.2.1 Chinook Salmon

To estimate fall Chinook production potential for habitat above the Diversion Dam we utilized the 1991-2007 adult escapement data for the lower river below the Diversion Dam (Table 4-2) and scaled these spawner estimates (average of 508) to the bypass reach based on ratios of available spawning habitat as well as available rearing habitat between the above- and below-Diversion-Dam reaches. This scaling approach should provide optimistic estimates of Chinook production because it is based on current production in the lower river that has benefitted from several Project-provided enhancements (CH2M HILL 2005).

Table 4-2. Sultan River adult escapement estimates for Chinook salmon and steelhead trout (1991-2007).

Year	Chinook	Steelhead
1991	235	NA
1992	338	NA
1993	353	261
1994	520	310
1995	563	295
1996	610	301
1997	326	332
1998	705	300
1999	690	574
2000	537	205
2001	435	66
2002	714	107
2003	510	126
2004	937	228
2005	298	78
2006	546	140
2007	324	NA
Average	508	237

Source: Snohomish County PUD

4.2.1.1 Spawning Habitat Approach

For the spawning habitat approach we use the estimated length of stream containing substrate of large gravel (1-3 inch) and cobble (3-6 inch) as reported in the PAD (2005). First we converted the percent of each reach consisting of gravel and cobble to river-mile equivalents with these substrates (Table 4-3). We then grouped the reaches into a lower section (RM 0.0-9.7) and the upper bypass section (RM 9.7-16.0). This resulted in total spawnable substrate estimate of 2.49 miles-equivalent in the lower section and 0.17 miles-equivalent in the bypass. Applying the above-dam to below-dam ratio of spawnable habitat (0.17/2.49) to the average number of Chinook spawners (508) for the lower reach yields a production estimate for the bypass reach of **35 adult spawners**.

Table 4-3. Visible gravel-cobble (GR-CB) substrate by reach in the Sultan River.

Reach	River Mile	Miles	Percent GR-CB	Miles-equivalent GR-CB	Total
1A	0.0 to 2.7	2.7	78.6	2.12	2.49
1B	2.7 to 4.3	1.6	3.1	0.05	
2	4.3 to 9.7	5.4	6.0	0.32	
3	9.7 to 16.5	6.8	2.5	0.17	0.17

Gravel = 1-3 inches diameter; Cobble = 3-6 inches diameter

Source: Pre-Application Document 2005

4.2.1.2 Rearing Habitat Approach

For the rearing habitat approach we used the estimated shoreline length of bar edge habitat (BEH) as reported in the results of Study 18 (Stillwater Sciences 2008). The bypass reach contains 3,865 ft of BEH shoreline (Table 4-4). This compares to 27,504 ft below the Diversion Dam. Applying the above-dam to below-dam ratio of BEH to the 508 average number of Chinook spawners for the lower reach yields a production estimate for the bypass reach of **71 adult spawners**. This estimate is approximately twice that obtained from the spawning habitat approach, but both estimates reveal that the production potential for Chinook salmon in the bypass reach is relatively minor compared to the lower river because of the lesser amount of spawning and fry rearing habitat in the bypass.

Table 4-4. Bar Edge Habitat (BEH) in the Sultan River.			
River Reach	Length of Bar Edge (ft)	Percent BEH within Reach	Percent BEH of Total
No. 1 (RM 0.0-4.95)	17,772	34	56.7
No. 2 (RM 4.95-10.07)	9,732	18	31.0
No. 3 (RM 10.07-16.17)	3,865	6	12.3
Total	31,369		100.0
Data Source: Study 18: Riverine, Riparian and Wetland Habitat Assessment Technical Report. 12/27/2007.			

The Chinook salmon production estimates above are computed in terms of adult escapement to the Sultan River and do not account for harvest. For the period for which escapement data are available (1991-2007) the harvest rate for Snohomish Basin Chinook salmon averaged approximately 40 percent (Snohomish Basin Salmon Recovery Forum 2005). Applying this harvest rate to the spawner estimates above yield total catch-plus-escapement estimates of **58** and **118 Chinook** for the bypass reach using the two estimating approaches, respectively.

4.2.1.3 WUA Approach

A PHABSIM instream flow study was recently completed for all three reaches of the Sultan River (Study Plan No. 3 - R2 Resource Consultants 2008). Results are depicted as Weighted Usable Area (WUA) of habitat as a function of flow for the various salmonid species and life stages. These habitat indices incorporate preferred water depth, water velocity, and streambed substrate in defining habitat, and therefore, provide a more complete measure of habitat suitability compared to the more simplistic habitat descriptors used in the other fish production estimating approaches. These WUA results for Chinook salmon spawning and steelhead trout rearing were used to scale the current known production of these two species in the lower river to the bypass reach. The WUA values corresponded to the approximate median flows as developed by the District's hydrologic model for each of the three river reaches for the appropriate life stage time periods (Chinook spawning – September-October, steelhead rearing – June –September). These WUA values, depicted as total surface acres within each reach, are presented in Table 4-5. In addition to these approximate existing flows, we also considered an alternative flow of 100 cfs for the bypass reach to demonstrate the effect of increasing the existing flows. The 100 cfs alternative also was used in a water temperature model to predict temperature changes that would be expected to result from such flows in the bypass - see discussion in Section 4.3.2.

Table 4-5. Weighted Usable Area (acres) for fall Chinook salmon spawning and steelhead trout juvenile rearing by river reach at approximate median flows. Source: R2 Resource Consultants 2008.

Reach	Chinook Spawning[a]		Steelhead Rearing[b]	
	Flow (cfs)	WUA	Flow (cfs)	WUA
1	385	19.30	365	13.47
2	195	11.50	150	9.84
3	30[c]	1.46	30[c]	1.46
	100[d]	5.45	100	3.46

[a]Chinook spawning period September – October

[b]Steelhead rearing period June – September

[c]30 cfs is the approximate current flow condition in the bypass during summer and fall, consisting of 20 cfs release at Culmback Dam plus accretion.

[d]100 cfs is an arbitrary alternative flow used to demonstrate effect of increasing the current bypass flow.

The combined WUA in reaches 1 and 2 for Chinook spawning is 30.8 acres. Applying the average spawning escapement of 508 adults yields a unit estimate of 508/30.8, or 16.49 adult Chinook per acre of WUA. Applying this ratio to the WUA for the bypass reach yields the following estimates:

@ 30 cfs: 16.49 adults/WUA **X** 1.46 acres = **24 Chinook spawners**

@ 100 cfs: 16.49 adults/WUA X 5.45 acres = **90 Chinook spawners**

Applying an average harvest rate of 40 percent yields total Chinook production estimates of **40 adults and 150 adults**, respectively for the 30 cfs and 100 cfs flow alternatives.

4.2.2 Coho Salmon

Coho salmon would likely utilize available habitat above the Diversion Dam. Although not considered prime habitat for coho rearing because of the high gradient of the river, the limited amount of woody debris, and the near-lack of small tributaries and side channels, some coho production would undoubtedly occur. This assumes that enough adult coho are able to successfully pass the Marsh Creek cascades and pass above the Diversion Dam to fully seed the bypass reach. Also, our initial estimate of coho production potential is based only on physical habitat available in the summer. It does not include the likely consequences of the cold water temperatures or the limited amount of winter habitat in this reach. These uncertainties are discussed later in Section 4.3.

The gradient of the bypass reach increases to about 7 percent at RM 16.0. Therefore, we assume that 6.3 mile (RM 9.7 – 16.0) could be used by coho salmon. This equates to a stream length 10,137 meters. Using the 1.45 coho smolt/m value (see Section 3.2.2) yields a potential smolt production estimate of:

10,137 m **X** 1.45 smolts/m = **14,700 coho smolts**

By comparison, the lower 9.7 miles of the Sultan River would be expected to yield 22,631 coho smolts using the same production estimator.

Estimating adult coho salmon production for the bypass reach requires an assumption of smolt-to-adult return rate (SAR – includes harvest), which tends to vary greatly from year to year. Assuming an average SAR of 5 percent, for example, would yield a production potential of **735 adult coho salmon** from the bypass reach.

4.2.3 Steelhead Trout

Historically, steelhead trout were probably the anadromous species most able to successfully utilize the Sultan River between RM 9.7 and 16.0. Steelhead spawn in the spring after most high-flow events have passed, thereby allowing them to avoid the high egg scour potential. Also, juvenile steelhead, compared to salmon, tend to rear most successfully in high gradient, large bed-element streams such as the Sultan River bypass.

Steelhead trout production potential in the bypass reach was estimated using both a Washington Steelhead Methodology habitat-based approach (Gibbons et al. 1985) and a comparative-based approach using recent spawner escapement estimates for the Sultan River. In addition, we used WUA for steelhead juvenile rearing as a means to estimate potential production in the bypass by scaling the known adult production in the lower river per WUA to the bypass reach.

4.2.3.1 Rearing Habitat Approach

The Steelhead Methodology provides parr estimates for five different stream-reach gradient zones. The bypass reach, at 1.6 percent average gradient, falls into the 1.1-3.0 percent zone, which equates to the highest steelhead parr production potential. In this zone the parr utilization rate is 6.68 parr/100 m^2. Based on 10,137 m of accessible length (6.3 miles) and an average width of 15.5 m (Study 18), the bypass contains 157,124 m^2. The resultant steelhead parr estimate is:

RM 9.7-16.0: 157,124 m^2 **X** 6.68 parr/100 m^2 = **10,496 parr**

An assumed parr-to-smolt ratio of 0.50 results in an estimated production potential of **5,248 steelhead** smolts for the bypass reach.

Like coho salmon, steelhead trout SAR ratios are highly variable. There are years when it can exceed 10 percent, but in the last two decades it has declined to an average of about 1 percent for Puget Sound winter steelhead (WDFW 2007). Although this average SAR is for hatchery smolts, limited data outside of Puget Sound indicate that hatchery and wild

SARs are similar (WDFW 2007). A 1 percent SAR applied to the smolt estimate results in an estimate for the bypass reach of **52 adult steelhead**.

To provide a reality check of this above estimate we used the same approach and assumptions to estimate adult steelhead production in the currently accessible reaches below the Diversion Dam. This was then compared with average adult escapement for years 1993 -2006. The computation of parr potential required a different parr density value (4.10 parr/100 m^2) for the lower 2.7 miles than for the upper 7 miles (6.68 parr/100 m^2) because of different gradient zones per Gibbons et al. (1985). The parr estimates are:

RM 0.0-2.7: 99,478 m^2 X 4.1 parr/100 m^2 = 4,079 parr

RM 2.7-9.7: 212,871 m^2 X 6.68 parr/100 m^2 = 14,220 parr

Total RM 0.0-9.7: **18,299 parr**

Assuming a parr-to-smolt ratio of 0.50 and a 1 percent SAR, results in an estimate of adult production for the lower river of 91steelhead. This estimated number of adult steelhead is considerable less than the average estimated escapement to the Sultan River of 237 spawners between 1993 and 2006 (see Table 4-2). Possible reasons for this discrepancy include 1) the SAR for the Sultan River generally may be higher than other streams in Puget Sound, 2) the SAR for wild Sultan River smolts may be higher than Puget Sound hatchery smolts, 3) the adult steelhead escapement estimates for the Sultan River may include a number of hatchery fish, and 4) the production of steelhead in the lower Sultan River may be greater than that in the other streams used in the Gibbons et al. methodology because of more favorable instream flows and water temperatures provided by the Project's current enhancements measures.

During the period for which steelhead spawner estimates are available for the Sultan River the harvest rates for the Snohomish system averaged only about 5 percent (WDFW 2008) as a result of wild-fish harvest restrictions imposed during most of this period. To convert the spawner estimates above to total catch-plus-escapement estimates would require a simple 5 percent increase.

4.2.3.2 WUA Approach

The lower Sultan River (Reaches 1 and 2) under median flow conditions for the June-September period provides 23.31 acres of juvenile steelhead trout rearing habitat as defined by WUA (see Table 4-5). Assuming an average spawner escapement of 237 adult steelhead yields a unit estimate of 10.17 steelhead per acre of WUA. Applying this ratio to the WUA for the bypass reach yield the following estimates:

@ 30 cfs: 10.17 adults/acre of WUA **X** 1.46 acres = **15 adult steelhead**

@ 100 cfs: 10.17 adults/acre of WUA **X** 5.45 acres = **35 adult steelhead**

These WUA-based estimates are somewhat lower than those derived from the more simplistic Gibbons et al. approach presented above.

4.2.3.3 Resident Trout Vs Steelhead Parr Estimates

Another reality check on the estimate of steelhead parr production for the bypass reach is its comparison to the estimated number of resident rainbow trout currently occupying the reach. Such a comparison is applicable because the rearing requirements of resident rainbow trout are essentially identical to those of juvenile steelhead trout, and one would assume that steelhead trout would totally displace resident rainbow trout in the bypass after a few generations.

Two estimates of rainbow trout abundance in the bypass are available, one for 2004 (Binkley 2005) and one for 2007 (Normandeau Associates and Thomas R. Payne and Associates 2008). Both estimates combine fry, juvenile and adult trout that roughly correspond to ages 0+, 1+, and 2++, respectively. Steelhead parr consist primarily of age 1+ juveniles. So while the mixed age structure of the resident trout population does not specifically equate to the mostly single-aged steelhead parr definition, the inclusion of both the younger fry and older adults in the resident population estimates tends to provide a reasonable indicator for the single mid-aged steelhead parr estimates.

Binkley (2005) estimated a rainbow trout population in the bypass of 4,236 fish. Normandeau Associates and Thomas R. Payne and Associates (2008) derived a population estimate of 1,852 trout using the same snorkeling methods as Binkley. The authors of the 2007 study note, however, that their estimate is subject to high variability due to the possibility of some fish avoiding detection as a result of poor visibility during the surveys and a possible hiding behavior of the fish in the cold water. While these two estimates differ considerable from each other, both are much less than the 10,459 steelhead parr estimate derived from the WDW Steelhead Methodology (Gibbons et al. 1985). The reason for this discrepancy is believed to be associated with the cold water conditions in the upper portion of the bypass, as discussed in the following section.

4.3 Production Qualifiers and Uncertainties

The production estimates provided above did not account for several site-specific factors that would significantly diminish the production potential from the bypass and could make it biological infeasibility to achieve sustainable runs of salmon and/or steelhead in the reach. These factors include:

1. Fish passage impediment at the Marsh Creek cascade below the Diversion Dam
2. The adverse effects of cold water in the bypass reach on salmonid growth, smolt development, and egg incubation
3. The limited amount of winter habitat for coho salmon

These factors are discussed below.

4.3.1 Marsh Creek Slide

A major landslide occurred in the Sultan River December 11, 2004 at RM 7.6. This created a series of cascades just below the confluence of Marsh Creek. Initially, the site was believed to be a near-complete barrier to upstream migration. During routine spawning surveys in 2005 and 2006 no redds or live adults were observed above the side area, whereas prior to the side an average of 15 percent of the Chinook redds and 7 percent of the steelhead redds were observed above the slide area (Figure 4-4). However, one steelhead carcass and a small number of coho fry were observed during subsequent surveys, suggesting the slide area was not a complete barrier.

In the winter of 2006/2007 several high flow events (up to 3,300 cfs) stabilized the Marsh Creek cascade by clearing out the large woody debris and smaller substrate material. Based on several lines of evidence used to evaluate fish passage at the site in 2007 it was concluded that the cascade still is a partial upstream barrier to Chinook and coho salmon and steelhead trout (Ruggerone 2008). Chinook observations in 2007 and steelhead observations in 2008 continued to show much reduced presence above the cascade compared to the period prior to the slide. The assessment also concluded that the site is a greater barrier at higher flows, such that flows greater than 250 cfs probably block the migration of most if not all steelhead and salmon. Flows in this reach, which are controlled by the Project, are almost always less that 250 cfs under current license conditions, which stipulate minimum flows of 95 cfs to 175 cfs depending on season.

How long the barrier conditions at the Marsh Creek site might persist in the future is unknown. The remaining substrate that creates the cascades consists of large boulders wedged between bedrock on one side of the river and a still-active slide area on the other. Therefore, the newly created cascades appear to be quite stable at this time. If the Marsh Creek cascade remains a near-complete migration barrier as it does now, or if it the site worsens with new landslides, there would be little justification in pursuing fish passage at

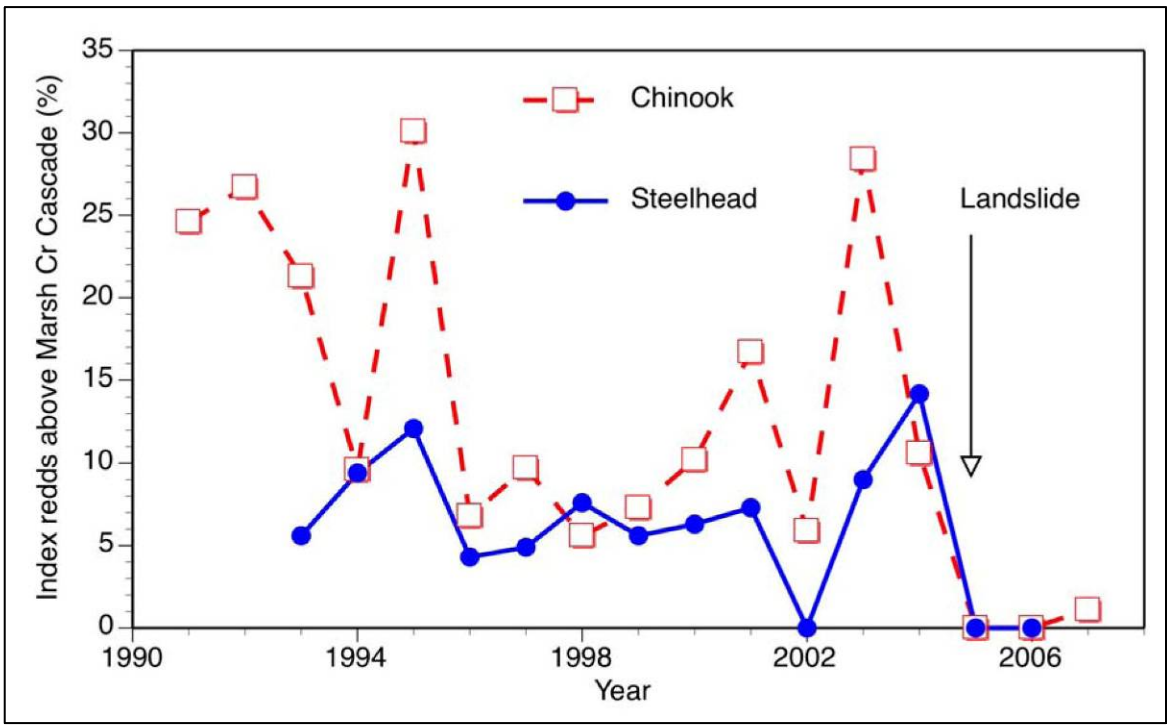

Figure 4-4. Percentage of Chinook and steelhead redds observed above the Marsh Creek cascade compared with total redds in the Sultan River, 1991-2007. Source: Ruggerone 2008.

the upstream Diversion Dam. The notion of modifying the cascades to make the site more passable for fish could be considered; however, that action may be technically very challenging given the size of the material creating the cascade, the inability to access the site with heavy equipment, and safety concerns. In addition any consideration of modifying what appears to be a naturally-created condition, especially with the likelihood of future landslides at the site, could raise potential policy and legal issues.

4.3.2 Water Temperature

The fish production estimates presented above for the bypass reach did not consider the effects of water temperature regime. However, water temperatures in this reach tend to be very cold due to the 20 cfs of bottom discharge from Culmback Dam. This cold water and its effect on fish growth was one of several reasons why the Joint Agencies decided against prescribing a fishway at the Diversion Dam in 1983. This issue is explored further here.

A comparison of monthly average temperatures for sites just below Culmback Dam (RM 16.0), just above the Diversion Dam (RM 9.8), and about one mile above the powerhouse (RM 5.4) are shown in Figure 4-5. At the site just below Culmback Dam, average temperatures are consistently cold, ranging from about 4°C in the winter to only 6°C in the summer and early autumn. By the time this water plus any accretion flow reaches the Diversion Dam temperatures become similar to those above the powerhouse from January through mid-July. However, during late summer and autumn when

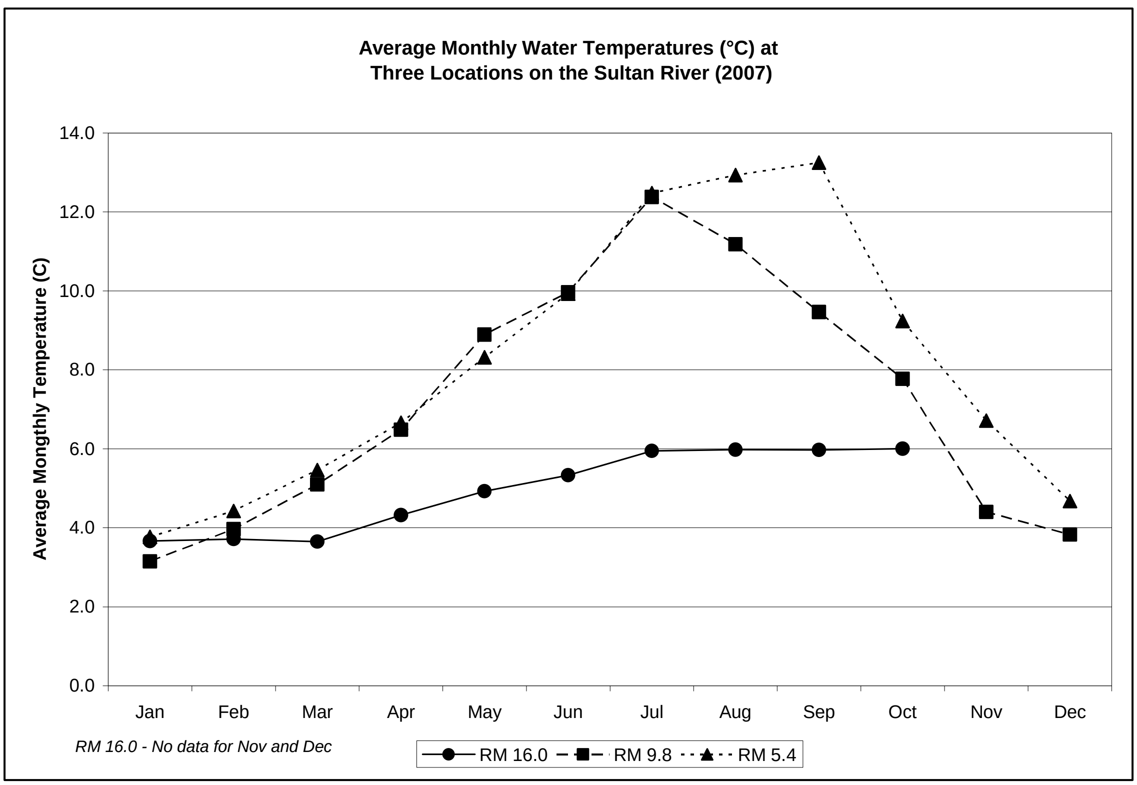

Figure 4-5. Comparison of average monthly water temperatures at three sites below Culmback Dam on the Sultan River.

accretion flows into the bypass are minimal, water temperatures just above the Diversion Dam are much cooler that the water below the Diversion Dam. Water temperatures below the Diversion Dam are controlled to a large degree by the Project operations that route water to this point from the powerhouse (see Figure 2-3).

Rainbow trout, including steelhead trout, generally grow well at temperatures between 10°C and 20°C (Railsbach and Rose 1999, Hokanson et al. 1977). Growth potential tends to drop linearly below 12°C to about 5°C, below which growth typically cannot be achieved (Figure 4-6). With average water temperatures in the upper bypass rarely exceeding 6°C even in the warmest late summer period, it is clear that growth of juvenile salmonids would be extremely slow. However, by the time this water reaches the Diversion Dam, temperatures increase to the point where good growth can occur.

Given the undesirable growth conditions in the upper bypass it likely that most juvenile salmonids would tend to avoid using this area or be stimulated to migrate downstream in search of better growth opportunities. Clear evidence of this can be seen in the current distribution of resident rainbow trout in the bypass (Figure 4-7). When surveyed in 2004, trout densities in the lower third of the bypass were more than 10 times greater than in the upper two thirds. The observed increase in densities moving downstream occurred where summer water temperatures began to exceed 9°C. Similar results via snorkeling were obtained in 2007 where 87 percent of the fish were observed in the lower 2.5 miles of the reach (Normandeau Associates and Thomas R. Payne and Associates 2008).

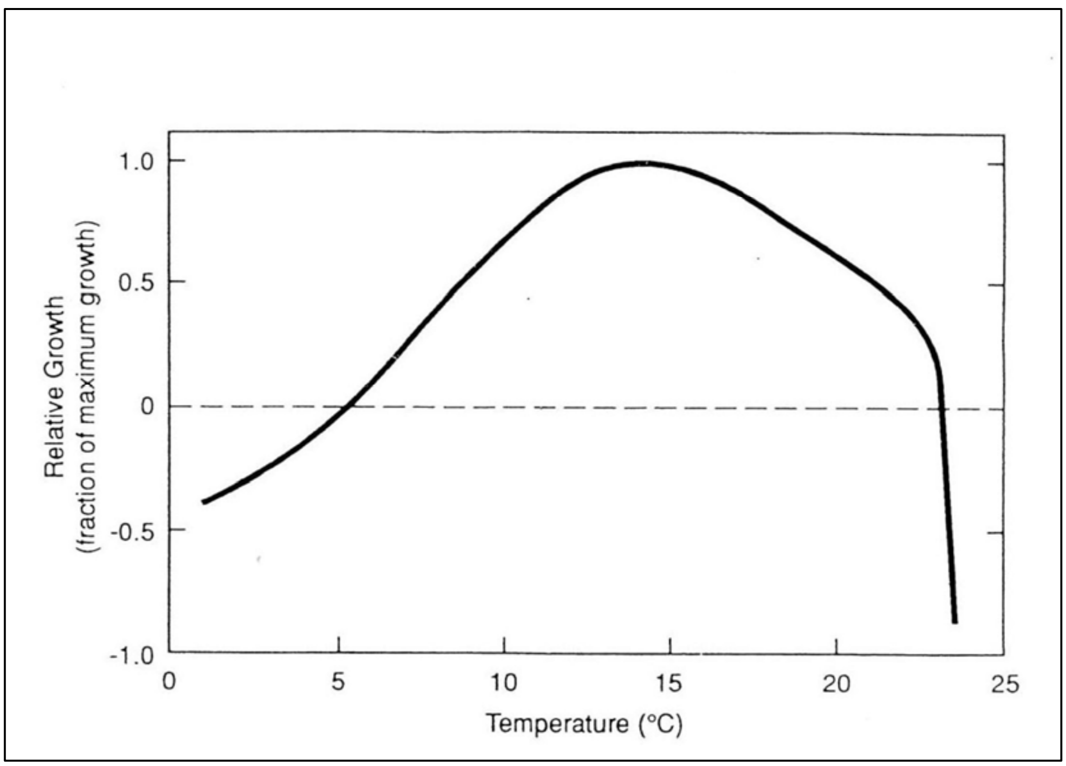

Figure 4-6. Approximate dependence of rainbow trout growth on water temperature.
Source: Railsback and Rose 1999.

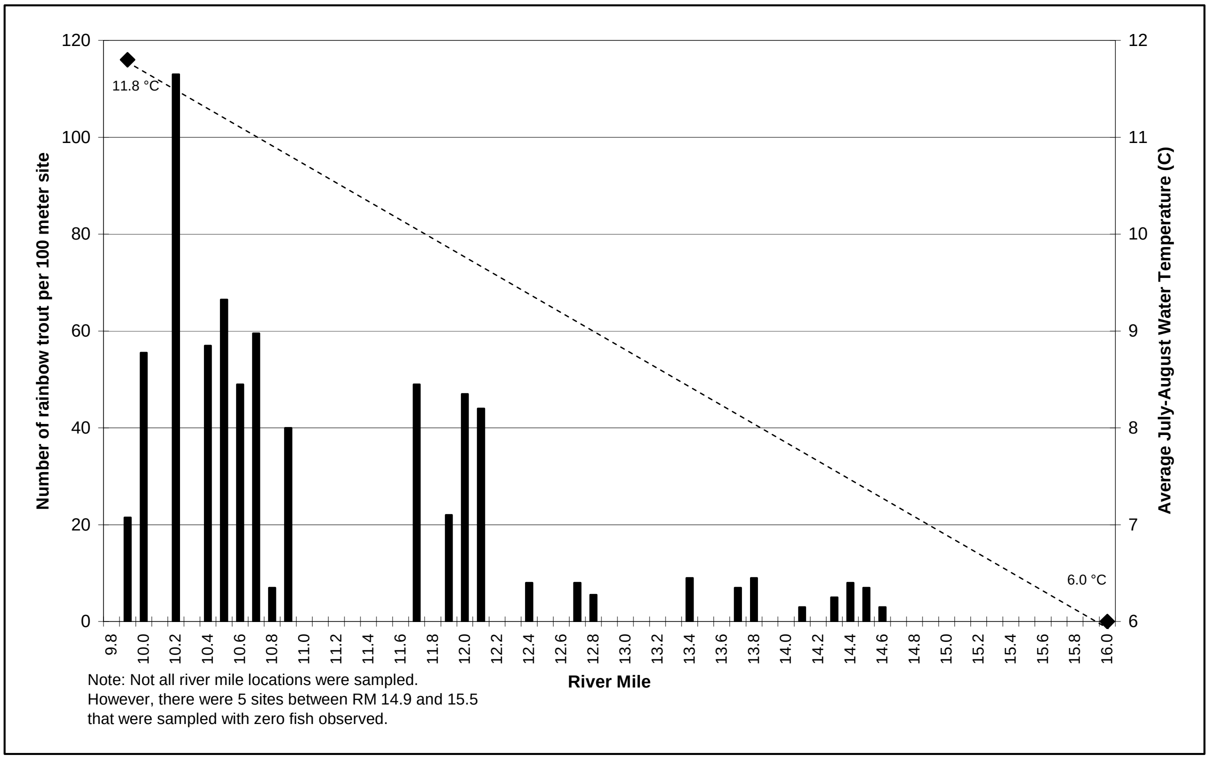

Figure 4-7. Observed distribution of rainbow trout in the Sultan River bypass in summer 2004 compared to river mile and approximate water temperature.

The fewer trout observed in the upper section may have been partly due to the tendency of trout to be less active and closer to the substrate at very cold temperatures. Chapman and Bjornn (1969) noted that steelhead juveniles in Idaho sought shelter in stream substrates at temperatures below 5°C. Similarly, Campbell and Neuner (1985) observed resident rainbow trout in a tributary of the upper Skykomish River beginning to use sheltered positions in the substrate during the fall when water temperatures dropped below 8°C. The extent to which such behavior may have occurred during the bypass surveys is unclear. However, electrofishing results in 2007 provide compelling evidence that much fewer trout reside in the upper bypass reach compared to the lower bypass reach (Normandeau Associates and Thomas R. Payne and Associates 2008). From a 700 ft shallow pool habitat area in the lower bypass (0.5 mile above Diversion Dam) a total of 57 trout were captured. From a similar-length riffle in the upper bypass (near Springer Bridge) only 12 trout were captured. Additional snorkeling surveys indicated that riffles supported much higher trout densities (~7X) than shallow pools. Thus, taking into account this habitat preference difference would further accentuate the higher density of trout in the lower bypass reach compared to the upper bypass reach.

If steelhead trout or coho salmon were allowed to access the bypass reach, and if they successfully spawned in the upper portion of the bypass, most of the resulting juveniles would likely move downstream to avoid the low-growth conditions associated with cold water. This, in effect, would markedly reduce the production potential for both coho salmon and steelhead trout in the bypass reach. If the juveniles instead remained in the upper bypass, their growth could be retarded enough that they may not be able to achieve a requisite smolt size in the typical time period (1 year for coho, 2 years for steelhead) and, additional mortality would occur with the extended rearing time. In either case, production potential in the upper bypass would be much reduced compared to what was estimated above without consideration of temperature.

In addition to growth impairment, cold water would be expected to impair smolt development during the critical early spring period for Chinook and coho salmon. For Chinook salmon, cold water during the smolt development period has been shown to delay activity of Na+-K+ ATPase (an important smolting enzyme) and extend the downstream migration over a longer period (Folmar and Dickoff 1980). This delay can be further exacerbated with slow growth associated with cold water. For coho salmon, reduced smolt activity and a migration delay of about two months was observed when pre-smolts were reared in water of 6°C compared to 10°C (Zaugg and McLain 1976). During the pre-smolt period of March and April the upper bypass water temperatures are only about 4°C.

The relatively cold water in the bypass would be expected to extend the egg incubation time for Chinook salmon. Even at the lower end of the bypass reach, temperatures are about 2°C colder from mid-September through November compared to water downstream of the Diversion Dam (see Figure 4-5).

If Chinook, coho, or steelhead spawned in the upper section of the bypass where winter and spring temperatures average only 4-5°C, significant delays in fry emergence would be expected for all three species.

The issue of cold water temperatures in the bypass is inextricably linked to the issue of instream flows. Although the instream flow study (Study Plan 3 – R2 Resources 2008) for this reach is in its final stages of being completed, results clearly show that flows greater than what occur now would provide more hydraulic habitat (defined by water depth and velocity). However, higher flows achieved with greater discharges from Culmback Dam would only exacerbate the cold water concerns. The cold water “plume” that now affects the upper half of the bypass would extend further downstream thereby reducing juvenile growth, impairing smolt development, or, even worse, forcing fish to move down out of the reach to avoid the cold water (as appears to be the case now for resident trout). Thus, what might be gained by providing additional physical space for fish could be more than offset by expanding the length of stream with water of unsuitable temperature. This concern also extends to the reach below the Diversion Dam because instream flows there would consist more of the cold bypass-reach water and less of the augmented temperature-controlled water now routed to the Diversion Dam from the powerhouse.

A water temperature modeling exercise is being done as part of the Water Quality Parameter Study (Study Plan-1) to assist in evaluating instream flow alternatives for the bypass reach. Initial results for the month of August indicate that a minimum flow release of 50 cfs at Culmback Dam would produce an end-of-reach water temperature of 9.52°C at RM 9.8. A 100 cfs release would produce an ending temperature of only 8.36°C.

The issue of water temperature, especially in conjunction with alternative instream flows to be evaluated for this reach, raises considerable uncertainty as to the biological feasibility of fish passage at the Diversion Dam. This temperature issue as well as the concern over fish passage impairment at the Marsh Creek cascade will need to be incorporated into the final decision on fish passage at the Diversion Dam.

4.3.3 Coho Winter Habitat

The estimates of coho salmon production presented above are based on an assumption that summer rearing conditions are the primary factor limiting production in fresh water. However, numerous studies have shown that the availability of winter habitat can often be the primary limiting factor (Nichelson et al. 1992). In many cases, streams that provide good summer rearing habitat can provide good winter conditions as well. This occurs especially in smaller streams that contain pools, backwaters, and off-channel ponds with large woody debris (Nickelson 1998). However, in larger streams, mid-channel pools and glides without LWD can support coho fry in the summer but may become unsuitable in the winter because of the fry's reduced swimming ability with the colder water temperatures and higher flows occurring in winter (Grette 1985, Sullivan 1986). Other stream habitats such as riffles, glides, and pools without cover rarely support overwintering coho (Heifetz el at 1986, Tschaplinski and Hartman 1983). Also, coho fry do not tend to utilize rubble substrates as cover during the winter (Ruggles 1966).

The Sultan River bypass reach contains little if any of the features typically defining suitable winter habitat for coho salmon. Therefore, it is likely that most juvenile coho that might rear there in the summer would move downstream out of the bypass reach during the autumn in search of suitable over-wintering habitat. Considerable losses of historical coho salmon winter habitat have been documented for the Snohomish basin (Haas and Collins 2001). Thus, if downstream winter habitat in the Skykomish and Snohomish River systems is already occupied at carrying capacity, which is possible given the current healthy status of Snohomish Basin coho, the increased summer production possible from the Sultan bypass reach may not result in an increase in overall coho production in the Snohomish system. Such an outcome is even more likely given the fact that juvenile coho from the bypass would be very small as a result of the cold rearing temperatures there, and, therefore, they would be at a competitive disadvantage compared to other coho occupying winter habitat. Several researches have found that coho size at the end of summer is a primary factor influencing overwinter survival and smolting success (Holtby and Scrivener 1989, Quinn and Peterson (1996).

4.4 Project Consequences and Costs

A provision for anadromous fish passage at the Diversion Dam likely would have major economic consequences to the Project in addition to the mere cost of fish passage facilities. The presence of anadromous fish in the bypass reach would trigger the need to consider alternative instream flows, which likely would be higher than current flows. Because this water cannot be routed through the powerhouse, each 1 cfs of instream flow released at Culmback Dam would result in an additional annual cost to the ratepayers of approximately $73,000 to purchase replacement power (assumes $0.10/kwh). For example, an instream flow of 100 cfs (80 cfs increase) would cost the ratepayers $5,840,000 per year.

As discussed above, the issue of instream flow must consider the linkage between flow and water temperature. The adverse consequences of cold water temperatures that are seen now in the upper bypass would extend downstream to the lower bypass and perhaps to below the Diversion Dam if the amount of water released at Culmback Dam is increased. This concern raises the potential to consider constructing another multi-level outlet structure at Culmback Dam to reliably provide water temperatures in the bypass that are more favorable to salmonids. Design concepts for such a structure have not been contemplated to date. However, the cost for constructing another outlet structure could be high given the need to design for high water pressures, construction in deep water, and potential constraints associated with maintaining the City of Everett's water supply during construction.

An increase in instream flow requirements in the bypass reach (as well as other reaches) also would increase the extent of late summer drawdown in Spada Lake. This, in turn, could affect the ability of the Project to control water temperatures in the lower river because the powerhouse intake structure is able to withdraw cooler hypolimnetic water, which is below a depth of 30-40 feet in late summer (Figure 4-8), only when the lake

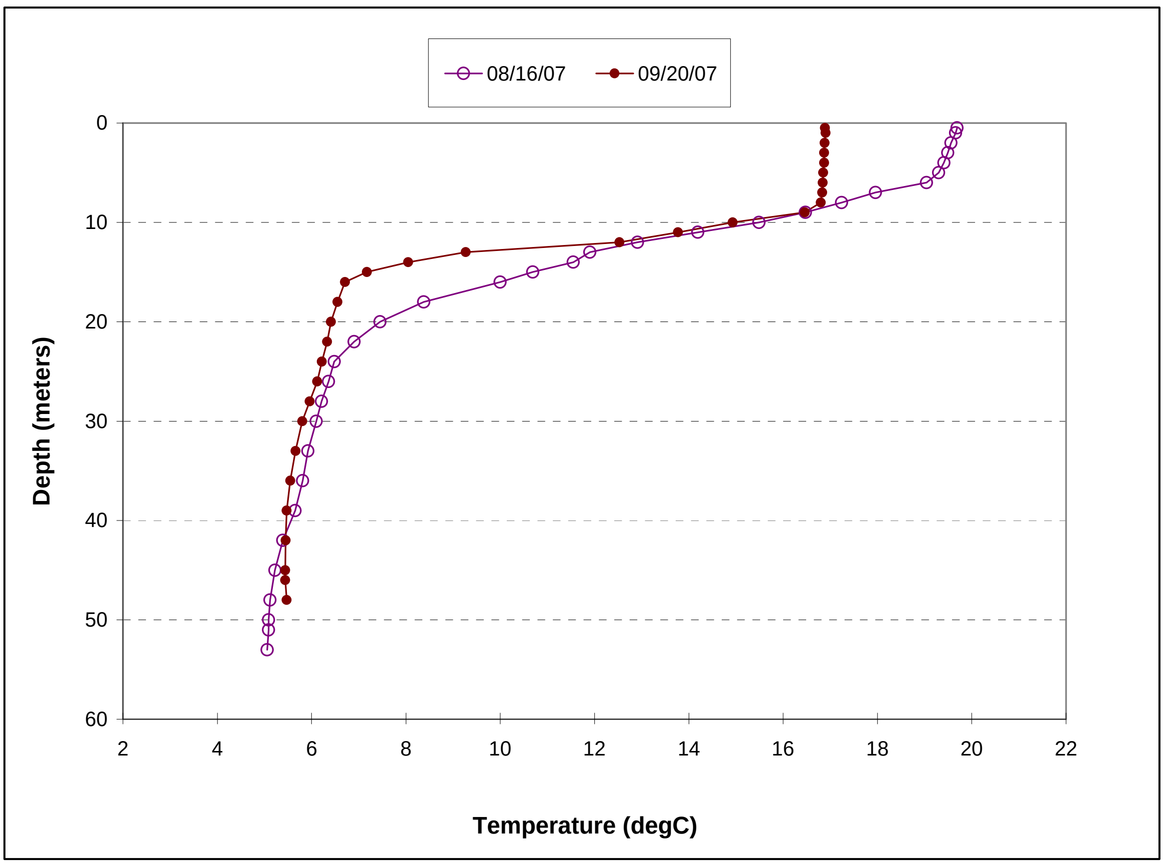

Figure 4-8. Temperature-depth profile of Spada Lake near Culmback Dam in August and September 2007.

elevation is above approximately 1,410 ft (Figure 4-9). Furthermore, increased use of hypolimnetic water for instream flows would tend to deplete more of the available cold water, lower the elevation of the thermocline, and thereby further reduce the ability of the Project to control water temperatures in the lower river during the summer and fall. In very dry years it is possible that the reservoir could become low enough to totally preclude use of the multi-level powerhouse intake tower. Under such conditions downstream water requirements for the City of Everett and instream flows would be provided by the cold deep-water releases from Culmback Dam. This, in turn, would produce undesirably cold water for salmonids in most of the Sultan River. Reduced summer and early fall inflow to the reservoir, as is predicted for the future with climate change (Climate Impacts Group 2006**)** would further increase this probability.

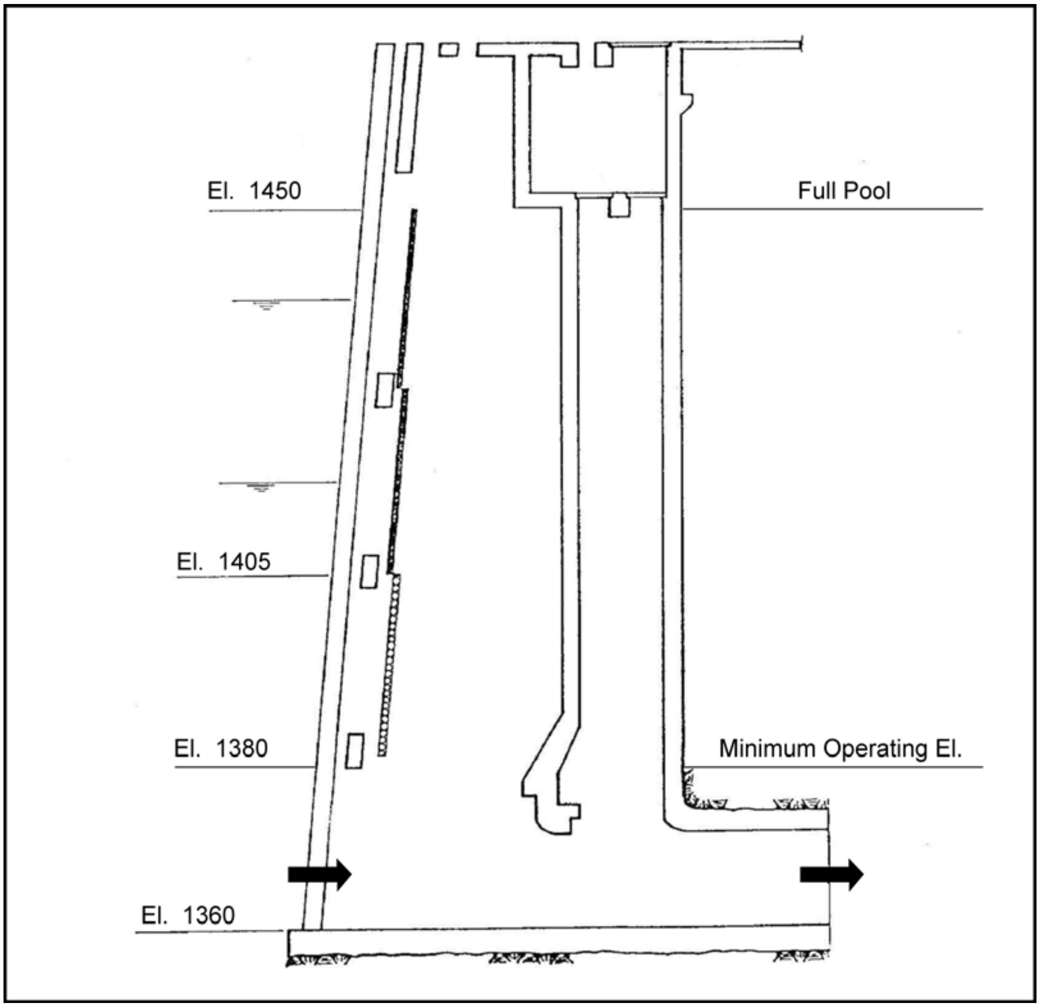

Figure 4-9. Spada Lake Powerhouse Intake Structure Showing Full-Pool Elevation (1,450 ft) and Minimum Powerhouse Operating Water Elevation (1,380 ft).

5.0 CONCLUSIONS

Two options were identified for fishway alternatives at the Diversion Dam. One option would be to construct a fishway that would accommodate the full 20-ft operating head of the dam in its current configuration. The second option would be to lower the water level behind the dam to the minimum that can be controlled with the current sluiceway gate. This would produce an effective head of only 8-9 ft. However, any type of fishway constructed in the existing sluiceway would reduce the ability to sluice accumulated gravel out of the forebay near the water intake trash racks and pass the large woody debris that becomes mobile during high flow events. These concerns, especially for gravel sluicing, may preclude the lowered-head option. For the full-head option, a conventional vertical slot fishway could be constructed on the right bank of the dam at an estimated cost of $3.6 million. For the lowered-head option, either a vertical slot or a pool-and-chute fishway would be feasible. Either of these lower-head designs would cost approximately $2.16 million.

Estimates of anadromous fish production potential for the bypass reach, by estimating method, are shown in Table 5-1.

Table 5-1. Estimated adult Chinook, coho, and steelhead production (escapement plus catch) for the Sultan River bypass reach by estimating method.

	Adult Production Estimate[a]		
Estimating Method	Chinook	Coho	Steelhead
Spawning Substrate	58		
Fry Rearing Habitat	118		
Spawning – WUA			
@ 30 cfs	40		
@ 100 cfs	150		
Rearing – Zillges / Beechie et al.		735	
Rearing – Gibbons et al.			52
Rearing – WUA			
@ 30 cfs			15
@ 100 cfs			35

[a]Estimates are based on physical habitat only. They do not consider other possible production – limiting factors such as migratory access to the bypass, water temperature effects, or availability of over-winter habitat. See report for discussion.

These anadromous fish production estimates reflect approximate average marine survival rates experienced in the last two decades, which have been relatively low compared to those in previous decades. If marine survival rates increase in the future so will the estimated adult production for the bypass.

Of the several methods used to estimate bypass production potential for fall Chinook salmon and steelhead trout, the WUA approach likely provides the most reasonable estimates because it relies on the most detailed description of site-specific and species-specific habitat and is based on extrapolating (via habitat scaling) 17 years of known production from in the lower river.

The production estimates provided in this report do not quantitatively account for several site-specific factors that could significantly diminish the production potential from the bypass reach and, in fact, could make it biological infeasibility to achieve sustainable runs of salmon and/or steelhead in the reach. These factors include:

1. Fish passage impediment at the Marsh Creek cascade below the Diversion Dam
2. The adverse effects of cold water in the bypass reach on salmonid growth, smolt development, and egg incubation
3. The limited amount of winter habitat for coho salmon in the bypass reach

The presence of anadromous fish in the bypass reach would trigger the need to consider alternative instream flows, which likely would be higher than current flows. However, greater discharges from Culmback Dam would exacerbate the cold water concerns by extending the cold water further downstream. Therefore, the fish production that might be gained by providing additional physical space for fish with increased flows may be offset by expanding the length of stream with water of unsuitable temperatures. In addition, an increase in instream flow requirements would increase the extent of late-summer drawdown in Spada Lake, which, in turn, would limit the ability of the Project to control water temperatures in the lower river especially on dry years.

The notion of providing anadromous fish passage at the Diversion Dam initially might appear as though it could benefit anadromous fish production in the Sultan River; however, other consequences associated with such an action could compromise the ability of the Project to maintain the current successful fish enhancement measures now in place for the river below the Diversion Dam. While it is beyond the scope of this report to assess these consequences in detail, it will be necessary at some point to evaluate the interactions among these linked consequences in order to consider any new potential protection, mitigation, and enhancement measures that would truly benefit the net production of anadromous fish in the Sultan River while being within the feasibility constraints of the Project.

6.0 REFERENCES

Agrawal, A. and seven co-authors. 2005. Predicting the potential for historical coho, Chinook, and steelhead habitat in northern California. NOAA Technical Memorandum. NOAA-TM-NMFS-SWFSC-379. Southwest Fisheries Science Center, Santa Cruz, CA. 25 p.

Baranski, C. 1989. Coho smolt production in ten Puget Sound streams. Technical report No. 99. State of Washington Department of Fisheries. 29 p.

Beechie, T., E. Beamer, and L. Wasserman. 1994. Estimating coho salmon rearing habitat and smolt production losses in a large river basin, and implications for habitat restoration. North American Journal of Fisheries Management 14:797-811.

Binkley, K. 2005. Bull trout distribution in the Sultan River watershed. Prepared for Snohomish County Public Utility District No. 1. Everett, WA. 17 p.

Bustard, D.R. and D.W. Narver. 1975. Aspects of winter ecology of juvenile coho salmon (Oncorhynchus kisutch) and steelhead trout (Salmo gairdneri). J. Fish. Res. Board Can. 32:667-680.

Campbell, R.F., and J. H. Neuner. 1985. Seasonal and diurnal shifts in habitat utilized by resident rainbow trout in western Washington Cascade Mountain streams. Pages 39-48 in F.W. Olson, R.G. White, and R.H. Hamre, editors. Proceedings of the symposium on small hydropower and fishes. American Fisheries Society Western Division. 1-3 May 1985. Aurora, Colorado.

Chapman, D.W., and T.C. Bjornn. 1969. Distribution of salmonids in streams, with special reference to food and feeding. Pages 153- 176 in T.G. Northcote, editor. Symposium on salmon and trout in streams. H.R. MacMillan Lectures in Fisheries. University of British Columbia, Vancouver, British Columbia. 388pp.

CH2M HILL. 2005. Project effects on anadromous salmonids and bull trout in the Sultan River. Henry M. Jackson Hydroelectric Project. FERC Project No. 2157. Prepared for Snohomish County Public Utility District No. 1. and City of Everett, WA.

Chilcote, M.W., S.A. Leider, and J.J. Loch. 1984. Kalama River salmonids studies, 1983. Washington Department of Game, Fish Management Division. Progress Report 84-5, Olympia, WA.

Clay, C.H. 1995. Design of Fishways and Other Fish Facilities. Second Edition. Lewis Publishers. CRC Press. Boca Raton, FL.

Climate Impacts Group. 2006. Climate impacts on salmon recovery in the Snohomish River basin. U. of Washington and Northwest Fisheries Science Center. Power Point presentation available at: cses.washington.edu/cig/outreach/workshopfiles/kelso06/palmer.ppt.

Eicher, G.J. 1981a. Quantification of fish enhancement by the Sultan Project. Report prepared for Snohomish County Public Utility District. Everett WA. 7p.

Eicher, G.J. 1981b. Impact Analysis of Sultan Project Flows on Salmon and Steelhead. Report prepared for Snohomish County Public Utility District. Everett, WA.

Everest, F.H., G.H. Reeves, J.R. Sedell, J. Wolfe, D. Hohler, and D.A. Heller. 1985. Abundance , behavior, and habitat utilization by coho salmon and steelhead trout in Fish Creek, Oregon, as influenced by habitat enhancement. Annual report 1985. Bonneville Power Administration Project no. 84-11. Portland, OR.

Folmar, L.C., and W.W. Dickhoff. 1980. The parr-smolt transformation (smoltification) and seawater adaptation in salmonids: A review of selected literature. Aquaculture 21: 1-37.

Gibbons, R., P. Hawn, and T. Johnson. 1985. Methodology for determining MSH steelhead spawning escapement requirements. Washington Department of Game. Fisheries Management Division. Report 85-11.

Geist, D.R. and D.D. Dauble. 1998. Redd site selection and spawning habitat use by fall Chinook salmon: the importance of geomorphic features in large rivers. Environ. Manag. 22: 655-669.

Grette, G. B. 1985. The abundance and role of large organic debris in juvenile salmonid rearing habitat in small streams. Master's thesis. University of Washington, Seattle.

Haas, A. and B. Collins. 2001. A historical analysis of habitat alterations in the Snohomish River valley, Washington, since the mid-19th century. Implications for Chinook and coho salmon. Report prepared for the Tulalip Tribes and Snohomish County Public Works, Surface Water Management. Everett, WA.

Heifetz, J., M. L. Murphy, and K. V. Koski. 1986. Effects of logging on winter habitat of juvenile salmonids in Alaskan streams. North American Journal of Fisheries Management 6: 52-58.

Hokanson, K. E. F., C. F. Keliner and T. W. Thorslund. 1977. Effects of constant temperatures and diel temperature fluctuations on specific growth and mortality rates and yield of juvenile rainbow trout, Salmo gairdneri. J. Fish. Res. Bd of Can.34: 639 – 648.

Holtby, L.B. and J.C. Scrvener. 1989. Observed and simulated effects of climate variability, clear-cut logging, and fishing on the numbers of chum salmon and coho salmon returning to Carnation Creek, British Columbia. In: C.D. Levings, L.B. Holtby, and M.A. Henderson, eds. Proceedings of the National Workshop on the effects of habitat alteration on salmonid stocks. Can. Spec. Publ. Fish. Aquat. Sci. 105: 62-81.

Kiefer R.B., and J.N. Lockhart. 1995. Intensive evaluation and monitoring of Chinook salmon and steelhead production, Crooked River and Upper Salmon River sites. Annual Progress report 1993. Idaho Department of Fish and Game. IDFG Report No. 95-21.

Lister, D.B. and C.E. Walker. 1966. The effect of flow control on the freshwater survival of chum, coho and Chinook salmon in the Big Qualicum River. Canadian Fish Culturist 37:3-25.

Martin, D., L. Benda and D. Shreffler. 2004. Core areas: a framework for identifying critical habitat for salmon. Prepared for King County Dept. of Natural Resources and Parks. Seattle, WA.

Miller, J.A., M.A. Wert, and T. Dunne. 1984. River Gravel Quantity Study. Henry M. Jackson Hydroelectric Project (Sultan River), Snohomish County, WA. FERC Project No. 2157. Public Utility District No. 1 of Snohomish County, Everett, WA.

Nickelson, T. E. 1998. A habitat-based assessment of coho salmon production potential and spawner escapement needs for Oregon coastal streams. Information Reports Number 98-4. Oregon Department of Fish and Wildlife, Portland. 17 p.

Nickelson, T.E., Rodgers, J.D., Johnson, S.L., and Solazzi, M.F. 1992. Seasonal changes in habitat use by juvenile coho salmon (Oncorhynchus kisutch) in Oregon coastal streams. Can. J. Fish. Aquat. Sci. 49: 783–789.

Normandeau Associates and Thomas R. Payne and Associates. 2008. Population analysis of coastal cutthroat trout in the bypass reach of the Sultan River, summer 2007. Prepared for Snohomish County Public Utility District No. 1. Everett, WA.

Pre-Application Document. 2005. Pre-Application Document for the Henry M. Jackson Hydroelectric Project. FERC No. 2157. Prepared by Public Utility District No. 1 of Snohomish County and City of Everett, WA. Available at ww.snopud.com/WaterResources/relicensing/relicensingdocs/pad.ashx?p=3121.

Quinn, T. and N. Peterson. 1996. The influence of habitat complexity and fish size on the over-winter survival and growth of individually marked juvenile coho salmon in Big Beef Creek, Washington. Can. J. Fish. Aquat. Sci. 53: 1555-1564.

R2 Resource Consultants, Inc. 2008. Determination and evaluation of habitat-flow relationships in the Sultan River, Washington. Prepared for Snohomish County Public Utility District, Everett, WA.

Railsback, S.F. and K.A. Rose. 1999. Boienergetics modeling of stream trout growth: temperature and food consumption effects. Trans. Am. Fish. Soc. Vol 128: 241-256.

Ruggerone, G.T. 2008. Evaluation of salmon and steelhead migration after a landslide on the Sultan River. Phase I: Fish Passage Assessment. Prepared for Snohomish County Public Utility District No. 1. Everett, WA.

Ruggerone, G.T. 2006. Evaluation of salmon and steelhead migration through the upper Sultan River canyon prior to dam construction. Report to the City of Everett, WA. 48p.

Ruggles, C.P. 1966. Depth and velocity as a factor in stream rearing and production of juvenile coho salmon. Canadian Fish Culturist 38:37-53.

Sharma, R. and R. Hilborn. 2001. Empirical relationships between watershed characteristics and coho salmon (*Oncorhynchus kisutch*) smolt abundance in 14 western Washington streams. Can. J. Fish. Aquat. Sci. 58: 1453-1463.

Snohomish Basin Salmon Recovery Forum. 2005. Snohomish River basin salmon conservation plan. Snohomish County Public Works, Surface Water Management Division. Everett, WA.

Stillwater Sciences. 2008. Study Plan 18: riverine, riparian, and wetland habitat assessment technical report. Prepared for Snohomish County PUD. Everett, WA.

Sullivan, K. 1986. Hydraulics and fish habitat in relation to channel morphology. Doctoral dissertation. Johns Hopkins University, Baltimore, Maryland.

Tschaplinski, P. J., and G. F. Hartman. 1983. Winter distribution of juvenile coho salmon (Oncorhynchus kisuich) before and after logging in Carnation Creek, British Columbia, and some implications for overwinter survival. Can. J. Fish. Aquat. Sci. 40:452-461.

Ward, B.R. and P.A. Slaney. 1993. Egg-to-smolt survival and fry-to-smolt density dependence of Keogh River steelhead trout. Pages 209-217 *in* R.J. Gibson and R.E. Cutting, editors. Production of juvenile Atlantic salmon in natural waters. Canadian Special Publication of Fisheries and Aquatic Sciences 118.

Washington Department of Fish and Wildlife. 2008. Onchorhyncus mykiss: Assessment of Washington State’s anadromous populations and programs. Edited by J.B. Scott and W.T. Gill. WDFW. Olympia, WA.

Zaugg WS, McLain LR. 1976. Influence of water temperature on gill sodium, potassium-stimulated ATPase activity in juvenile coho salmon (Oncorhynchus kisutch). Comp. Biochem. Physiol. 54A:419-421.

Zillges, G. 1977. Methodology for determining Puget Sound coho escapement goals, escapement estimates, 1977 pre-season run size prediction and in-season run assessment. Washington Department of Fisheries Technical Report No. 28. April 1977. Olympia, Washington. 65 p.

Appendix A

Stakeholder Comments on Draft Report

October 13, 2008

To: Dawn Presler, Snohomish Public Utility District Number 1
From: Rich Johnson, Washington Department of Fish and Wildlife

SUBJECT: Jackson Project Study Plan 20 Fish Passage at Sultan River Diversion Dam

As noted in Study Plan 20, *Fish Passage Feasibility At The Sultan River Diversion Dam*, anadromous fish have been blocked from accessing about six miles of the Sultan River upstream of the diversion dam. The study looked at the possibility of constructing either a pool and chute or a vertical slot fishway to provide upstream passage of anadromous fishes above the diversion dam. The study concluded that either type of fishway could be successfully installed. WDFW has extensive experience with fishways. WDFW finds that in rivers with extreme flow fluctuations the vertical slot design provides fish passage over a range of flows without requiring adjustments of stop logs or baffles. The pool-chute design is still considered experimental and is not recommended for drops over six feet. A pool-chute fishway at the diversion dam would need to have large resting pools at every third step, which would extend the fishway further downstream and away from the attractant flows at the base of the dam. The fishway depicted in Figure 4-3 has an energy dissipation factor exceeding our standard of four foot-pounds per cubic foot of water. While the pool-chute fishway is less likely to plug with debris than the vertical slot, it is not self-cleaning. All fishways require a high degree of maintenance in order to function properly.

The study's quote of Eicher 1981a that pre-project high flows and unstable substrate would have limited the production of salmon is speculative and has no application to the existing conditions. The statement that the bypass reach is of moderately high gradient is deceptive. It is only the upper half mile of the bypass reach that is high gradient, while the lower 5.5 miles is of a similar gradient to the river upstream of mile 4.0, and is well within the range preferred by anadromous salmonids.

The study also looked at other issues which affect the decision of providing fish passage. First issue is the partial blockage to fish migration created by a recent slide near Marsh Creek. The cascade is relatively new, is changing over time, and is passable under certain flow conditions. WDFW concludes that the Marsh Creek cascade is not of sufficient size or durability to make providing of fish passage at the diversion dam unnecessary. However, the at this time the cascade does hinder migration, so we recommend that a feasibility study be conducted to analysis modifying the cascade to improve fish migration.

The second issue is the low temperature of water being released from the base of Culmback Dam. WDFW agrees with the conclusion that the temperature is to cold for good production of salmon and trout, but does not agree that this is a reason for not providing fish passage. The ecosystem of the bypass reach is adversely affected by the unnaturally cold water being released into it. Even if fish passage is not provided, the release of water into the river near Culmback Dam should be modified to provide temperatures within the range found pre-project, as is already being done downstream of the diversion dam. This modification will allow fish, amphibians, and aquatic insects to live within the temperature range they are naturally adapted to.

The third issue is that of estimating the production potential in the bypass reach. Use of the weighted useable area (WUA) method, and use of habitat productivity are both acceptable methods. However, the factors that have been applied to both methods provide numbers reflective of minimum production, not the maximum potential. The escapement and survival numbers used were taken during a period of steep decline in Chinook and steelhead and low ocean survival, as reflected in the listing of both species under the Endangered Species Act (ESA). The production of coho and steelhead is likely to be higher than calculated, as the lower Sultan River and Skykomish River provide some excellent rearing areas that could be utilized by fishes produced in the bypass reach. Over-wintering habitat is not considered a limiting factor for coho production in the Snohomish basin. Even so, the estimated increase in adult salmon production of about 100 Chinook, 750 coho, and 50 steelhead is significant. Data found in Study Plan 3, Instream Flows, indicates, based on flows maximizing spawning habitat in each reach, the bypass reach would add about 30 percent to the spawning area for Chinook, coho, and steelhead. In addition, cutthroat, which are no longer found in the bypass reach, would benefit significantly from being allowed to once again inhabit this reach. Recovery planning for the listed species, Chinook and steelhead, specifically lists spatial structure as playing a significant role in recovery, so the addition of six miles of habitat would play an important role in the recovery of these fishes.

The fourth issue is loss of hydroelectric production by increasing flows through the bypass reach. The existing base flow of 20 cfs is supplemented by natural inflows during much of the year (see Table 2-4 in the study) by approximately 50 cfs, reducing the need for augmentation. The existing flow during October would need augmentation to provide migrating and spawning flows for Chinook, but WDFW is willing to work to minimize the loss of hydroelectric production while still providing for a significant increase in fish production. We recognize that there are many competing interests for the available water, and water allocation plays a major role this relicensing effort. A different approach to water allocation is needed in the future to assure adequate flows for fish and wildlife, flows for white-water boating, flows to mobilize sediments, channel changing flows, flood control, water supply, and hydroelectric production, among others.

There is much more emphasis on the protection and production of wild salmonids today then when the existing license conditions were developed. With Puget Sound Chinook and steelhead now listed under ESA, and with fundamental changes in hatchery practices made with the intend of protecting wild stocks, providing passage for these wild fishes is very important. WDFW finds that returning anadromous fishes to the bypass reach is an important and necessary step for the recovery of these fishes. The diversion dam provides a redundancy in the City of Everett's water system that should either be eliminated or replaced by a method that does not block migration. If the dam is kept, WDFW recommends the installation of a vertical slot fishway designed to meet Federal and State requirements. A fish handling station should be constructed with the fishway to allow the monitoring of the fishes that repopulate the bypass reach.

-----Original Message-----
From: Steve Fransen [mailto:Steven.M.Fransen@noaa.gov]
Sent: Friday, October 17, 2008 4:03 PM
To: Presler, Dawn
Subject: Jackson Project (FERC No. 2157) Comments on SP 3, 20, & PMEs

Dawn,
I'm a couple days late, I've reviewed SP20, the fish passage feasibility study, SP3, the instream flow study, and the PUD's proposed PMEs.
I'll begin with SP20, the Phase 2 assessment of fish passage feasibility at the Sultan River Diversion Dam and have these comments.
1. The PUD provided funding to the State of Washington in 1957 for construction of salmon and steelhead rearing facilities at May Creek and Reiter, respectively. I have no information indicating that this funding was intended to be complete mitigation for all impacts and for all time. And I have no information indicating that the costs of operation and maintenance were and are still also covered by the PUD. If the PUD doesn't fund O&M as well, I conclude that the mitigation effort was partial at best. There is no indication that funding of alternative fish rearing facilities absolves the PUD of the responsibility of providing effective fish passage under the Federal Power Act.
2. The prospective fish production potential is significant enough to consider passage for ESA listed Chinook and steelhead.
3. Unstable gravel was cited by Eicher in 1981 as a limiting factor to sustainable salmon production in the accessible portion of the bypass reach. I don't necessarily disagree. All sustainable salmon populations are limited by a variety of factors, and the stability of gravel substrates is but one of them. In spite of that limitation, innumerable salmon populations survive and even flourish in habitat containing gravel instability. The extant rainbow trout population in the bypass reach is further empirical evidence that a sustainable salmonid populations exists in the bypass reach. I don't see the gravel stability conditions in the bypass reach as a factor affecting fish passage feasibility.
4. During the project's licensing proceeding, the joint agencies accepted in a 1983 Settlement Agreement alternative measures to enhance salmonid populations in lieu of fish passage at the Diversion Dam. As you know, Settlement Agreements that accompany a FERC license expire with that FERC license unless there is specific contract language to the contrary. Just as conditions change over time, so do our natural resource needs. Given the presence of Chinook and steelhead populations in the Sultan River that are part of larger population groups that are listed as threatened under the Endangered Species Act, the need for fish passage at the Diversion Dam may be different today than it was in 1983. The feasibility study finds that a standard vertical slot fishway is technically feasible at the Diversion Dam at an estimated cost of $3.6 million, which appears reasonable for a project of this size.
5. The 6.4 mile bypass reach upstream of the Diversion Dam is described as having a high gradient, averaging 90 feet per mile in a steep walled canyon. Neither the gradient, which is equivalent to 1.7%, and is emphatically not high gradient, nor steep walled

canyons are inconsistent with productive salmon and steelhead habitat, although canyons tend to be less productive than alluvial plain stream channels due in part to having less floodplain space to dissipate the high energy of flood flow events.
6. Cold water temperatures, averaging 6°C, are cited as being too cold for optimal salmon and steelhead production. I also conclude that it is less than optimal. The PUD developed a multi-level outlet for the power tunnel which delivers water to the powerhouse and lower river reach and the mid-river reach downstream of the Diversion Dam. However no similar allowance was included for the discharge from Culmback Dam. While this doesn't affect the feasibility of fish passage into the bypass reach, it does call into question the purpose of doing so. However I believe the more significant question is associated with the failure to include the option of temperature control for normative water temperatures in the Culmback Dam discharge. I conclude that the fish passage feasibility assessment is deficient in its lack of investigation of what it will take to provide a multi-level outlet so that the Culmback Dam water discharge temperatures are normative.
7. The feasibility assessment notes that fish passage into the bypass reach would necessitate higher instream flows in the bypass reach in order to provide spawning and rearing habitat for anadromous fish. Those higher flows would put more cold water into river reaches 2 & 1, and the presumable result would be a reduction in productivity of the lower river reaches. Of course that is true. However the assessment sidesteps that the cold water release is also a project impact to public trust resources, and that those resources naturally and logically are entitled to water temperature mitigation on their own merit.
8. The Marsh Creek slide that originated in 2006 at RM 7.6 appears to limit fish passage at certain flows. This natural slide could be a temporal partial obstacle to fish passage, or it may persist for a long time. The slide is a hydraulic control, and a discussion of restoring passage is due. It's not an action that would be required of the PUD, but could be sponsored by the PUD, one of the resource agencies, or Tribe. It has the potential to qualify under the Salmon Recovery Funding Board. The point to note is that the presence of the Marsh Creek slide is not inconsistent with fish passage at the Diversion Dam, but it may be a reason to delay it.
9. Higher instream flows would reduce the amount of water available to energy production, potentially rendering the Jackson Hydro Project economically unviable. This may be true.
As you are aware, it is not the responsibility of the Federal Power Act, FERC, or the several agencies, tribes, and other stakeholders to make hydroelectric projects economically viable by permitting the PUD to externalize the costs of environmental impacts, in effect providing a public fishery resource subsidy to the PUD. I believe that the full mitigation of project impacts to public trust resources is a natural and logical cost of hydroelectric energy generation.

APPENDIX B

Responses to Draft Report Comments

STAKEHOLDER COMMENT	LICENSEE RESPONSE
Rich Johnson – Washington Dept of Fish and Wildlife (Oct 13, 2008)	
WDFW finds that in rivers with extreme flow fluctuations the vertical slot design provides fish passage over a range of flows without requiring adjustments of stop logs or baffles. The pool-chute design is still considered experimental and is not recommended for drops over six feet.	We recognize that the pool-and chute fishway design is still considered experimental by WDFW and that the state does not recommended it for drops greater than six feet. However, this design has been very successfully used in recent years with 8-foot drops on the Santiam River in Oregon and the Sacramento River in California. In both cases the design was approved by the state fisheries agencies and NOAA Fisheries Service. We would hope that WDFW would be open to considering this alternative.
WDFW concludes that the Marsh Creek cascade is not of sufficient size or durability to make providing of fish passage at the diversion dam unnecessary. However, at this time the cascade does hinder migration, so we recommend that a feasibility study be conducted to analysis modifying the cascade to improve fish migration.	It was not the objective of the study to assess means to modify the Marsh Creek slide cascade. We only point out that providing fish passage facilities at the upstream Diversion Dam would make little sense if the Marsh Creek cascade were to remain in its current state. We agree that a logical next step would be to look at modifying the cascade.
WDFW agrees with the conclusion that the temperature is to cold for good production of salmon and trout, but does not agree that this is a reason for not providing fish passage. The ecosystem of the bypass reach is adversely affected by the unnaturally cold water being released into it. Even if fish passage is not provided, the release of water into the river near Culmback Dam should be modified to provide temperatures within the range found pre-project, as is already being done downstream of the diversion dam.	It was not the objective of the study to assess means to modify the temperature of water released at Culmback Dam. We only point out that providing fish passage facilities at the upstream Diversion Dam would make little sense if the cold water release situation remains in its current state. We agree that a logical next step would be to look at means to condition the water temperatures so that they would be in better line with the needs of fish in the bypass reach.
Use of the weighted useable area (WUA) method and use of habitat productivity are both acceptable methods. However, the factors that have been applied to both methods provide numbers	You state that our approach to estimating production is acceptable but that the numbers reflect minimum production, not maximum production. Our estimates were based on actual production that has occurred in the Sultan River since 1991. Similar to your

STAKEHOLDER COMMENT	LICENSEE RESPONSE
reflective of minimum production, not the maximum potential. The escapement and survival numbers used were taken during a period of steep decline in Chinook and steelhead and low ocean survival, as reflected in the listing of both species under the Endangered Species Act (ESA).	comments, we note in the Conclusion and Executive Summary that these estimates reflect the relatively low marine survival that has occurred in the last two decades.
The fourth issue is loss of hydroelectric production by increasing flows through the bypass reach. The existing base flow of 20 cfs is supplemented by natural inflows during much of the year (see Table 2-4 in the study) by approximately 50 cfs, reducing the need for augmentation. The existing flow during October would need augmentation to provide migrating and spawning flows for Chinook, but WDFW is willing to work to minimize the loss of hydroelectric production while still providing for a significant increase in fish production.	It was not the purpose of Study Plan 20 to evaluate the instream flows in the bypass, and most of our production estimates were flow-neutral. However, we did provide alternative estimates for fall Chinook salmon and steelhead trout at an arbitrarily assumed higher flow (100 cfs). We recognize that the instream flow issue will be subject to further discussion in the relicensing process, and appreciate your constructive comments in this regard.
Steve Fransen – NOAA Fisheries (Oct 17, 2008)	
1. The PUD provided funding to the State of Washington in 1957 for construction of salmon and steelhead rearing facilities at May Creek and Reiter, respectively. I have no information indicating that this funding was intended to be complete mitigation for all impacts and for all time. And I have no information indicating that the costs of operation and maintenance were also covered by the PUD. If the PUD doesn't fund O&M as well, I conclude that the mitigation effort was partial at best. There is no indication that funding of alternative fish rearing facilities absolves the PUD of the responsibility of providing effective fish passage under the Federal Power Act. .	Your summary of the past mitigation obligations appears to be an accurate account.
The prospective fish production potential is significant enough to consider passage for ESA listed Chinook and steelhead.	Comment noted.

STAKEHOLDER COMMENT	LICENSEE RESPONSE
Unstable gravel was cited by Eicher in 1981 as a limiting factor to sustainable salmon production in the accessible portion of the bypass reach. I don't necessarily disagree. All sustainable salmon populations are limited by a variety of factors, and the stability of gravel substrates is but one of them. In spite of that limitation, innumerable salmon populations survive and even flourish in habitat containing gravel instability. The extant rainbow trout population in the bypass reach is further empirical evidence that a sustainable salmonid populations exists in the bypass reach. I don't see the gravel stability conditions in the bypass reach as a factor affecting fish passage feasibility.	We describe the gravel stability topic only because it was a factor taken into consideration in developing the mitigation package contained in the 1983 Settlement Agreement, which decided against fish passage at the time. We agree that gravel stability under current Project operations is much more favorable to salmon production in the bypass, and thus should not be a factor affecting fish passage feasibility at the Diversion Dam. However, if high channel maintenance flows or process flows in this reach are to be proposed in a new mitigation package, gravel stability and the potential for salmon egg scour in the bypass reach should be addressed.
During the project's licensing proceeding, the joint agencies accepted in a 1983 Settlement Agreement alternative measures to enhance salmonid populations in lieu of fish passage at the Diversion Dam. As you know, Settlement Agreements that accompany a FERC license expire with that FERC license unless there is specific contract language to the contrary. Just as conditions change over time, so do our natural resource needs. Given the presence of Chinook and steelhead populations in the Sultan River that are part of larger population groups that are listed as threatened under the Endangered Species Act, the need for fish passage at the Diversion Dam may be different today than it was in 1983. The feasibility study finds that a standard vertical slot fishway is technically feasible at the Diversion Dam at an estimated cost of $3.6 million, which appears reasonable for a project of this size.	Comments noted.
The 6.4 mile bypass reach upstream of the Diversion Dam is described as having a high gradient, averaging 90 feet per mile in	We agree that the relatively steep conditions in the bypass reach are not inconsistent with productive salmon and steelhead habitat,

STAKEHOLDER COMMENT	LICENSEE RESPONSE
a steep walled canyon. Neither the gradient, which is equivalent to 1.7%, and is emphatically not high gradient, nor steep walled canyons are inconsistent with productive salmon and steelhead habitat, although canyons tend to be less productive than alluvial plain stream channels due in part to having less floodplain space to dissipate the high energy of flood flow events.	although steeper reaches are generally less productive than low gradient alluvial reaches such as the lower Sultan River.
Cold water temperatures, averaging 6°C, are cited as being too cold for optimal salmon and steelhead production. I also conclude that it is less than optimal. The PUD developed a multi-level outlet for the power tunnel which delivers water to the powerhouse and lower river reach and the mid-river reach downstream of the Diversion Dam. However no similar allowance was included for the discharge from Culmback Dam. While this doesn't affect the feasibility of fish passage into the bypass reach, it does call into question the purpose of doing so. However I believe the more significant question is associated with the failure to include the option of temperature control for normative water temperatures in the Culmback Dam discharge. I conclude that the fish passage feasibility assessment is deficient in its lack of investigation of what it will take to provide a multi-level outlet so that the Culmback Dam water discharge temperatures are normative.	It was not the objective of the study to assess means to modify the temperature of water released at Culmback Dam. We only point out that providing fish passage facilities at the upstream Diversion Dam would make little sense if the cold water release situation remains in its current state. We agree that a logical next step would be to look at means to condition the water temperatures so that they would be in better line with the needs of fish in the bypass reach.
The feasibility assessment notes that fish passage into the bypass reach would necessitate higher instream flows in the bypass reach in order to provide spawning and rearing habitat for anadromous fish. Those higher flows would put more cold water into river reaches 2 & 1, and the presumable result would be a reduction in productivity of the lower river reaches. Of course that is true. However the assessment sidesteps that the cold water release is also a project impact to public trust resources, and that those	It was not the purpose of Study Plan 20 to evaluate the instream flows in the bypass, and most of our production estimates were flow-neutral. However, we did provide alternative estimates for fall Chinook salmon and steelhead trout at an arbitrarily assumed higher flow (100 cfs). We recognize that the instream flow issue will be subject to further discussion in the relicensing process, and appreciate your constructive comments in this regard.

STAKEHOLDER COMMENT	LICENSEE RESPONSE
resources naturally and logically are entitled to water temperature mitigation on their own merit.	
The Marsh Creek slide that originated in 2006 at RM 7.6 appears to limit fish passage at certain flows. This natural slide could be a temporal partial obstacle to fish passage, or it may persist for a long time. The slide is a hydraulic control, and a discussion of restoring passage is due. It's not an action that would be required of the PUD, but could be sponsored by the PUD, one of the resource agencies, or Tribe. It has the potential to qualify under the Salmon Recovery Funding Board. The point to note is that the presence of the Marsh Creek slide is not inconsistent with fish passage at the Diversion Dam, but it may be a reason to delay it.	It was not the objective of the study to assess means to modify the Marsh Creek slide cascade. We only point out that providing fish passage facilities at the upstream Diversion Dam would make little sense if the Marsh Creek cascade were to remain in its current state. We agree that a logical next step would be to look at modifying the cascade.
Higher instream flows would reduce the amount of water available to energy production, potentially rendering the Jackson Hydro Project economically unviable. This may be true. As you are aware, it is not the responsibility of the Federal Power Act, FERC, or the several agencies, tribes, and other stakeholders to make hydroelectric projects economically viable by permitting the PUD to externalize the costs of environmental impacts, in effect providing a public fishery resource subsidy to the PUD. I believe that the full mitigation of project impacts to public trust resources is a natural and logical cost of hydroelectric energy generation.	Comments noted.