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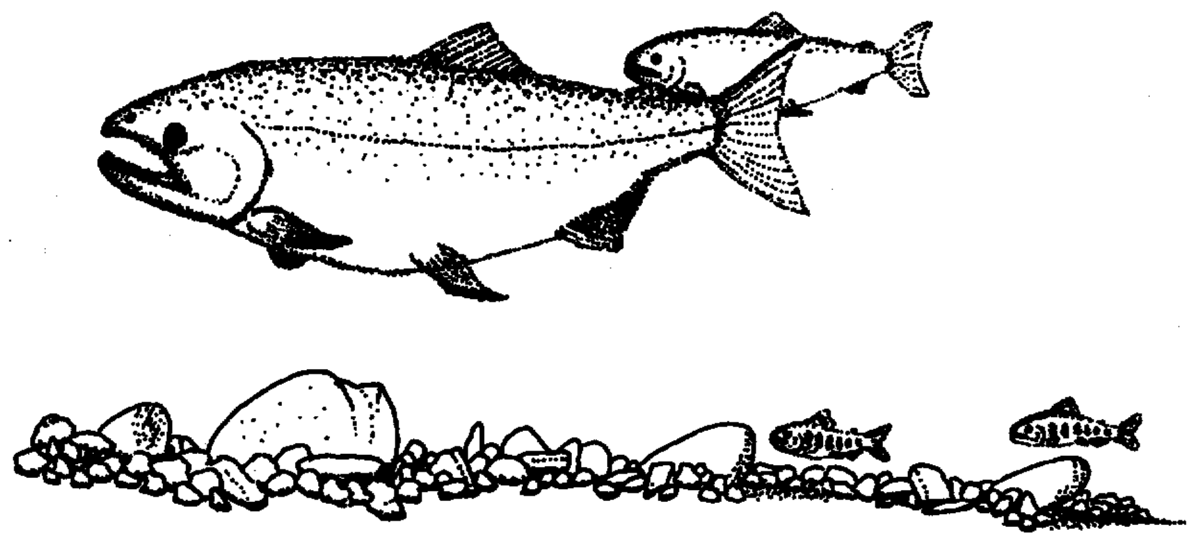
POTENTIAL EFFECTS OF INUNDATING SALMONID TRIBUTARY HABITAT DUE TO INCREASED IMPOUNDMENT AT HOWARD HANSON DAM



WESTERN WASHINGTON FISHERY RESOURCE OFFICE

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Potential Effects of Inundating Salmonid Tributary Habitat due to Increased Impoundment at Howard Hanson Dam

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ABSTRACT

To augment late-summer flows below Howard Hanson Dam, a 36-foot increase in spring/summer elevation of the Howard Hanson Reservoir is proposed. The increase in reservoir level would seasonally inundate portions of the mainstem Green River and nine other tributaries in the Howard Hanson Reservoir basin. Upper watershed tributaries are annually planted with subyearling chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), and steelhead (*O. mykiss*). Adult steelhead planting began in 1992. We conducted periodic fish and habitat surveys in the tributaries in 1991 to: (1) assess the extent and quality of additional tributary habitat impacted by an increase in maximum level of summer conservation pool, (2) characterize present fish usage of these habitats, and (3) evaluate the effects of the pool raise on salmonid rearing and potential steelhead spawning. We determined that the proposed pool raise would seasonally inundate approximately 3.2 miles of tributaries with a wetted area of 1,350,000 square feet during typical spring flow, and 808,000 square feet at late-summer flow. This habitat provides short-term rearing for juvenile chinook (most subyearlings appear to emigrate from tributaries by late spring/early summer), and year-round rearing for other salmonids. Potential smolt production from the affected tributary habitat is estimated to be approximately 21,000 to 210,000 chinook salmon, 11,710 coho salmon, and 1,785 steelhead trout. About 640,000 square feet of steelhead trout spawning habitat is also available in the reservoir's large tributaries affected by the proposed project. Potential inundation of steelhead redds during spring refill would probably cause high embryo mortality. Resident trout utilize all tributaries, and juvenile cutthroat are dominant. Large tributaries presently offer relatively high habitat suitability for both juvenile and adult salmonids; small tributaries offer generally lower and more variable habitat suitability than the large tributaries. Seasonal tributary inundation will likely reduce 1) the percent and cover value of pools, 2) riparian vegetative cover, and 3) streambank stability, while increases will occur in riffle fines. These effects are progressive, that is, the upper reaches of inundation in each tributary will be less affected because inundation occurs for less time than in downstream reaches. Inundation would typically occur for about six months (early April to late September) and result in an average increase of 180 surface acres of reservoir and 5.2 miles of reservoir shoreline. This seasonal increase in reservoir habitat may benefit anadromous fish production, particularly that of coho salmon, but no estimation techniques are available to reliably quantify such benefits. Resident lake-rearing trout may also benefit from this seasonal increase in reservoir habitat.

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INTRODUCTION

Additional water storage is proposed for Howard Hanson Reservoir to augment late summer flows in the Green River below Howard Hanson Dam. This added water storage would elevate reservoir pool levels in the spring and summer to a maximum of 1177 feet above mean sea level, as opposed to the existing maximum pool level of 1141 feet. Added water storage would also require that spring filling begin sooner than presently occurs. The exact shape of the annual refill and drawdown schedule under the added storage proposal has not yet been determined, however.

State and tribal agencies annually plant young-of-the-year chinook, coho, and steelhead in the watershed above Howard Hanson Dam (Appendix B), and adult steelhead planting began in 1992. Added water storage in the reservoir during the spring and summer would further inundate reservoir tributaries containing rearing and spawning habitat for anadromous and resident salmonids. Tributaries which would be flooded include portions of the mainstem Green River, the North Fork of the Green River, and eight other streams of consequence (Figure 1).

Presently, the U.S. Army Corps of Engineers (Seattle District) is conducting an investigation of the feasibility of increasing summer storage in the Howard Hanson basin. One component of the feasibility study addresses impacts to tributary habitat in the immediate reservoir basin from seasonal inundation which would occur with the proposed higher pool. Although many multi-purpose reservoirs such as Howard Hanson seasonally flood tributaries, few evaluations specifically address impacts to tributaries resulting from such inundation.

In 1991, the Western Washington Fishery Resource Office (WWFRO) assessed the impacts of the proposed increase in summer pool elevation on salmonid rearing habitat and steelhead spawning habitat in tributary reaches affected by the seasonal pool raise. The specific study objectives were:

1) Quantify the amount of tributary rearing and spawning habitat affected by the pool raise.

2) Qualitatively assess the value of tributary rearing and spawning habitat affected by the pool raise.

3) Qualitatively assess the impacts of the pool raise on rearing and spawning habitat in the reservoir basin.

METHODS

General Approach

We conducted monthly surveys from April to October of 1991 within each tributary affected by the proposed pool raise. We assessed salmonid use by electroshocking and snorkeling representative reaches of each tributary. We also inventoried key habitat features of each tributary during the spring and late-summer months. Spring surveys focused on potential spawning habitat for steelhead and resident trout (the proposed higher pool would inundate spawning habitat for steelhead and resident trout), and rearing habitat for all species of interest. Late-summer surveys focused on low-flow rearing habitat and general habitat features within both the proposed and the existing inundation zones of each tributary. Habitat in the existing inundation zone of each stream was examined to contrast habitat quality in inundated and non-inundated portions of the same stream. Table 1 summarizes major field activities. Potential smolt production was calculated from stream habitat data. Changes in reservoir area and shoreline length were measured (Table 2) to evaluate possible tradeoffs between stream and reservoir rearing area.

Inundation Bounds

In our initial April surveys, we located and marked the bounds of proposed inundation in streams affected by the pool raise (Figure 1). On the first stream surveyed (Charley Creek on April 23, 1991), we used the existing lake level elevation as a benchmark, surveyed to elevation 1141 feet with a transit, and determined that the existing tree/shrub line at high summer pool was a useful elevation guide. Thereafter, we relied on visual estimates of the tree/shrub line to locate the 1141-foot level in other streams, and surveyed with the transit to elevation 1177 feet, the upper limit of inundation 36 feet above the existing high summer pool. Lower and upper bounds of inundation in each stream were flagged during the survey for future reference. Within the proposed inundation zone of each stream, we also flagged a 100-yard representative reach for fish sampling. The representative reach typified habitat in the proposed inundation zone, and was located near its center.

We did not survey the bounds of inundation in Page Creek (Figure 1) until September, because we overlooked this independent tributary in our initial April surveys. Page Creek is not listed in the stream catalog (Williams et al. 1975) and it was incorrectly assumed to be a minor side channel of the North Fork during the spring-flow period. However, its relatively high flow in late summer prompted us to examine its source (Page Mill Pond), separately survey it, and label it Page Creek for this report.

Fish Usage of Tributaries

We assessed fish usage in representative reaches of each stream during the third week of each month from April to October (except Page Creek, above). We electroshocked the North Fork (within a shallow side channel only), Gale Creek, Cottonwood Creek, Piling Creek, and streams 0202, 0212, and 0215

(Figure 1). Each electroshock survey consisted of a thorough upstream sweep, by the same personnel, in the same manner. Numbers and lengths of salmonids collected were recorded. We took scales from some salmonids to aid in determining their age. We examined all juvenile chinook with a black light and noted presence of fluorescent dye-marks applied to portions of chinook groups released at two locations in the upper mainstem, and in the North Fork (Appendix Table B). Captured fish were returned to their places of collection at the conclusion of each survey.

We used length-frequency analysis and available scale information to identify age classes of electroshocker-caught fish. We also contacted personnel at Washington Department of Wildlife for information on resident trout age-length relationships in this drainage.

We snorkeled the Green River mainstem, North Fork, and Charley Creek (Figure 1) because electroshocking was generally not practical in these large streams. Each monthly snorkel survey consisted of one downstream drift by the same personnel through the representative reach. Numbers and approximate sizes of salmonids observed were noted. We also conducted supplemental snorkel surveys of the mainstem and North Fork in July, September, and October, outside of the representative reaches for habitat assessment purposes described below. During these supplemental surveys, fish observations were noted.

We sampled salmonids with hook-and-line in the lower mainstem and the mouth of Charley Creek in late fall to help identify species composition and age class of adult salmonids concentrated in these areas (all adult salmonids were resident fish; no adult steelhead releases occurred above Howard Hanson Dam either prior to or during the study period). Fish collected were measured for length, scales were taken, and, in addition, gonads were examined in several specimens to determine maturation.

We recorded resident cutthroat redds observed during the course of our monthly surveys from April through June, which covered the late-spring spawning period.

We reviewed fyke trap catches in the mainstem and North Fork (Figure 1). Fyke trapping occurred concurrently for the WWFRO fish passage study at Howard Hanson Dam in 1991 (Dilley and Wunderlich 1992). These catch data provided added information on fish usage in tributaries. The mainstem fyke was located within the proposed inundation zone, while the North Fork trap was located, for access reasons, about 0.6 stream miles above the proposed inundation zone.

Potential Smolt Production

Chinook Salmon

We computed potential chinook smolt production in affected tributaries by applying smolt density values to available rearing habitat. We assumed a predominate late spring/early summer outmigration pattern based on mainstem fyke trap catches and ATPase values observed in the concurrent WWFRO outmigration study, and life history information for Green River fall chinook (Grette and Salo 1986). We used spring wetted area of the affected tributaries as the rearing habitat base because of the assumed late spring/early summer outmigration pattern. Rearing densities for juvenile chinook salmon at this stage are quite uncertain, so we applied a possible low value (0.14 smolts/yd^2) and a high value (1.40 smolts/yd^2) based on a review of chinook density values reported by Natural Resources Consultants, Inc. (1991). This yielded a range of potential chinook smolt production.

Further assumptions and limitations of this approach (including use of density values) appear below.

Coho Salmon

We classified tributaries as large (> 18 feet width at summer low flow) or small, then applied appropriate coho smolt production factors. Potential production in large tributaries was determined by applying 2.5 smolts/yd of thalweg length (Zillges 1977). Production in small tributaries was calculated by applying 0.092 smolts/yd^2 low-flow wetted area, based on production factors reported by Baranski (1989).

Steelhead

We estimated steelhead smolt production in tributary streams with the parr utilization factors reported in Gibbons et al. (1985), and an assumed parr-to-smolt survival rate. Following this methodology, we stratified tributaries by gradient and discharge, then applied the following Green River parr density factors per 100 m^2 of low-flow area (Table 12 in Gibbons et al. (1985)): 4.10 for the Green River mainstem; 6.68 for other large tributaries (greater than 10 cfs late-summer flow); and 5.11 for the remaining small tributaries. We assumed a 50% parr-to-smolt survival rate in all streams, as this value has been used in previous applications of this type (Thom Johnson, Washington Department of Wildlife, personal communication).

Habitat Impact Assessment

Several habitat features were noted in the proposed inundation zones of each stream during spring. We recorded information on stream widths and depths to approximate potential steelhead spawning area. We also estimated amount of backwater habitat of value for coho rearing during winter (April only). We evaluated potential adult steelhead barriers in the inundation zones using the method of Powers and Orsborn (1985). Habitat above a potential steelhead barrier was examined to see if any new spawning area would be accessible if the barrier were inundated with the proposed higher spring pool.

For low-flow surveys, we selected a stream habitat inventory method used by the U.S. Forest Service (1990), and modified it for this assessment. This method allowed a relatively rapid, but extensive, assessment of stream size and key habitat features within each tributary (plus determination of HSI values described below). After stream habitat was classified as pool or riffle, its area and depth were physically measured. Then we qualitatively assessed pool class (if pool), substrate type, woody debris, instream cover, substrate embeddedness, riparian cover, bank cover, and canopy cover. Specific assessment criteria are provided in Appendix Table A. Qualitative assessments were made by the same observers in all sections of all streams to reduce variation in data due to observer bias.

Late summer/early fall habitat inventories were conducted in both the proposed and the existing inundation zones of each tributary. This permitted a contrast between zones, and thus a basis for predicting the specific effects of seasonally inundating new areas of these same streams. We surveyed the entire 36-foot elevation gain in proposed inundation zones, and the top 30-foot gain in existing zones (except as noted below). Although proposed zones were surveyed in late August/early September, we delayed surveying the existing zones until late October in order to take advantage of the unusually low lake level and stream flow caused by the dry fall weather of 1991. This was accomplished by checking daily weather forecasts. This delay permitted the best possible contrast between zones because stream flows were still comparable in both time periods, yet more of the existing zones were exposed by late October.

We used a computer spreadsheet to summarize and tabulate habitat inventory data which were used, in part, to determine Habitat Suitability Index (HSI) values described below. Gradient was calculated from measured thalweg length and elevation gain in each stream. Qualitative habitat assessments in each habitat type (pool or riffle) of each stream were weighted by their respective area or length to better characterize habitat features throughout the entire inundation zone. That is, we made individual assessments of all habitat features in each habitat type. To characterize the entire stream reach for each habitat feature, assessments in each habitat type were weighted by the proportion of the total reach the habitat type represented. Substrate type, substrate embeddedness, and instream cover were weighted by stream area; riparian cover, bank cover, and canopy cover were weighted by stream length. Appendix Table A provides more detail on weighting.

In addition to collecting the habitat measures described above, we measured instantaneous stream temperatures during monthly habitat surveys, and measured low-flow discharges in all streams to help characterize stream habitat.

Habitat suitability of the tributaries was assessed using the Service's HSI models for chinook salmon (Raleigh et al. 1986), coho salmon (McMahon 1983), rainbow/steelhead trout (Raleigh et al. 1984), and cutthroat trout (Hickman and Raleigh 1982). These references provided an index of habitat suitability for a variety of habitat variables at different life stages of each species. HSI values for each variable (or habitat feature, such as pool/riffle ratio) are uniformly scaled on a 0 to 1 basis (0 being poorest; 1 being best habitat suitability for a given habitat variable). We selected a range of fundamental habitat variables for juvenile and adult life stages, and estimated HSI values for each variable in each stream (proposed and existing inundation zones).

Habitat variables used for juvenile salmonids are described in Table 3, and adult salmonids in Table 4. For juvenile salmonids, we determined that most variables were reasonably common to all species of interest. The only exceptions were canopy cover and winter-backwater area, which we found were most relevant only to juvenile coho salmon and not other juvenile salmonids. Adult salmonid variables were also the same for both species (rainbow/steelhead and cutthroat), except distinction was made for adult size as it related to suitable thalweg depth. For this evaluation, we used HSI variable curves which related to large adult trouts only (which would include adult steelhead).

We assessed the probable impacts of seasonal inundation by contrasting HSI values for the proposed and existing inundation zones within each steam, for each life stage. Because HSI values are scaled similarly (0 to 1), between-stream comparisons of habitat features were also made.

Redd Inundation

We reviewed the available scientific literature regarding the effects of inundating redds. With adult steelhead releases in the upper basin, spawning may occur in tributaries later inundated during the egg-incubation period. We examined literature available at the University of Washington and Washington State Library.

RESULTS AND DISCUSSION

For descriptive purposes in this report, we divided the Howard Hanson tributaries into large and small categories. Large tributaries consisted of the Green River mainstem, the North Fork of the Green River, Page Creek, Charley Creek, and Gale Creek (Figure 1). These streams had late-summer flow of at least 10 cfs, and represented the bulk of the tributary fish habitat affected by the proposed project. Small tributaries consisted of Piling Creek, Cottonwood Creek (or stream 0195), and streams 0202, 0212, and 0215 (Figure 1). These streams exhibited low summer flows of substantially less than 10 cfs, and provided relatively little fish habitat as a group compared to the large tributaries. Some of these small tributaries had no flow in late summer, as described below.

An additional small tributary in the basin, stream 0213, enters the reservoir on the left bank between the reservoir's upper and lower lobes. It flows in a long, steep, half-round culvert through virtually its entire length in both existing and proposed inundation zones. Because of this extensive culvert, we omitted stream 0213 from monthly surveys, although records indicate that this stream has recently been planted with chinook (Appendix Table B).

Appendix Tables D to R provide detailed results of habitat inventories in each stream for reference.

Fish Usage of Tributaries

Both rearing and migratory fish were observed in tributary habitat affected by the proposed project. Distinction between the two is noted below, where possible.

Chinook Salmon

The bulk of juvenile chinook salmon observations within the proposed inundation zones occurred at the mainstem fyke trap, which was situated at a railroad bridge about 0.5 river mile upstream of full pool level near the center of the proposed inundation zone (Figure 1). Because the primary purpose of the mainstem fyke (and North Fork fyke) was to gauge fish movement into the reservoir as part of the concurrent WWFRO fish-passage study in 1991, additional and more detailed information on fyke catch data is provided in that study (Dilley and Wunderlich 1992). Here we highlight fyke-trap information as it relates to fish usage of the proposed inundation zones.

Juvenile chinook catches in the mainstem fyke ranged from late April until early July, peaking in mid-to-late June. Preliminary data indicate we recovered a total of 548 chinook at this site. All chinook captures were subyearling fish planted in late February and early March in the upper watershed. Appendix Table B provides detailed planting data.

At the mainstem fyke trap, we recovered one dye-marked chinook on June 5th showing the North Fork planting color (green). Juvenile chinook have been observed to move upstream in small tributaries to the upper Elwha River reservoir (Hosey and Associates 1990) and in lower Fraser River tributaries (Murray and Rosenau 1989). However, we doubt that this individual (78-mm forklength) could move approximately one river mile up the Green River mainstem (from the North Fork) to the fyke trap at spring flows. We therefore suspect the individual was a mis-mark.

We observed no juvenile chinook in the proposed inundation zone of the mainstem during our snorkel surveys (Appendix Table C), which included the fyke trap site. Most juvenile chinook captures occurred at night at the fyke, which may explain our lack of juvenile chinook observations while snorkeling.

North Fork observations of juvenile chinook occurred almost exclusively in a shallow side channel near the center of the proposed inundation zone. At this site, we recovered a total of 143 subyearling chinook by electroshocker, with a peak catch of 74 in early June (Table 5). We only recovered green-dyed chinook, which originated from a February 21st planting by the Tribe about 0.8 river miles upstream. The most productive collection point at this location consisted of a shallow root-wad narrowly connected to the main channel. This root-wad site totally dried up by late July, but appeared to be an ideal short-term rearing site for spring subyearling chinook, based on similar observations in the upper Nooksack River (Wunderlich et al. 1982). The North Fork has a relative abundance of such sites, compared to the other reservoir tributaries.

North Fork fyke trap catches of juvenile chinook were sporadic with only a total of 7 captures, 5 of which occurred in late June. The fyke was not particularly effective at this location (RM 1.0 at a road bridge), and became non-functional by early August due to lack of flow. Additionally, planting records indicate that most chinook were released at RM 1.0 in late February and early March, so probably moved downstream before the start of trapping in early April.

We electroshocked several similar side-channels in the upper mainstem during late May and early June in an attempt to locate other chinook concentrations, but were not successful. We sampled on two occasions near the confluence of Smay Creek (RM 75) and near Lester (RM 81), below major chinook planting sites.

The only additional observations of juvenile chinook in reservoir tributaries occurred in Gale Creek (Appendix Table C). Surprisingly, these recoveries only occurred in June and July, despite relatively large plants in this drainage in late winter of 1991 (Appendix Table B). This collection site included shallow water habitat suitable for young-of-the-year salmonids.

We consider the reservoir tributaries to be important short-term rearing areas and transportation corridors for planted subyearling chinook. By about late June/early July, most juvenile chinook use appears completed based on electroshocker and fyke collections in the mainstem and North Fork.

Coho Salmon

The bulk of coho salmon collections again occurred in the mainstem fyke trap, and more detailed presentation of that data is provided in the WWFRO fish-passage report. We recovered a total of 897 juvenile coho at this site (309 smolts, 588 fry). No coho were observed while snorkeling on any date in the mainstem (Appendix Table C). Smolt collections in the fyke occurred from April 22nd (first date of operation) until late June, peaking in late May and early June. This pattern of coho smolt movement is consistent with earlier scoop trapping in the upper Green River (Seiler and Neuhauser 1985), and is common elsewhere, such as the Elwha River (Wunderlich et al. 1989). Fry collections peaked on the first day of trapping, and then occurred sporadically until July 30th, with no apparent trend. We note that fry were planted upriver from April 17th to 19th (Appendix Table B), so initial fry collections in the proposed inundation zone undoubtedly were fish displaced from upper planting sites.

North Fork collections were relatively light compared to the mainstem, with some evidence of a comparable peak in smolt movement. Smolt catches above the inundation zone in the fyke trap totalled only 16, with a peak of 4 fish on May 19th, and the last recovery on June 14th. Only 5 fry were recovered in the fyke, and an additional 9 by electroshocking in the representative reach over the total collection period. Evidence of fry displacement from upstream plants was not apparent in this drainage.

Our sample site in Gale Creek included a mix of habitat types that harbored juvenile coho in relatively large numbers throughout the collection period, peaking in June (Appendix Table C).

We did not encounter coho salmon in other tributaries, except stream 0215 in late summer. Other tributaries were not planted in 1991 or 1990 (with the exception of Charley Creek in 1990). The coho observed in stream 0215 (0+ fish as confirmed by scale analysis) evidently originated from another tributary and moved upstream from the reservoir during summer. Stream 0215 is a small, densely overgrown tributary with extensive seeps in its proposed inundation zone.

Trouts

Steelhead smolts were noticeably absent in most collections/observations. Preliminary data indicate only two recoveries in the mainstem fyke trap, and five in the scoop trap. Seiler and Neuhauser (1985) reported a fingerling-to-smolt survival of 2.1% for steelhead planted in the upper Green River in 1982 and recovered by scoop trap in 1984 below Howard Hanson Dam. Planting records indicate that 46,530 fingerlings were released in 1989 in the upper mainstem (Appendix Table B). At the 2.1% survival rate reported by Seiler and Neuhauser (1985), approximately 977 smolts would have passed the project in 1991 during the spring period. It is unclear why greater numbers were not observed in the 1991 work.

Tributary collections were dominated by juvenile cutthroat trout in most streams (Appendix Table C), although catches in fyke nets in both the North

Fork and mainstem contained insignificant numbers of trout compared to juvenile salmon. Rainbow trout, and "unknown" trout, were present to a lesser extent. Unknown trout included individuals displaying features of both rainbow and cutthroat; hybridization between the two species does occur (Raleigh et al. 1984).

Two trends in abundance were apparent in our monthly trout observations (Appendix Table C). First, juvenile cutthroat (0+) were collected in greater numbers in mid-to-late summer, as opposed to the early and late portions of our collection period. We believe this coincided with the time of emergence within and above our sample reaches. Second, we observed substantially more adult rainbow and cutthroat in the mainstem in late summer. These increases may be related to spawning movement. Numbers of fish in the mainstem peaked in September for both species. We also observed similar concentrations of adult trout (approximately 12 to 20 inches long) above our sample reach, and within the existing inundation zone of the mainstem, during habitat surveys in late summer. Adult concentrations were also noted at the mouth of Charley Creek in late summer. Hook-and-line samples indicated relatively mature egg masses among several individuals collected at these locations.

We observed only two certain resident trout redds during monthly surveys, but most spawning may have occurred before our surveys. Both redds were observed in the upper portion of Cottonwood Creek (above an impassable culvert barrier) on June 4th. One additional possible redd site was noted in lower Gale Creek at this time, but may only have been an elk hoof print. Both cutthroat and rainbow trout spawning occurs from January to July (Hickman and Raleigh 1982; Raleigh et al. 1984), although resident trout spawning in the upper Green River occurs primarily from January to March (Stew Mercer, Washington Department of Wildlife, personal communication), prior to our survey period. However, we collected one gravid female cutthroat (205-mm forklength) in the upper reach of stream 0212 in late April.

We believe the resident cutthroat and rainbow trout in the Howard Hanson basin are likely composed of stream-rearing and lake-rearing strains, which are reproductively isolated. Such segregation is not uncommon (Raleigh et al. 1984; Trotter 1989; Carlander 1969). Stream-rearing strains complete their life history within small, headwater streams such as the small tributaries in the Howard Hanson basin and reach sexual maturity at a smaller size than the lake-rearing form. The gravid female cutthroat collected in stream 0212, and redds observed in upper Cottonwood Creek likely represent the stream-rearing strain. In contrast, the lake-rearing strain typically enters large tributary streams for spawning, the young rear for one to two years in a large tributary, then return to a lake (or reservoir) for additional rearing and reach much greater size than their stream-rearing counterparts. Concentrations of large trout observed in the mainstem in late summer and fall are likely a lake-rearing strain.

Char

We collected brook trout (*Salvelinus fontinalis*) in Page Creek in August (Appendix Table C), which was the only sampling conducted in that tributary. No other salmonids were collected in Page Creek. Brook trout were collected in the lower reach of this tributary downstream of an abandoned timber crib dam, described below. Brook trout were not encountered anywhere else in the basin.

Potential Smolt Production

Chinook Salmon

We calculated a potential chinook smolt production of 21,013 to 210,134 for the tributary habitat seasonally inundated with the proposed project (Table 6). The bulk of this potential production is associated with the mainstem and North Fork, followed by the other large tributaries. Potential small-tributary chinook production is a negligible portion of the total (less than 3%).

Estimating potential chinook smolt production is problematic because questions exist regarding rearing densities and limiting factors. The range of values suggested for the Howard Hanson tributaries is considered reasonable, however, based on the available information. We drew habitat density data from a fairly extensive review of the subject (Hosey and Associates 1988) which listed a range of 0.01 to 1.60 smolts per square yard in 20 Pacific northwest streams. Based on that review, Natural Resources Consultants, Inc. (1991) deemed a range of 0.14 to 1.40 smolts per square yard as "reasonable" for the Elwha River chinook, which exhibit a predominate summer-fall emigration pattern (Dilley and Wunderlich 1990) similar to that observed in the concurrent WWFRO fish passage study at Howard Hanson Dam. In comparison, a 0.2 smolts per square yard density is suggested for Columbia basin streams (Northwest Power Planning Council 1986), and a 0.1 to 0.6 fish per square yard density was reported for the Skagit River (Graybill et al. 1978). Our sole chinook collection site in the North Fork of the Green River supported a peak density of approximately 1 chinook per square yard this past spring (Table 5), which was within the 0.14 to 1.4 smolts per square yard range used in this estimate.
We provide no estimate for juvenile chinook production in the higher reservoir pool because no methodology is available for this purpose. Undoubtedly, juvenile chinook rear in the existing reservoir pool during the summer period, as evidenced by the chinook captured in the concurrent WWFRO fish passage evaluation at Howard Hanson Dam, and as observed by Cropp (undated). Similar use is made of the upper Elwha River reservoir by late-summer-emigrating juvenile chinook (Dilley and Wunderlich 1990; Wunderlich and Dilley 1988). Lengths of subyearling chinook passing the Howard Hanson Dam in late summer and fall of 1991 ranged from about 150 to 225 mm based on scale analysis and dye-mark recoveries of chinook collected at the scoop trap below the dam in the concurrent WWFRO fish passage study. This suggested that substantial growth occurred since their February planting in the upper watershed (Appendix Table B), much of which may have occurred in the reservoir.

Coho Salmon

Potential coho production in tributary habitat affected by the pool raise is estimated at 11,710 smolts (Table 6). The mainstem provides nearly half the estimated production (47%), while other large tributaries provide most of the balance. Small tributaries account for less than 2% of the total due to their small size and relatively high gradient.

Potential tributary coho production may be overestimated. The smolt estimator we used for the small tributaries was based on relatively current work, but the large-tributary factor (Table 6) is believed less accurate. Baranski (1989) updated the small-tributary factors and also included the influence of gradient in his update. However, he noted that the large-tributary factor needed to be refined. The value used here, 2.5 smolts per lineal yard based on Zillges (1977), may overestimate production value of such habitat.

We provide no estimate for potential coho production associated with the higher reservoir pool itself because we found no reliable estimation method for this purpose. Undoubtedly, juvenile coho rear in the existing reservoir pool during the summer period as evidenced by coho captured in the concurrent WWFRO fish-passage evaluation at Howard Hanson Project, and in reservoir gillnetting by Cropp (undated) and Seiler and Neuhauser (1985). Zillges (1977) suggested a production factor of 1.25 coho smolts per yard of lakeshore in Puget Sound, but Baranski (1989) noted that this value needed to be updated and refined. Moreover, extreme seasonal fluctuations in Howard Hanson Reservoir levels, and the highly anomalous coho emigration pattern recently observed in the concurrent WWFRO fish passage at Howard Hanson Dam, prevent meaningful estimation of coho production due to the higher reservoir pool.

Steelhead

Potential steelhead smolt production in tributaries affected by the pool raise is estimated at 1,785 (Table 6). Again, the mainstem accounts for most potential production (64%), followed by other large tributaries (34%). Small tributaries account for just over 2% of the total.

Several considerations are important in these estimates. Not all parr utilization values, which were applied to habitat area to estimate parr production, are measures of absolute abundance. Values used for large tributaries were originally based on snorkel counts and therefore would be minimum estimates of parr abundance (Bob Gibbons, Washington Department of Wildlife, personal communication). Thus, estimates of production may be conservative for large tributaries. The parr-to-smolt survival value (50% from 1+ parr to 2+ smolt) is only a generic estimate (Thom Johnson, Washington Department of Wildlife, personal communication).

We provide no estimate for potential steelhead production associated with the proposed increased pool because we are not aware of any reliable method for this purpose.

Potential Steelhead Spawning Habitat

Table 7 shows estimates of steelhead spawning habitat in tributaries affected by the pool raise. A total of 641,887 ft^2 is indicated. The mainstem and North Fork provide the bulk of potential spawning area. Page Creek contains an impassable barrier which blocks the upper 40% of the proposed inundation zone. This barrier would be inundated at high spring pool with the added storage project, but no spawning habitat exists above the barrier because the tributary terminates in a series of soft-bottom beaver ponds which eventually lead to Page Mill Pond, a soft-bottom seep.

We judge all of the small tributaries to be unsuitable for adult steelhead trout utilization due to lack of depth, flow, and other constraints listed in Table 7. Culvert barriers exist in Cottonwood Creek and stream 0202 which would be inundated at high spring pool, but no suitable steelhead spawning habitat occurs above either barrier.

Habitat Impact Assessment

The proposed pool raise essentially extends the effects of seasonal inundation observed in the existing upper basin to the proposed areas of inundation. In general, the dominant effects of seasonal inundation of tributaries are: 1) substantial reductions in vegetative cover, stream bank stability, percent and structure of pools, and 2) increases in riffle fines. Figures 2 through 5 contrast HSI values for proposed and existing inundation zones in the large and small tributaries (where available), for both juvenile and adult life stages of the species of interest. Specific streams are further discussed below.

We completed surveys of seasonally inundated stream reaches for all large tributaries. However, only stream 0215 of the small streams was surveyed within the inundation zone because only it had appreciable surface flow at the time of survey.

HSI values shown in Figures 2 through 5 indicate "average" values for the reaches in question. However, the inundation effects are actually progressive, that is, the upper reaches of the tributaries are less affected than the lower reaches because the upper reaches are seasonally inundated for less time. Perhaps the most striking examples of such progressive effects are exhibited by the mainstem and North Fork due to their low gradients. Appendix Tables N and O indicate, for example, the progressive loss of riparian cover as these streams descend into the existing reservoir basin.

There are two other implications associated with progressive inundation effects. First, the proposed pool raise would further reduce habitat suitability of the upper reaches of the existing inundation zones surveyed, as these areas would be subjected to longer periods of inundation with the pool raise. We did not explicitly assess that impact here. Second, our within-basin surveys only covered the top 30 vertical feet of tributaries due to weather and flow constraints (except Gale Creek, where we only surveyed the top 22 vertical feet because it merged with the mainstem below that elevation). Our contrasts are therefore conservative, because the more severe effects of inundation in the lowermost reaches of each stream are not included in the HSI values shown for existing inundation zones.

In general, the proposed inundation zones of the large tributaries offer relatively good habitat suitability for both juveniles and adults, with some exceptions (Figures 2 and 3). The mainstem has relatively little shallow backwater area. The North Fork exhibits relatively high riffle fines, presumably due to logging in the watershed. Page Creek in the North Fork has an abandoned timber crib dam and extensive beaver ponds in its upper reach (approximately the upper 40% of the proposed inundation zone, Appendix Table F); aquatic vegetation and a shallow, soft-bottom channel dominate its lower reach. Charley Creek's substrate is relatively coarse, dominated by small-boulder and cobble (Appendix Table G).

The proposed inundation zones of the small tributaries offer generally lower quality and more variable habitat suitability for juvenile and adult salmonids than large tributaries (Figures 4 and 5). Stream size and depth are limiting to large adult trout in all streams. Piling Creek is dominated by bedrock substrate (Appendix Table J). Except for Cottonwood Creek, pools in small streams are of limited size and provide limited cover. Portions of Cottonwood Creek were dry by late summer. Streams 0212 and 0215 exhibit a high degree of substrate embeddedness (Appendix Tables L and M), presumably due to logging in their drainages.

Available stream temperature data (Table 8) suggest that no salmonid life stages of the species of interest are limited by temperature problems within the proposed inundation zones of these streams.

With seasonal inundation of presently non-inundated stream reaches, we expect a marked reduction in habitat suitability. Figures 2 through 5 suggest reductions in most variables, particularly proportion and structure of pools, vegetative cover, and streambank stability which would negatively affect both juvenile and adult salmonids. Loss of vegetative cover would affect small tributaries to a greater extent than large streams, as size and depth of smaller tributaries would limit their capacity to buffer the effects of vegetation loss as it relates to shading, erosion control, and allochthonous input. We also suspect that loss of pools due to seasonal inundation means shallow backwater habitat, of particular value to overwintering coho parr, would be eliminated or substantially reduced as well (not through direct inundation, as winter flood elevations would not reach tributary habitat in the proposed inundation zones, but rather through the indirect effects of annual summer refilling).

Effects of Redd Inundation

Inundation of tributaries will result in lower water velocities, decreased oxygen levels, and increased sediment loads in the redd environment. Fine sediment (< 0.8 mm) in spawning substrate is a major cause of embryo and larval mortality (Iwamoto et al. 1978). When intragravel spaces are filled with fines, surface flows are reduced and alevins trying to emerge into the water column become trapped.

Increased pool levels will reduce velocity in the lower reaches of the contributing tributaries. Such velocity reductions will no longer enable these systems to carry suspended loads, resulting in increased sedimentation (Dunne and Leopold 1978). Accelerated sedimentation can be detrimental to several growth stages of salmonids. Since survival of eggs is dependent on a continuous supply of well-oxygenated water through the streambed gravels, the infiltration of fine sediments can lead to suffocation of eggs (Silver et al. 1963) and may cause immediate mortality. Dissolved oxygen is a biological requirement for embryo development, and intragravel waterflow transports dissolved oxygen to the embryo and removes metabolic waste from the surroundings (Cordone and Kelly 1961). Certain investigations have demonstrated the effect of low velocity, and hence its inability to provide sufficient oxygen, on the size of steelhead and chinook salmon embryos (Silver et al. 1963) and coho salmon embryos (Shumway et al. 1964). Even under conditions that are not lethal for embryos, delay of hatching and reduction in size of fry presumably can result in a high mortality because of emergence from the gravel of many small and weak fry; their subsequent success in the natural environment may be impossible.

Inundation of redds will result in lower dissolved oxygen levels, posing a wide range of problems for incubating eggs. It has been recognized that salmonids are extremely sensitive to hypoxia (deficiency of oxygen reaching body tissues) during early life (Shumway et al. 1964). Unless the incubating eggs are wetted by groundwater seeps, high mortality is incurred within a few days after exposure to low dissolved oxygen levels (Decker-Hess and McMullin 1983).

In addition, environmental factors such as temperature can have a significant effect on both the course of development and the incipient limiting level at any given stage of aquatic life (Davis 1975). Water depth and water temperature are inversely related because as water depth increases, water temperature decreases. Embryo development may therefore be slowed by inundation of tributary gravels.

Benthic insects are an important salmonid food source; their reduction due to reservoir drawdown could also negatively affect fish populations. Benthic biomass surveys conducted in Libby and Hungry Horse Reservoirs (Chisholm and Fraley 1986; May et al. 1988) showed that reservoir drawdown during late summer had a negative impact on benthic insect production. Dewatering substrate near full pool during peak insect emergence resulted in the greatest loss of benthic production (Grimas 1961; Fillion 1967).

In summary, available scientific literature suggests that inundation of steelhead redds would likely result in high mortality of embryos and alevins. Although specific empirical measures of the effects of redd inundation were not located in the literature, most evidence points to potentially poor survival.

Tributary versus Reservoir Habitat

Changes in tributary and reservoir habitat in the Howard Hanson basin are dynamic. Available information indicates that the proposed inundation zones would be inundated about six months of each year, or from approximately early April to late September. The remainder of the year the proposed inundation zones would not even be temporarily inundated, as they lie well above winter flood pool levels. A total of 3.2 miles (17,038 ft) of tributary stream will be inundated at full pool (Table 6), versus an average increase of about 180 surface acres of reservoir and 5.2 miles (9,200 yd) of reservoir shoreline compared to the existing project (Table 2).

Although seasonal inundation will render tributary habitat much less suitable during the low-pool period, as noted above, salmonids will still use them. Dilley (1991) observed small numbers of juvenile coho and trout, and adult steelhead in Wynoochee Reservoir's tributaries (existing inundation zone) during the winter low-pool period. Hosey (1990) noted that juvenile chinook moved upstream from an Elwha River reservoir into a tributary stream (non-inundated) during spring rearing. In this work, we observed juvenile coho moving upstream from Howard Hanson Reservoir into stream 0215 during late-summer drawdown. We also noted large concentrations of adult trout in mainstem pools only recently exposed during fall reservoir drawdown.

Value of tributary versus lake rearing habitat during the refill period probably varies by species. Of the anadromous species, coho salmon may be most benefitted as they display a high affinity for pond and lake rearing (Reeves et al. 1989; Canada Department of Fisheries and Oceans 1991). In contrast, we suspect that juvenile chinook would be least suited for lake rearing compared to tributary rearing due to their small size at emigration (assumed to be late spring/summer in the Green River) although, as noted above, late-fall chinook migrants recovered at the scoop trap (Dilley and Wunderlich 1992) showed substantial growth since their February planting in the upper watershed, possibly due to reservoir rearing.

Lake-rearing trout may be benefitted by the increased reservoir which could result in greater predation on juvenile anadromous fish. The proposed reservoir increase occurs during the growing season, and includes relatively shallow portions of the impoundment. These factors are known to positively influence resident fish production (Bennet 1970). If so, predation on anadromous fish could increase. Resident trout, for example, were important predators in a Lewis River reservoir, causing substantial juvenile coho mortality (Hamilton et al. 1970).

Seasonal inundation of reservoir tributaries will also reduce their suitability as spawning habitat for both resident and anadromous trout, and inundation of trout redds may lead to high embryo mortality, as noted above. No new spawning habitat will be accessible at higher spring pool.

SUMMARY

We evaluated the effects of inundating salmonid tributary habitat in the Howard Hanson basin due to a proposed 36-foot raise in the summer pool. We quantified the amount and value of tributary rearing and spawning habitat affected by the pool raise, and qualitatively assessed the impacts of the pool raise on this habitat in the reservoir basin.

For this assessment, we conducted monthly fish surveys by electroshocking and/or snorkeling representative reaches of the affected tributaries during the proposed annual inundation period (April to October), and reviewed fyke trap catches in the mainstem and North Fork of the Green River which occurred during the same time period for the concurrent WWFRO fish-passage study at Howard Hanson Dam. We also performed habitat surveys during spring and late summer in these tributaries. Late-summer habitat surveys were conducted in both the proposed and the existing inundation zones of each tributary (where possible). The latter surveys provided a basis for estimating the impacts of seasonally inundating reservoir tributaries. Habitat value was primarily assessed by means of Habitat Suitability Indices. Potential smolt production (chinook, coho, and steelhead) was estimated with regional production indices. The scientific literature was reviewed to assess the probable effects of inundating steelhead redds due to the spring pool raise.

Our principal findings were:

1) Ten tributaries are affected by the proposed pool raise. Large tributaries provide the bulk of tributary habitat in the basin and represent the vast majority of potential anadromous fish production. The small tributaries offer relatively little salmonid habitat and potential fish production.

2) Total length of tributaries potentially inundated equals approximately 3.2 miles. Their total area at spring flow is approximately 1,350,000 ft^2, and at late-summer flow, 808,000 ft^2.

3) Added summer storage results in an average increase of 180 surface acres of reservoir and 5.2 miles of reservoir shoreline.

4) Reservoir tributaries offer important short-term rearing for juvenile chinook, which appear to emigrate from them by late spring/early summer. We estimate potential chinook production at approximately 21,000 to 210,000 in the tributary habitat affected. No off-setting value was developed for added reservoir habitat because of lack of appropriate methodology.

5) Reservoir tributaries provide year-round rearing for juvenile coho. Peak smolt emigration occurs in late May and early June. Displaced coho fry passed through the mainstem shortly after planting. No major fry displacement was observed in other tributaries. We estimate potential coho smolt production to be approximately 11,700 in the tributary habitat

affected. No off-setting value was developed for added reservoir habitat because of lack of appropriate methodology.

6) We encountered very few steelhead smolts in our surveys and collections, even though 46,000 fingerlings were planted in 1989. We observed no evidence of juvenile steelhead displacement after fish were planted in August 1991, based on mainstem fyke trap catches. Potential steelhead smolt production was estimated at 1,785 from all tributaries; no reservoir value was developed due to lack of methods. The smolt production estimate may be low.

7) Resident trout, primarily juvenile cutthroat, utilize all reservoir tributaries. In late summer and early fall, we observed significant increases in adult trout in the mainstem. We suspect that a lake-rearing strain ascends the larger tributaries at this time for eventual spawning, and their progeny rear for one to two years before returning to the reservoir. A stream-rearing trout strain may inhabit the small headwater tributaries, completing their life cycle totally within the small tributaries. Brook trout inhabit the outflow from Page Mill Pond in the North Fork.

8) Large tributaries offer about 640,000 ft^2 of potential steelhead spawning habitat. Small tributaries offer none. Inundation of redds due to spring refill would probably cause high embryo mortality. No added spawning habitat becomes accessible with higher spring pool.

9) Large tributaries offer relatively good habitat suitability for both juvenile and adult salmonids, while small tributaries offer generally less and more variable suitability. Seasonal inundation will reduce vegetative cover, stream bank stability, percent and structure of pools, and increase riffle fines. Most of these effects are progressive, that is, the upper reaches of inundation will be less affected because inundation occurs for less time than in downstream reaches.

10) The higher pool would typically inundate tributaries for up to six months annually, from about early April to late September. During non-inundation, juvenile and adult anadromous fish may use these tributaries. Coho may best adapt to added reservoir area; chinook the least. Resident lake-rearing trout may increase with the added pool, and this could cause increased predation on juvenile anadromous fish.

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REFERENCES

Baranski, C. 1989. Coho smolt production in ten Puget Sound streams. Technical Report Number 99. Washington Department of Fisheries, Olympia.

Beecher, H. 1986. Memorandum dated April 30, 1986, describing substrate/cover preferences for steelhead. Washington Department of Game, Olympia.

Bennet, G. 1970. Management of lakes and ponds. Second edition. Van Nostrand Reinhold Company.

Canada Department of Fisheries and Oceans. 1991. Strait of Georgia coho salmon resource status and management planning process. Interim Report.

Carlander, K. 1969. Handbook of Freshwater Fishery Biology. Volume One. Iowa Cooperative Fishery Unit, Iowa State University, Ames.

Chisholm, J. and J. Fraley. 1986. Quantification of Libby Reservoir levels needed to maintain or enhance reservoir fisheries. Report to Bonneville Power Administration. Montana Department of Fish, Wildlife, and Parks. 65 pp.

Cordone, A. J., and D. W. Kelly. 1961. The Influences of inorganic sediment on the aquatic life in streams. California Department of Fish and Game 47(2): 189-228.

Cropp. T. undated. Howard Hanson Reservoir fish population study, July - August, 1989. Washington Department of Wildlife.

Davis, J. C. 1975. Minimal dissolved oxygen requirements of aquatic life with emphasis on Canadian species: a review. J. Fish. Res. Bd. Can. 32: 2295-2332.

Decker-Hess, J. and S. McMullin. 1983. Impacts of water level fluctuations on kokanee reproduction in Featherhead Lake. Report to Bonneville Power Administration. Montana Department of Fish, Wildlife, and Parks. 58 pp.

Dilley, S. 1991. Evaluation of inundating salmonid habitat by increased winter impoundment at Wynoochee Reservoir, Washington. U.S. Fish and Wildlife Service, Western Washington Fishery Resource Office, Olympia, Washington.

Dilley, S. and R. Wunderlich. 1990. Juvenile chinook passage at Glines Canyon Dam, Elwha River, 1989-1990. U.S. Fish and Wildlife Service, Fisheries Assistance Office, Olympia, Washington.

Dilley, S. and R. Wunderlich. 1992. Juvenile anadromous fish passage at Howard Hanson Project, Green River, Washington, 1991 (draft). U.S. Fish and Wildlife Service, Western Washington Fishery Resource Office, Olympia, Washington.

Dunne T., and B. L. Leopold. 1978. Water in Environmental Planning. W. H. Freeman and Company.

Fillion, D. 1967. The abundance and distribution of benthic fauna of three Montana reservoirs on the Kananaskio River in Alberta. Journal of Applied Ecology 4: 1-11.

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

Graybill, T. et al. 1978. An assessment of the reservoir-related effects of Seattle City Light's dams on the Skagit River fishery resource. Fisheries Research Institute, University of Washington.

Grette, G. and E. Salo. 1986. The status of anadromous fishes of the Green/Duwamish River system. Report submitted to Seattle District, U.S. Army Corps of Engineers by Evans-Hamilton, Inc., Seattle, Washington. 213 pp.

Grimas, V. 1961. The bottom fauna of natural and impounded lakes in Northern Sweden (Ankorvatthe and Biasjon). Institute of Freshwater Research, Drottningholm. Report 45: 5-21.

Hamilton, J. et al. 1970. Use of a hydroelectric reservoir for the rearing of coho salmon. Research Bulletin Number 9. Washington Department of Fisheries.

Hickman, T., and R. Raleigh. 1982. Habitat suitability index models: cutthroat trout. FWS/OBS-82/10.5. U.S. Fish and Wildlife Service.

Hosey and Associates. 1988. Fish production potential. In: Appendix 6 of Response to Request for Additional Information of May 28, 1987, Volume 3. Elwha River Hydroelectric Projects.

Hosey and Associates. 1990. 1989 Fish Studies. Response to October 23, 1989 FERC Request for Additional Information. Elwha River Hydroelectric Projects.

Iwamoto, R. N., E. O. Salo, M. A Madej, and R.L. McComas. 1978. Sediment and Water Quality: A Review of the Literature Including a Suggested Approach for Water Quality Criteria. Environmental Protection Agency 910/9-7.048.

Joint Fish and Wildlife Agencies. 1988. Joint Fishery Agencies' comments to response to FERC request for additional information of May 28, 1987, FERC No. 2683 and FERC No. 588. 50 pp.

May, B. et al. 1988. Quantification of Hungry Horse Reservoir levels needed to maintain or enhance the fishery. Report to Bonneville Power Administration. Montana Department of Fish, Wildlife, and Parks. 148 pp.

McMahon, T. 1983. Habitat suitability index models: coho salmon. FWS/OBS/82/10.49. U.S. Fish and Wildlife Service.

Murray, C. and L. Rosenau. 1989. Rearing of juvenile chinook salmon in nonnatal tributaries of the lower Fraser River, British Columbia. Trans. Amer. Fish. Soc. 118: 284-289.

Natural Resources Consultants, Inc. 1991. Review of the draft environmental impact statement, Glines Canyon (FERC No. 588) and Elwha (FERC No. 2683) Hydroelectric Projects, Washington. In: Comments on FERC's DEIS of February, 1991, Elwha Project and Glines Canyon Project, prepared by Harza Northwest, Inc.

Northwest Power Planning Council. 1986. Council Staff: Technical Planning Report, dated October 22, 1986.

Powers, P. and J. Orsborn. 1985. An investigation of the physical and biological conditions affecting fish passage success at culverts and waterfalls. Bonneville Power Administration Project Number 82-14. Portland, Oregon.

Raleigh, R., T. Hickman, R. Solomon, and P. Nelson. 1984. Habitat suitability information: rainbow trout. FWS/OBS-82/10.60. U.S. Fish and Wildlife Service.

Raleigh, R., W. Miller, and P. Nelson. 1986. Habitat suitability index models and instream flow suitability curves: chinook salmon. Biological Report 82(10.122). U.S. Fish and Wildlife Service.

Reeves, G., F. Everest, and T. Nickelson. 1989. Identification of physical habitats limiting the production of coho salmon in western Oregon and Washington. General Technical Report PNW-GTR-245. U.S. Forest Service.

Seiler, D. and S. Neuhauser. 1985. Evaluation of downstream migrant passage at two dams: Condit Dam, Big White Salmon River, 1983 & 1984, Howard Hanson Dam, Green River, 1984. Progress Report No. 235. Washington Department of Fisheries.

Shumway, D., C. Warren, and P. Doudoroff. 1964. Influence of oxygen concentration and water movement on the growth of steelhead trout and coho salmon embryos. Trans. Amer. Fish. Soc. 93 (4): 342-356.

Silver, S.J., C.E. Warren, and P. Doudoroff. 1963. Dissolved oxygen requirements of developing steelhead trout and chinook salmon embryos at different water velocities. Trans. Am. Fish. Soc. 92: 327-343.

U.S. Forest Service. 1990. Stream Inventory Handbook. Version 5.0. Region 6 Publication. 36 pages plus appendices.

Trotter, P. 1989. Coastal cutthroat trout: a life history compendium. Trans. Amer. Fish. Soc. 118: 463-473.

Williams, R., R. Laramie, and J. Ames. 1975. A Catalog of Washington streams and Salmon Utilization. Volume 3. Washington Department of Fisheries, Olympia.

Wunderlich, R., J. Meyer, and R. Boomer. 1982. Nooksack River juvenile spring chinook salmon investigations. U.S. Fish and Wildlife Service, Fisheries Assistance Office, Olympia, Washington.

Wunderlich, R. and S. Dilley. 1988. Evaluation of juvenile chinook and juvenile steelhead passage at Glines Canyon Dam. U.S. Fish and Wildlife Service, Fisheries Assistance Office, Olympia, Washington.

Wunderlich, R., S. Dilley, and E. Knudsen. 1989. Timing, exit selection, and survival of steelhead and coho smolts at Glines Canyon Dam. U.S. Fish and Wildlife Service, Fisheries Assistance Office, Olympia, Washington.

Zillges, G. 1977. Methodology for determining Puget Sound coho escapement goals, escapement estimates, 1977 pre-season run size prediction, and in-season run assessment. Technical Report Number 28. Washington Department of Fisheries, Olympia.

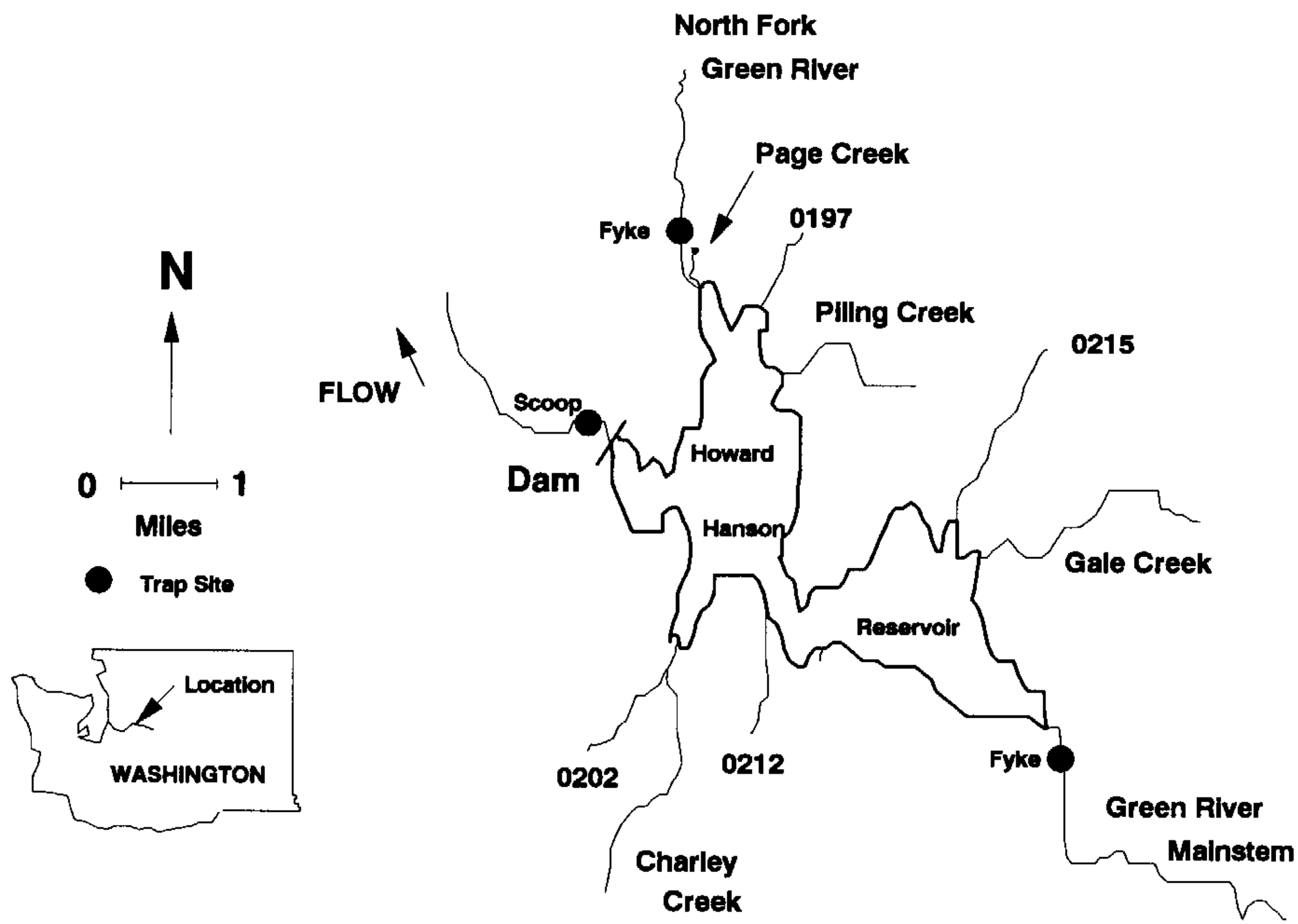

Figure 1. Howard Hanson Reservoir showing trap sites and principal tributaries. Map scale is approximate.

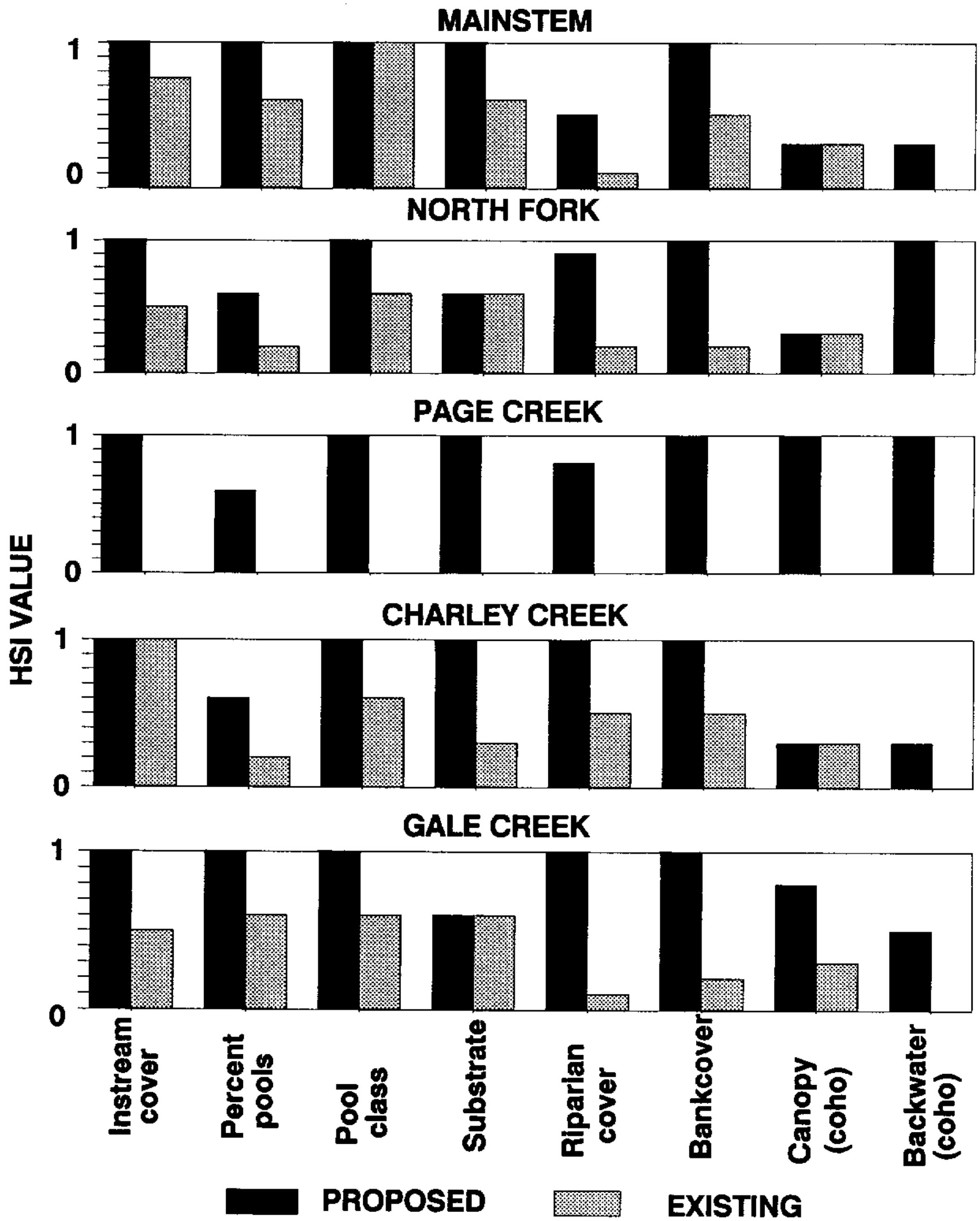

Figure 2. HSI values for juvenile salmonids in proposed and existing inundation zones of large tributaries. Where no value is shown for an existing condition, no measure was made (there were no zero values).

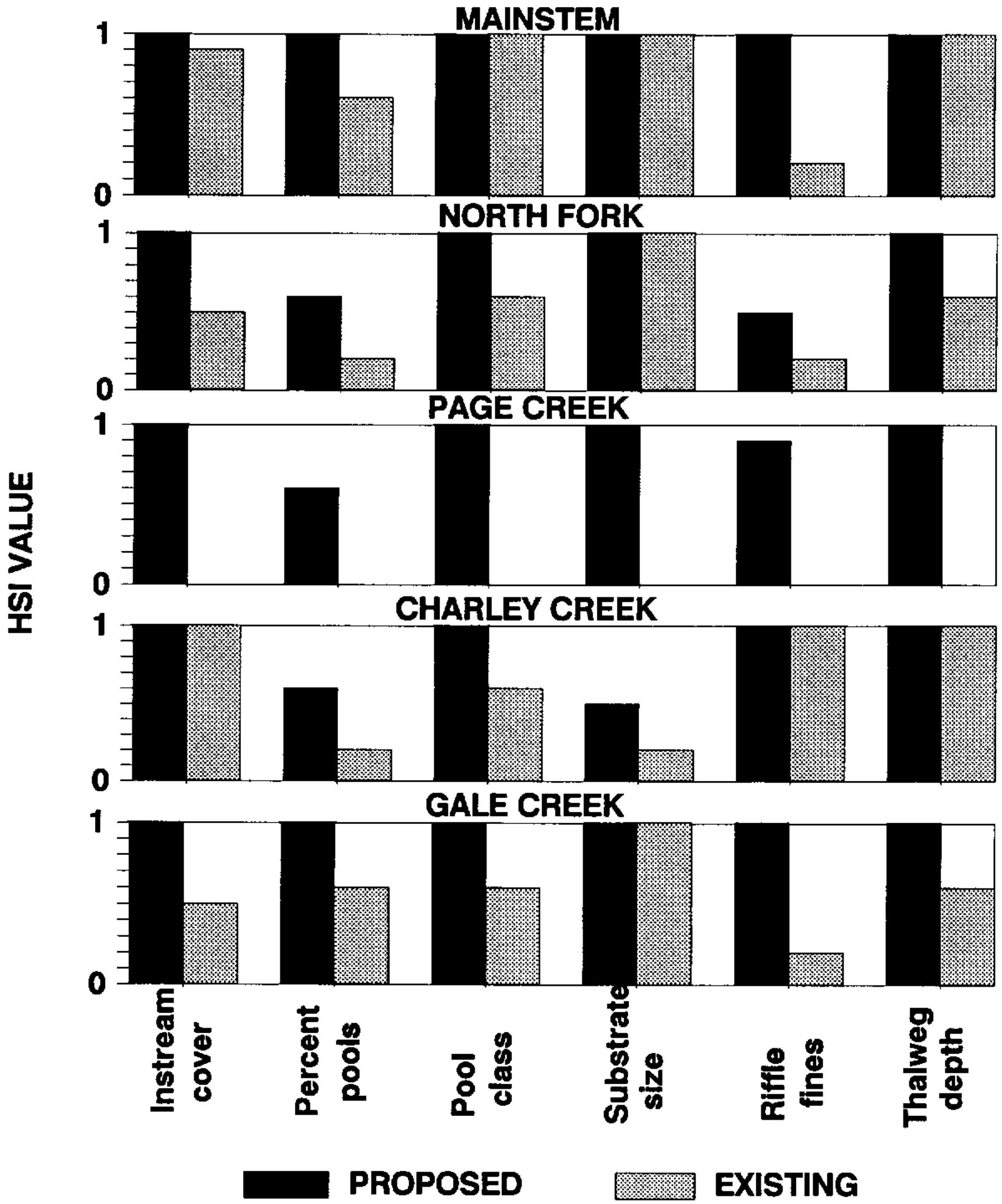

Figure 3. HSI values for adult trouts in proposed and existing inundation zones of large tributaries. Where no value is shown for an existing condition, no measure was made (there were no zero values).

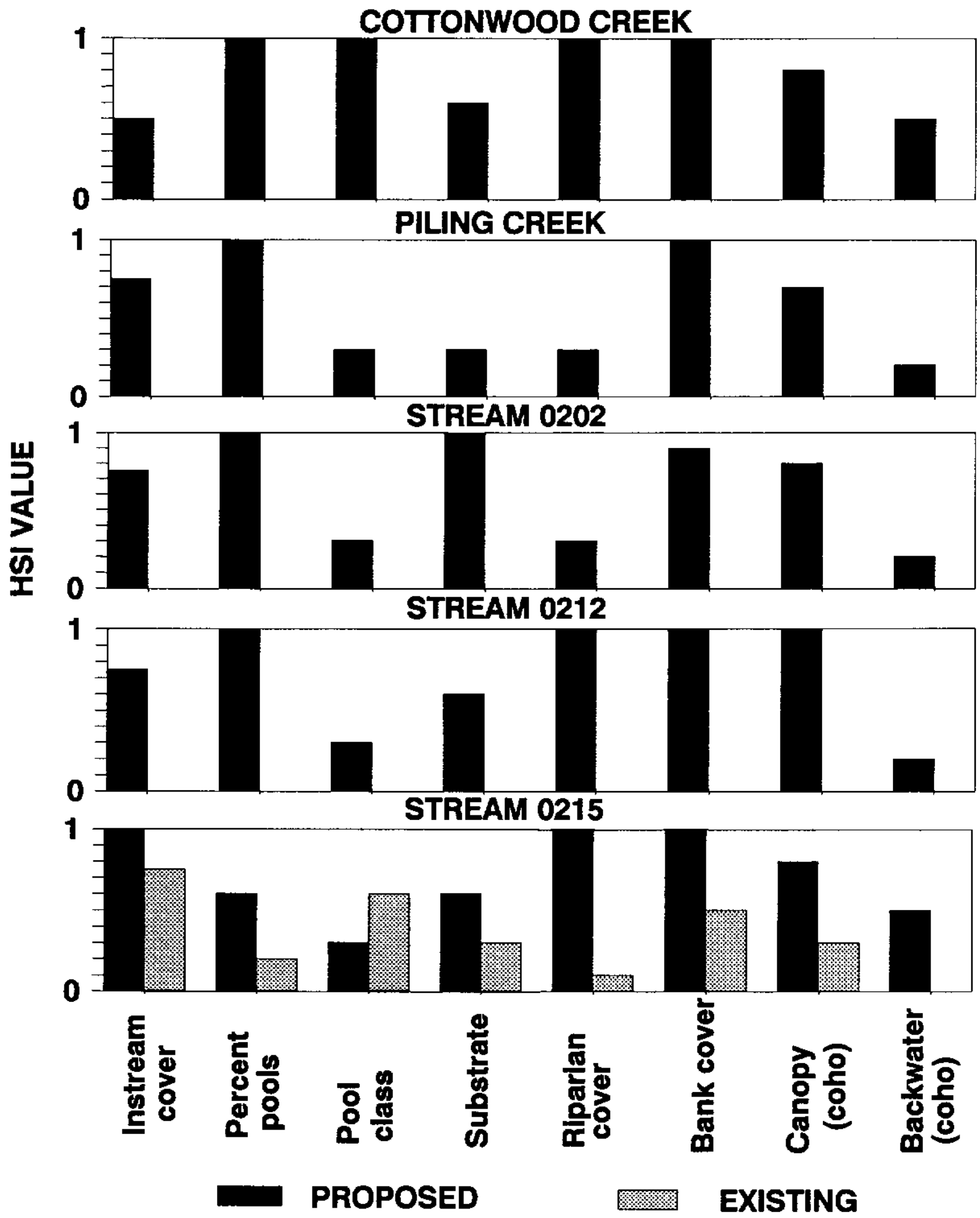

Figure 4. HSI values for juvenile salmonids in proposed and existing inundation zones in small tributaries. Where no value is shown for an existing condition, no measure was made (there were no zero values).

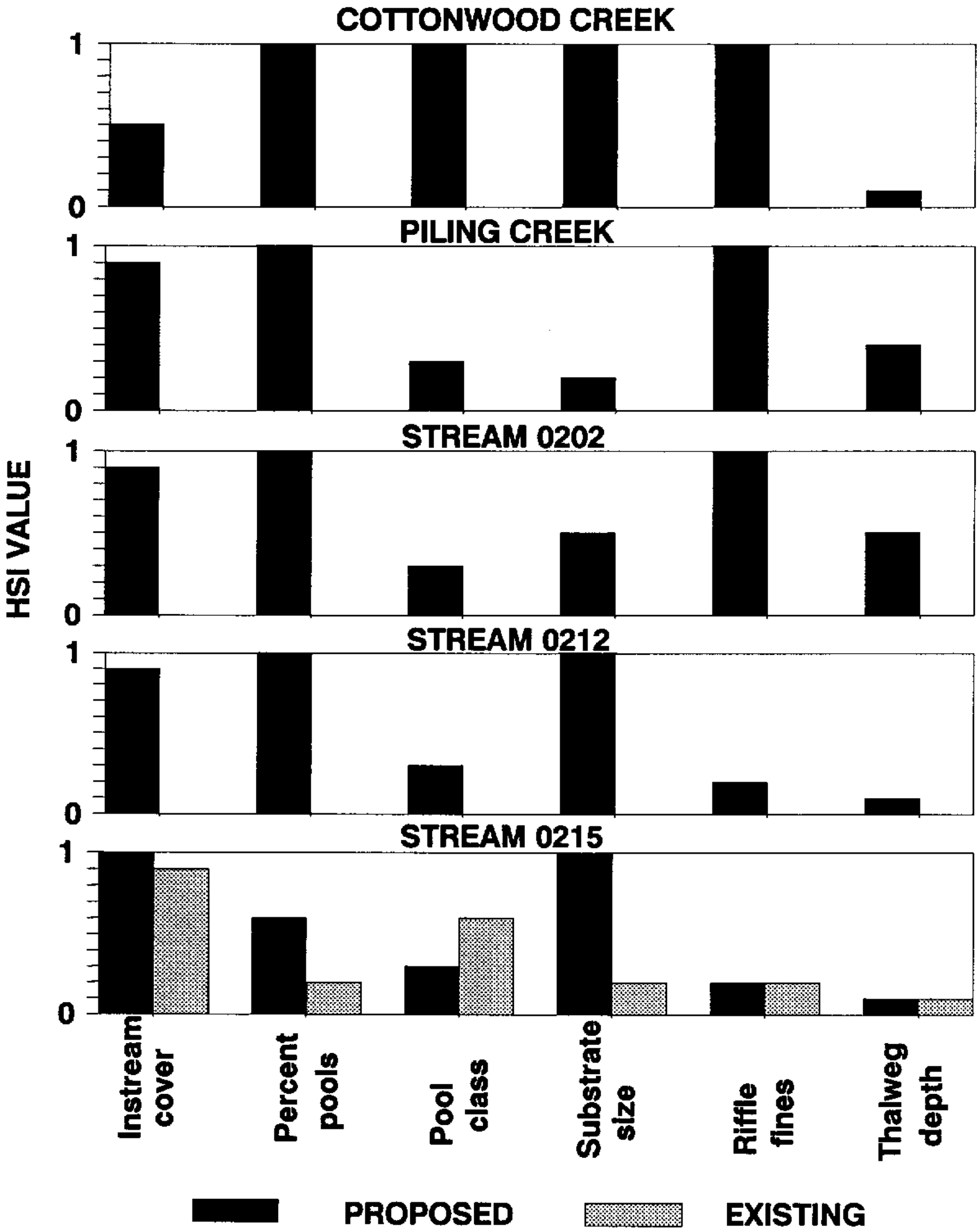

Figure 5. HSI values for adult trouts in proposed and existing inundation zones of small tributaries. Where no value is shown for an existing condition, no measure was made (there were no zero values).

Table 1. Schedule of field activities in 1991.

Activity	Apr	May	Jun	Jul	Aug	Sep	Oct
Survey and mark bounds of proposed inundation zones in all tributaries	--						
Evaluate adult steelhead barriers	--	--	--				
Assess fish usage in proposed inundation zones	--	--	--	--	--	--	--
Qualitatively assess rearing and spawning habitat in proposed inundation zones	--	--	--		--	--	
Qualitatively assess rearing and spawning habitat in existing inundation zones							--

Table 2. Average increase in acreage and shoreline length over winter low pool for the proposed and existing projects. Reservoir area and shoreline length were measured at elevation 1123 feet for the proposed project (midway between summer high at 1177 feet and winter low at 1069 feet), and at elevation 1105 feet for the existing project (midway between summer high at 1141 feet and winter low at 1069 feet).

Project condition	Elevation (ft)	Average increase over winter low pool	
		Acres	Yards of shoreline
Proposed	1123	470	17,000
Existing	1105	290	7,800
	Difference:	180	9,200

Table 3. HSI variables and curve numbers used in assessment of juvenile salmonid habitat. Specific chinook variables are described in Raleigh et al. (1986), coho variables in McMahon (1983), and trout variables in Raleigh et al. (1984) and Hickman and Raleigh (1982).

Habitat variable	Variable number			Comment/assumption
	Chinook	Coho	Trouts[A]	
Instream cover	16	12	6	Increased instream cover increases juvenile standing crop.
Percent	10	4	10	Approximately 40-60% pools pools results in optimal cover and food for all species, and greater or lesser proportion of pools results in proportionately less cover and food.
Pool class	5	11	15	Size and structure of pools influence juvenile standing crop.
Substrate	13,14	5	9,16	Gravel-cobble results in high autochthonous production of aquatic invertebrates; other substrate sizes result in less.
Riparian cover		9	11	The degree and type of riparian vegetation affect allochthonous input to the stream.
Bank cover			12	The degree of streambank stability (rooted vegetation or stable rock cover) affects erosion control and stream productivity.
Canopy cover		8		Approximately 50-75% vegetative canopy cover provides optimal shading and temperature control.
Backwater		13		Quiet backwater with dense cover provides excellent winter habitat for coho parr.

[A] Habitat variables and assumptions apply equally to rainbow/steelhead and cutthroat trouts.

Table 4. HSI variables and curve numbers used in assessment of adult trout holding and spawning habitat. Specific steelhead-rainbow trout variables are described in Raleigh et al. (1984) and Beecher (1986); specific cutthroat trout variables (same variable numbers as rainbow-steelhead) are described in Hickman and Raleigh (1982).

Habitat variable	Variable number	Comment/assumption
Instream cover	6A	Increased instream cover of all forms increases adult standing crop.
Percent pools	10	A 40-60% percentage maximizes cover availability and food production.
Pool class	15	Increased pool size and structure positively influence adult standing crop.
Substrate size	7	Small-gravel to small-cobble substrate provides optimal redd construction, water exchange in the redd, and high fry survival. Lesser or greater substrate sizes result in proportionately less redd quality and fry survival.
Riffle fines	16A	Decreased levels of fines (< ~30%) are associated with greater incubation success.
Thalweg depth	4	Minimum depths of approximately 1 to 1½ foot at low flow result in the best combinations of pools, instream cover, and opportunity for instream movement.

Table 5. Juvenile chinook collections in the North Fork of the Green River in 1991. Most collections occurred in a shallow 75-yd^2 side-channel site. Some collections were supplemental samples for the concurrent fish-passage evaluation at Howard Hanson Project (Dilley and Wunderlich 1992). Green dye-marked fish were planted as fry in the upper North Fork on February 21, 1991.

Collection date	Number	Mean fork length (mm)	Comment
Apr 25	9	50	Includes 1 green dye-marked fish.
May 21	30	56	Includes 5 green dye-marked fish.
Jun 4	74	57	Includes 11 green dye-marked fish.
Jun 20	14	59	
Jul 8	12	65	
Jul 22	0		Side channel nearly dry.
Jul 25	2	61	
Aug 6	2		

Table 6. Fish habitat and potential anadromous fish production in stream reaches inundated by the proposed 36-foot raise of the Howard Hanson reservoir pool. Low-flow measures were taken in late August and early September 1991.

Tributary	Thalweg length (ft)	Low flow: Mean width (ft)	Low flow: Wetted area (ft^2)	Low flow: Discharge (cfs)	Spring wetted area (ft^2)	Mean gradient (%)	Potential production: Chinook smolt[A] Low	Chinook smolt[A] High	Coho smolt[B]	Steelhead smolt[C]
Large tributaries										
Mainstem	6,658	85	595,146	~ 175	998,700	0.5	15,535	155,355	5,548	1,135
North Fork	2,148	30	68,484	36	161,100	1.7	2,506	25,060	1,790	213
Page Creek	1,826	26	47,866	17	47,866	1.9	745	7,446	1,522	149
Charley Creek	1,152	27	35,418	26	40,320	3.1	627	6,272	960	110
Gale Creek	2,083	22	45,772	11	62,490	1.7	972	9,721	1,735	142
Small tributaries										
Cottonwood Cr. (0197)	1,218	7	1,614	< 1	24,360	3.0	379	3,789	16	4
Piling Creek	633	10	6,489	< 1	7,596	5.7	118	1,182	66	16
Stream 0202	261	8	2,060	~ 2	3,132	5.6	49	487	21	5
Stream 0212	327	4	1,435	< 1	1,635	11.1	25	254	15	4
Stream 0215	732	5	3,588	< 1	3,660	4.9	57	569	37	9
Totals:	17,038		807,872		1,350,859		21,013	210,134	11,710	1,785

[A]Computed at 0.14 smolts/yd^2 (low) and 1.4 smolts/yd^2 (high) spring wetted area.
[B]Computed at 2.5 smolts per lineal yard of large tributaries (> 18 feet low-flow width) or 0.092 smolts/yd^2 of small tributary low-flow area.
[C]Computed at 4.10 parr/100 m^2 mainstem low-flow area; 6.68 parr/100 m^2 low-flow area of other large tributaries; and 5.11 parr/100 m^2 low-flow area of small tributaries; and 50% parr-smolt survival.

Table 7. Potential steelhead spawning habitat affected by the proposed 36-foot raise of the Howard Hanson reservoir. Estimated spawning habitat is riffle area currently accessible to steelhead during the spring months in the proposed inundation zones.

Tributary	Potential spawning habitat (ft^2)	Comment
	Large tributaries	
Mainstem	449,415	
North Fork	115,992	
Page Creek	12,818	Upper 40% of stream's length is blocked by timber dam.
Charley Creek	27,418	Substrate is much larger than optimal.
Gale Creek	36,244	
	Small tributaries	
Cottonwood Creek	--	Thalweg depth, flow, and culvert barrier are limiting.
Piling Creek	--	Thalweg depth, substrate, and flow are limiting.
Stream 0202	--	Thalweg depth, substrate, flow, and culvert barrier are limiting.
Stream 0212	--	Thaleg depth, substrate, flow, and extensive woody downfall are limiting.
Stream 0215	--	Thalweg depth, flow, and substrate are limiting.
Total:	641,887	

Table 8. Instantaneous daytime temperatures within the proposed inundation zone of each tributary taken during each month of survey, except as noted.

Tributary	Daytime temperature (°F)						
	Apr	May	Jun	Jul	Aug	Sep	Oct
Mainstem[A]	42	44	47	59	58	53	49
North Fork		48	49	45	58	50	48
Page Creek						46	
Charley Creek		48	47	60	51		48
Gail Creek		47	47	58	58		44
Cottonwood Cr.		48		50	51		
Piling Creek				58	57		44
Stream 0202		46		60	51		43
Stream 0212		47	49	47	47		45
Stream 0215		48		54	56		43

[A] Mean of daytime temperatures taken daily at the fyke trap site by Howard Hanson Dam personnel.

APPENDIX

Table A. Descriptions and derivations of column headings shown in tributary habitat survey tables (Appendix Tables D to R). Column headings are listed in order as they appear left to right in the tables. Source references are U.S. Forest Service (1990), Hickman and Raleigh (1982), McMahon (1983), and Raleigh et al. (1984; 1986).

Column heading	Description	Derivation
NSO	Natural sequence order	Sequential order of habitat types encountered in survey.
HT	Habitat type	Pool (P), riffle (R), or side channel (S).
HN	Habitat number	Sequential number of each habitat type.
HL	Habitat length	Thalweg length of respective habitat type (feet) as measured with tape or calibrated range finder.
HW	Habitat width	Width of habitat type in feet as measured with tape or calibrated rangefinder. Widths taken at least every 20 yards depending on irregularity of the habitat type.
HA	Habitat area	Area of habitat type in square feet.
PA	Pool area	Pool area in square feet.
RA	Riffle area	Riffle area in square feet.
LEN	Weighted length	Length of the habitat type expressed as a percentage of the total length of the inundation zone in the stream.
AREA	Weighted area	Area of the habitat type expressed as a percentage of the total area of the inundation zone of the stream.
POOL	Weighted pool	Area of the pool habitat type expressed as a percentage of the total pool area in the inundation zone of the stream.

Table A. Continued.

Column heading	Description	Derivation
RIFF	Weighted riffle	Area of the riffle habitat type expressed as a percentage of the total riffle area in the inundation zone of the stream.
MD	Maximum depth	Maximum depth of the habitat type to the nearest 0.1 foot.
MDP	Maximum depth of pool	Maximum depth of pool habitat type.
MDR	Maximum depth of riffle	Maximum depth of riffle habitat type.
PC	Pool class	Visual categorization of each pool into first (1), second (2), or third class (3) where: <u>First class pool</u>-large and deep; more than 30% obscured due to depth, surface turbulence, or structures such as logs, debris piles, boulders, or overhanging banks or vegetation. <u>Second class pool</u>-moderate size and depth sufficient to provide a low velocity resting area for a few adult trout. From 5-30% of bottom obscured due to surface turbulence, depth, or structures. Typically large eddies behind boulders and low velocity, moderately deep areas beneath overhanging banks and vegetation. <u>Third class pool</u>-shallow or small or both; depth and size are sufficient to provide a low velocity resting area for a few adult trout. Typically shallow pool areas or small eddies behind boulders, bottom visible.

Table A. Continued.

Column heading	Description	Derivation
DO	Dominant substrate	Visual estimate of dominant substrate (> 50%) in habitat type where: SA=sand, silt, & clay (<0.08 inches diameter) GR=gravel (0.08-2.5 inches) CO=cobble (2.5-10 inches) SB=small boulder (10-40 inches) LB=large boulder (>40 inches) BR=bedrock
SD	Sub-dominant substrate	Next-most dominant substrate as above.
B	Brush debris	Pieces of brush > 6 inches diameter and length > 20 feet
S	Small tree	Tree debris > 24 inches diameter and length > 50 feet
L	Large tree	Tree debris > 36 inches diameter and length > 50 feet
PR	Cover proportion	Visual estimate of the amount of instream escape cover of any form in the habitat type where 1= 0-5%, 2=6-20%, 3=21-40%, 4= >40%.
DO	Dominant instream cover	Visual estimate of dominant instream cover in habitat type where U=undercut banks, S=substrate, D=depth > 1 meter, H=overhanging vegetation, W=wood material, T=turbulence, A=aquatic/emergent vegetation.
SD	Sub-dominant instream cover	Next-most dominant instream cover as above.
BFW	Bank-full width	Measured width where stream would leave channel at high flow (nearest foot).
BFD	Bank-full depth	Measured depth at bank-full width (nearest foot).

Table A. Continued.

Column heading	Description	Derivation
EMB	Embeddedness	Y (yes) or N (no) if visually estimated embeddedness of the substrate (cobble/gravel) is greater than 35% by volume in the habitat type (see U.S. Forest Service (1990) for more detail).
PR	Proportion	Visual estimate of riparian cover vegetative cover in 10-yard band along both stream banks in each habitat type where 1= 0-25%, 2= 26-50%, 3= 51-75%, and 4= 76-100%.
DO	Dominant riparian	Visual estimate of dominant riparian vegetation in 10-yard band along steam shore in each habitat type where T= trees, S= shrubs, and G= grass.
SD	Sub-dominant	Visual estimate of next-most riparian dominant riparian vegetation as above.
GCO	Ground cover	Visual estimate of stream bank ground cover (rooted vegetation or stable rocky ground) in each habitat type serving as erosion control where 1= 0=25%, 2= 26-50%, 3= 51-75%, and 4= 76-100%.
CAN.	Canopy cover	Visual estimate of vegetative canopy cover over stream serving as shading function in each habitat type where 1= 0-25%, 2= 26-50%, 3= 51-75%, and 4= 76-100%.

Table B. Subyearling anadromous salmonids planted above Howard Hanson Dam. Sources of data: Washington Departments of Fisheries and Wildlife, and Muckleshoot Indian Tribe.

Release location	Release date	Size (number/ pound)	Number released
	Chinook salmon (1991)		
Upper mainstem:			
RM 76.5	Feb 21	449	274,326[A]
RM 85	Feb 25	449	150,000
RM 68.5	Feb 25	449	30,000
RM 74.8	Mar 6	515	202,653
RM 68	Mar 7	515	101,198
RM 87.2	Mar 7	515	103,773
Upper mainstem tributaries:			
Snow Cr. (RM 0.1)	Feb 22	449	275,120[B]
Friday Cr. (RM 0.1)	Feb 25	449	100,000
McCain Cr (RM 0.1)	Feb 25	449	50,000
Smay Cr. (RM 1.6)	Feb 25	449	50,000
Canton Cr. (RM 0.3)	Mar 7	515	100,940
Reservoir tributaries:			
Gale Cr. (RM 1.0)	Feb 25	449	50,000
Gale Cr. (RM 2.0)	Mar 6	515	100,554
North Fork:			
RM 1.0	Feb 21	515	199,382[C]
RM 3.0	Feb 25	515	50,000
RM 1.0	Mar 6	515	101,584
		Total:	1,939,530
	Chinook salmon (1990)		
Upper mainstem:			
RM 75-81	Feb 14	472	154,580
RM 68	Mar 1-6	406	363,776

Table B. Continued.

Release location	Release date	Size (number/ pound)	Number released
Upper mainstem tributaries:			
Sunday Cr.	Feb 14	472	56,404
May Cr.	Feb 28	406	20,300
Smay Cr.	Feb 28	406	60,900
Elder Cr.	Mar 1	406	70,542
Unnamed Cr.	Feb 28	406	60,900
Canton Cr.	Mar 6	406	126,672
McCain Cr.	Mar 7	406	142,201
Reservoir tributaries:			
Gale Cr. via Boundary Cr.	Feb 28	400	40,600
Gale Cr. (RM 1.5)	Feb 28	400	40,600
Charley Cr. (RM 0.3)	Mar 1-2	406	72,208
Piling Cr. (RM 0.5)	Feb 28	400	20,604
Stream 0212 (RM 0.2)	Mar 2	406	40,600
Stream 0213 (RM 0.2)	Mar 2	406	20,300
North Fork:			
RM 1.3	Feb 14-15	472	411,702
		Total:	1,702,889
Coho salmon (1991)			
Upper mainstem:			
RM 75	Apr 17	533	91,143
RM 76	Apr 17	533	108,732
RM 79.5	Apr 17	533	82,082
Upper mainstem tributaries:			
Smay Cr.	Apr 17	533	108,199
Green Canyon Cr.	Apr 17	533	9,594
Friday Cr.	Apr 17	533	15,990
McCain Cr.	Apr 17	533	15,990
Tacoma Cr.	Apr 18	533	227,591

Table B. Continued.

Release location	Release date	Size (number/ pound)	Number released
Sunday Cr.	Apr 19	533	143,910
Snow Cr.	Apr 19	533	13,325
<u>Reservoir tributaries</u>:			
Gale Cr. via Boundary Cr.	Apr 18	533	128,986
<u>North Fork</u>:			
Eagle Lake	Apr 18	533	31,980
Eagle Cr.	Apr 18	533	15,990
Upper No. Fk.	Apr 18	533	34,645
		Total:	1,028,157
	Coho salmon (1990)		
<u>Upper mainstem</u>:	May 7	387	30,960
	May 8	366	306,342
	May 9	379	97,782
	May 10	380	87,400
<u>Upper mainstem tributaries</u>:			
Smay Cr.	Mar 12	670	126,630
Stream 0230	Apr 3	499	21,457
Canton Cr.	Apr 3	499	14,970
Tacoma Cr.	May 7	387	64,629
Twin Camp Cr.	May 7	387	62,307
Smay Cr. trib.	May 9	379	19,329
Friday Cr.	May 9	379	20,087
Sunday Cr.	May 9	379	133,408
<u>Reservoir tributaries</u>:			
Charley Cr.	Apr 3	499	31,437
Gale Cr.	Mar 12	670	122,610

Table B. Continued.

Release location	Release date	Size (number/ pound)	Number released
North Fork:			
Eagle Lake	Apr 9	448	25,088
Eagle Cr.	Apr 9	448	13,440
Upper No. Fk.	Apr 9		157,066
			Total: 1,334,942
		Steelhead (1991)	
Upper mainstem:			
RM 73-87	Aug 8	362	39,820
Upper mainstem tributary:			
Smay Cr.	Aug 8	362	1,086
			Total: 40,906
		Steelhead (1990)	
Upper mainstem:			
RM 73-87	Aug 30	162	30,618
Upper mainstem tributaries:			
McCain Cr.	Aug 30	162	324
Smay Cr.	Aug 30	162	1,620
			Total: 32,562
		Steelhead (1989)	
Upper mainstem:			
RM 65-87	Aug 24	330	41,910

Table B. Continued.

Release location	Release date	Size (number/ pound)	Number released
<u>Upper mainstem tributaries</u>:			
McCain Cr.	Aug 24	330	330
Smay Cr.	Aug 24	330	1,650
Sunday Cr.	Aug 24	330	2,640
			Total: 46,530

[A] Includes 137,163 orange-dyed chinook.
[B] Includes 137,560 red-dyed chinook.
[C] Includes 99,691 green-dyed chinook.

Table C. Monthly observations of salmonids in tributaries affected by the proposed 36-foot raise of the Howard Hanson Reservoir. Observations were made by snorkeling (mainstem Green River, Charley Creek, and North Fork) and electroshocking (other tributaries, plus a side channel of the North Fork) in 100-yard representative reaches of each stream during the third week of each month, unless noted otherwise.

Tributary	Monthly catch or observation (mean fork length in mm)							Comment
	Apr	May	Jun	Jul	Aug	Sep	Oct	
Chinook salmon (0+)								
Mainstem								
North Fork	9 (50)	30 (56)	14 (59)	2 (61)				Additional catches occurred from June to August (Table 5).
Charley Cr.								
Gale Cr.			1 (58)	2 (97)				
Cottonwood Cr.								
Piling Cr.								
Stream 0202								
Stream 0212								
Stream 0215								
Coho salmon (0+)								
Mainstem								
North Fork	5 (50)	2 (76)	2 (31)					
Charley Cr.								
Gale Cr.	15 (44)	19 (50)	45 (50)	11 (72)	5 (87)	19 (86)		
Cottonwood Cr.								
Piling Creek								
Stream 0202								
Stream 0212								
Stream 0215				7 (94)	15 (93)	12 (96)	10 (89)	
Rainbow trout (0+)								
Mainstem								
North Fork						19 (52)		
Charley Creek				3 (40)				
Gale Creek								
Cottonwood Cr.	4 (62)							
Piling Creek								
Stream 0202								
Stream 0212								
Stream 0215								

Table C. Continued.

Tributary	Monthly catch or observation (mean fork length in mm)							Comment
	Apr	May	Jun	Jul	Aug	Sep	Oct	
				Rainbow trout (1+)				
Mainstem								
North Fork								
Charley Creek								
Gale Creek								
Cottonwood Cr.	1 (90)			1 (100)				
Piling Creek								
Stream 0202								
Stream 0212								
Stream 0215								
				Rainbow trout (2+ to 5+)				
Mainstem				2	60	315	2	Length: 8-12 inches (July); 18-24 inches (other months).
North Fork						2		Length: 12-14 inches.
Charley Creek		2						Length: 8-12 inches.
Gale Creek								
Cottonwood Cr.								
Piling Creek								
Stream 0202								
Stream 0212	2 (220)							One gravid female.
Stream 0215								
				Cutthroat trout (0+)				
Mainstem				33 (35)				
North Fork	1 (74)				45 (47)	12 (58)	4 (57)	
Charley Creek								
Gale Creek	1 (65)	1 (71)	1 (31)		3 (59)	19 (49)		
Cottonwood Cr.	2 (71)	1 (65)	2 (52)	17 (46)	62 (44)	19 (49)		
Piling Creek	1 (54)	1 (71)	4 (60)	25 (45)	20 (54)	47 (47)	26 (55)	
Stream 0202		1 (73)			31 (50)	1 (68)	4 (52)	
Stream 0212		1 (68)	3 (40)	18 (46)	60 (51)	65 (60)	19 (56)	
Stream 0215	6 (65)	12 (40)	17 (50)	7 (54)	27 (55)			

Table C. Continued.

Tributary	Apr	May	Jun	Jul	Aug	Sep	Oct	Comment
				Cutthroat trout (1+)				
Mainstem								
North Fork			1 (77)			4 (95)	1 (95)	
Charley Creek								
Gale Creek			3 (94)		1 (94)		3 (109)	
Cottonwood Cr.	1 (99)	3 (100)	3 (86)	3 (94)	1 (99)			
Piling Creek			11 (95)	1 (89)	4 (92)	5 (95)	3 (94)	
Stream 0202	2 (72)	1 (40)	4 (102)	5 (97)	2 (58)	7 (102)	9 (103)	
Stream 0212	2 (72)	7 (84)	6 (96)	3 (102)	4 (91)	3 (103)	2 (89)	
Stream 0215	5 (71)	7 (73)		18 (97)	11 (93)	24 (94)	15 (94)	
				Cuttthroat trout (2+ to 5+)				
Mainstem					12	161	75	Length: 12-18 inches.
North Fork						3 (152)	1 (163)	
Charley Creek								
Gale Creek								
Cottonwood Cr.	1 (156)							
Piling Creek					1 (121)	1 (122)		
Stream 0202	2 (220)		1 (253)	3 (134)		1 (141)	2 (131)	
Stream 0212			1 (128)	1 (137)				
Stream 0215	2 (123)			1 (121)		3 (127)	5 (131)	
				Unknown trout (0+)				
Mainstem								
North Fork								
Charley Creek				> 50 (~ 35)			21 (59)	
Gale Creek						12 (61)	8 (64)	
Cottonwood Cr.								
Piling Creek								
Stream 0202						2 (50)		
Stream 0212								
Stream 0215								

Table C. Continued.

Tributary	Apr	May	Jun	Jul	Aug	Sep	Oct	Comment
				Unknown trout (1+)				
Mainstem								
North Fork							4 (100)	
Charley Creek								
Gale Creek							3 (109)	
Cottonwood Cr.								
Piling Creek								
Stream 0202								
Stream 0212								
Stream 0215								
				Unknown trout (2+)				
Mainstem			1 (229)					
North Fork								
Charley Creek							5 (160)	
Gale Creek								
Cottonwood Cr.							3 (128)	
Piling Creek								
Stream 0202						1 (149)		
Stream 0212								
Stream 0215								
				Brook trout (2+)				
Page Creek					8 (154)			

Table D. Survey data for the proposed inundation zone in the Green River mainstem.

DATE OF SURVEY:AUG 23 1991   SURVEY DIRECTION: DOWNSTREAM

NSO	HT	HN	HL	HW	HA	PA	RA	-WEIGHTING- OVERALL (%) LEN.	AREA	AREA BY HABITAT TYPE (%) POOL	RIFF.	MD	MDP	MDR	PC	SUB. DO	SUB. SD	# LWD B	S	L	INSTR. COV. PR	DO	SD	BFW	BFD	EMB	RIP. COVER PR	DO	SD	GCO	CAN.
1	P	1	442	-84	37128	37128	0	7	7	12	0	5.5	5.5	0	1	GR	CO	0	0	1	4	D	S	190	15	N	3	T	S	4	1
2	R	1	565	121	68365	0	68365	8	12	0	27	2	0	2		CO	SB	0	0	0	3	S	T	160	15	N	4	T	G	4	1
3	P	2	730	110	80300	80300	0	11	14	26	0	12	12	0	1	SA	GR	0	0	0	4	D	S	200	20	Y	4	T	G	4	1
4	R	2	443	48	21264	0	21264	7	4	0	8	1.3	0	1.3		GR	CO	0	0	1	4	T	S	200	12	N	4	T	S	4	2
5	P	3	316	61	19276	19276	0	5	3	6	0	22	22	0	1	SA	GR	0	0	0	4	D	S	220	30	Y	3	T	S	4	1
6	R	3	150	25	3750	0	3750	2	1	0	1	2	0	2		CO	GR	0	0	0	4	T	S	220	14	N	2	T	S	4	1
7	P	4	195	72	14040	14040	0	3	2	5	0	4.5	4.5	0	1	CO	SB	0	0	0	4	D	S	170	12	Y	2	T	S	4	2
8	R	4	190	76	14440	0	14440	3	3	0	6	2.5	0	2.5		SB	CO	0	0	0	4	T	S			N	2	T	S	4	1
9	P	5	696	92	64032	64032	0	10	11	21	0	4	4	0	1	CO	GR	0	0	0	4	S	D	250	15	Y	4	T	S	4	1
10	R	5	170	80	13600	0	13600	3	2	0	5	1	0	1		CO	GR	0	0	0	4	T	S	250	15	N	4	S	T	4	1
11	P	6	185	55	10175	10175	0	3	2	3	0	4	4	0	1	CO	GR	0	0	1	4	D	S	200	12	Y	1	S	T	4	1
12	R	6	431	86	37066	0	37066	6	7	0	14	2.5	0	2.5		CO	SB	0	0	0	4	T	S	200	12	N	1	S	T	4	1
13	P	7	625	72	45000	45000	0	9	8	15	0	8	8	0	1	GR	SA	0	0	1	4	D	S	150	18	Y	1	S	T	4	1
14	R	7	270	50	13500	0	13500	4	2	0	5	3	0	3		CO	GR	0	0	1	4	S	W	225	12	N	2	T	S	2	1
15	P	8	540	72	38880	38880	0	8	7	13	0	8	8	0	1	SA	GR	0	1	0	4	D	S	175	15	N	2	T	S	2	1
16	R	8	710	118	83780	0	83780	11	15	0	33	2	0	2		CO	SB	0	0	2	4	T	S	200	15	N	4	T	S	4	1
SIDE CHANNELS:																															
5	S-P	1	680	20	13600	13600						1.5			3	CO	GR	0	0	0	3	S				N	2	T	S	4	1
5	S-P	2	565	30	16950	16950						4.5			1	CO	GR	0	0	4	3	T	S			N	2	T	S	4	1

ADDED HABITAT AREA: 30550

-SUMMARY-
(EXCLUSIVE OF SIDE CHANNELS, EXCEPT AS NOTED)

THALWEG LENGTH	6658
HORIZ. LENGTH	6658
GRADIENT %	0.54
POOL AREA	308831
RIFFLE AREA	255765
POOL/RIFFLE	0.55
TOTAL HABITAT AREA	564596
TOTAL HABITAT AREA (W/SIDE CHANNELS)	595146
AV MAX POOL DEPTH	8.5
AV MAX RIFFLE DEPTH	2.0
AV STREAM WIDTH	85
AV MAX STREAM DEPTH	5.3
POOL CLASSES	
% FIRST CLASS	100
% SECOND CLASS	0
% THIRD CLASS	0
SUBSTRATE-POOLS	
DOMINANT	SA
SUB-DOMINANT	GR
SUBSTRATE-RIFFLES	
DOMINANT	CO
SUB-DOMINANT	SB

SUBSTRATE-OVERALL	
DOMINANT	CO
SUB-DOMINANT	GR
PIECES LWD	
BRUSH	0
SMALL TREES	1
LARGE TREES	7
INSTREAM COVER-OVERALL	
PROPORTION	4
DOMINANT	D
SUB-DOMINANT	S
MEAN BANKFULL WIDTH	188
MEAN BANKFULL DEPTH	15
EMBEDDEDNESS- % YES	
POOLS	75
RIFFLES	0
OVERALL	41
RIPARIAN COVER	
PROPORTION	3
DOMINANT	T
SUB-DOMINANT	S
BANK GROUND COVER	4
PERCENT CANOPY	1
MEAN SPRING WIDTH (FIELD NOTES)	150
MEAN SPRING THALWEG DEPTH	4

Table E. Survey data for the proposed inundation zone in the North Fork.

DATE OF SURVEY: AUG 26 1991 SURVEY DIRECTION: UPSTREAM

NSO	HT	HN	HL	HW	HA	PA	RA	-WEIGHTING- OVERALL (%) LEN.	AREA	AREA BY HABITAT TYPE (%) POOL	RIFF.	MD	MDP	MDR	PC	SUB. DO	SD	# LWD B	S	L	INSTR. COV. PR	DO	SD	BFW	BFD	EMB	RIP. COVER PR	DO	SD	GCO	CAN.
1	R	1	36	44	1584	0	1584	2	2	0	3	2	0	2		CO	SB	0	2	1	4	T	S	160	10	Y	4	T	S	3	1
2	P	1	36	23	828	828	0	2	1	5	0	3.1	3.1	0	1	GR	SA	1	2	5	4	W	T	160	14	Y	4	T	S	3	3
3	R	2	89	36	3204	0	3204	4	5	0	7	2.1	0	2.1		GR	CO	2	3	5	4	W	T	160	10	N	4	T	S	4	3
4	P	2	20	15	300	300	0	1	0	2	0	4	4	0	1	GR	CO	0	1	1	4	W	D	160	15	Y	4	T	S	4	2
5	R	3	155	25	3875	0	3875	7	6	0	8	1.8	0	1.8		CO	GR	1	2	4	4	T	S	170	11	N	4	T	S	4	1
6	P	3	135	28	3780	3780	0	6	6	21	0	3.5	3.5	0	1	GR	CO	1	0	0	4	D	S	116	8	N	4	T	S	4	1
7	R	4	115	15	1725	0	1725	5	3	0	4	1.5	0	1.5		GR	CO	1	0	2	4	T	W	72	8	N	4	S	T	4	1
8	P	4	84	36	3024	3024	0	4	5	17	0	3.4	3.4	0	1	GR	SA	1	0	3	4	D	W	72	12	Y	3	T	S	3	1
9	R	5	62	25	1550	0	1550	3	2	0	3	1	0	1		GR	CO	0	0	0	3	T	S	95	8	N	4	T	S	4	1
10	P	5	125	30	3750	3750	0	6	6	21	0	3.1	3.1	0	1	GR	SA	3	1	2	4	U	D	120	6	N	4	T	S	4	2
11	R	6	721	38	27398	0	27398	34	42	0	58	1.5	0	1.5		GR	CO	0	0	4	4	T	S	80	10	Y	3	S	T	3	1
12	P	6	187	19	3553	3553	0	9	5	20	0	4.3	4.3	0	1	GR	SA	1	1	2	4	D	W	105	10	Y	3	T	S	4	3
13	R	7	159	19	3021	0	3021	7	5	0	6	2	0	2		GR	CO	2	4	5	4	T	W	105	10	N	4	T	S	4	1
14	P	7	140	21	2940	2940	0	7	5	16	0	2.8	2.8	0	2	GR	SA	3	2	6	4	W	S	95	11	Y	4	T	S	4	2
15	R	8	84	55	4620	0	4620	4	7	0	10	0.7	0	0.7		GR	CO	1	0	0	4	T	S	99	10	N	4	T	S	4	1
SIDE CHANNELS:																															
7	S-P	1	66	23	1518							4			1	SA	GR	1	1	3	4	D	W	72	8	Y	4	S	T	4	3
7	S-R	1	33	8	264							1				GR	CO	0	0	0	4	T	S	72	8	N	3	T	S	3	1
10	S-P	1	25	30	750							3.1			1	GR	SA	3	3	3	4	W	U	100	9	Y	3	T	S	4	1
10	S-R	1	80	10	800							0.8				GR	CO	1	1	1	3	U	S	100	9	N	3	T	S	4	1

ADDED HABITAT: 3332

-SUMMARY-
(EXCLUSIVE OF SIDE CHANNELS, EXCEPT AS NOTED)

THALWEG LENGTH	2148
HORIZ. LENGTH	2148
GRADIENT %	1.68
POOL AREA	18175
RIFFLE AREA	46977
POOL/RIFFLE	0.28
TOTAL HABITAT AREA	65152
TOTAL HABITAT AREA (W/SIDE CHANNELS)	68484
AV MAX POOL DEPTH	3.5
AV MAX RIFFLE DEPTH	1.6
AV STREAM WIDTH	30
AV MAX STREAM DEPTH	2.5
POOL CLASSES	
% FIRST CLASS	86
% SECOND CLASS	14
% THIRD CLASS	0
SUBSTRATE-POOLS	
DOMINANT	GR
SUB-DOMINANT	CO
SUBSTRATE-RIFFLES	
DOMINANT	GR
SUB-DOMINANT	CO

SUBSTRATE-OVERALL	
DOMINANT	GR
SUB-DOMINANT	CO
PIECES LWD	
BRUSH	17
SMALL TREES	18
LARGE TREES	40
INSTREAM COVER-OVERALL	
PROPORTION	4
DOMINANT	T
SUB-DOMINANT	S
MEAN BANKFULL WIDTH	118
MEAN BANKFULL DEPTH	10
EMBEDDEDNESS- % YES	
POOLS	59
RIFFLES	62
OVERALL	61
RIPARIAN COVER	
PROPORTION	4
DOMINANT	T
SUB-DOMINANT	S
BANK GROUND COVER	4
PERCENT CANOPY	1
MEAN SPRING WIDTH (FIELD NOTES)	75

Table F. Survey data for the proposed inundation zone in Page Creek.

DATE OF SURVEY: AUG 26 & 27 1991

SURVEY DIRECTION- UPSTREAM

NOTE: NSO 8 CONTAINS OLD LOG CRIB DAM

NOTE: PAGE CR ENTERS NORTH FORK @ 0.65 FT ELEV. ABOVE FULL POOL

								-WEIGHTING- OVERALL (%)		AREA BY HABITAT TYPE (%)						SUB.		# LWD			INSTR. COV.						RIP. COVER				
NSO	HT	HN	HL	HW	HA	PA	RA	LEN.	AREA	POOL	RIFF.	MD	MDP	MDR	PC	DO	SD	B	S	L	PR	DO	SD	BFW	BFD	EMB	PR	DO	SD	GCO	CAN.
1	R	1	170	38	6460	0	6460	9	13	0	51	1	0	1		GR	CO	0	0	1	4	A	S	165	12	N	4	T	S	4	1
2	P	1	85	23	1955	1955	0	5	4	6	0	2.5	2.5	0	2	GR	SA	1	0	0	3	A	T	165	12	Y	4	T	S	4	1
3	R	2	222	15	3330	0	3330	12	7	0	26	2	0	2		SA	GR	1	0	2	4	A	H	60	7	N	4	T	S	4	3
4	P	2	52	50	2600	2600	0	3	5	7	0	3	3	0	1	SA	GR	1	0	0	4	A	S	60	8	Y	4	S	T	4	3
5	R	3	117	23	2691	0	2691	6	6	0	21	3	0	3		SA	GR	1	0	0	4	A	H	70	8	Y	4	S	T	4	3
6	P	3	435	34	14790	14790	0	24	31	42	0	4	4	0	1	SA		1	0	1	4	A	H	75	10	Y	4	S	T	4	3
7	R	4	15	15	225	0	225	1	0	0	2	2.5	0	2.5		GR	SA	5	3	20	4	T	H	50	10	Y	4	S	T	4	4
*8	P	4	160	15	2400	2400	0	9	5	7	0	5	5	0	1	SA	GR	6	5	5	4	D	H	65	12	Y	4	T	S	4	2
9	P	5	65	15	975	975	0	4	2	3	0	3	3	0	1	SA	GR	1	1	1	4	U	H	100	8	Y	4	S	T	3	3
10	P	6	195	22	4290	4290	0	11	9	12	0	3.1	3.1	0	1	SA	GR	1	0	0	4	D	H	150	9	Y	4	T	S	3	2
11	P	7	150	33	4950	4950	0	8	10	14	0	4.2	4.2	0	1	SA	GR	0	1	1	4	D	W	200	7	Y	4	T	S	4	2
12	P	8	160	20	3200	3200	0	9	7	9	0	3	3	0	1	SA	GR	5	1	2	4	W	D	100	8	Y	4	T	S	4	3

-SUMMARY-

THALWEG LENGTH	1826
HORIZ. LENGTH	1825.7
GRADIENT %	1.94
POOL AREA	35160
RIFFLE AREA	12706
POOL/RIFFLE	0.73
TOTAL HABITAT AREA	47866
AV MAX POOL DEPTH	3.1
AV MAX RIFFLE DEPTH	2.1
AV STREAM WIDTH	26
AV MAX STREAM DEPTH	3.0
POOL CLASSES	
% FIRST CLASS	88
% SECOND CLASS	12
% THIRD CLASS	0
SUBSTRATE-POOLS	
DOMINANT	SA
SUB-DOMINANT	GR
SUBSTRATE-RIFFLES	
DOMINANT	GR
SUB-DOMINANT	SA

SUBSTRATE-OVERALL	
DOMINANT	SA
SUB-DOMINANT	GR
PIECES LWD	
BRUSH	23
SMALL TREES	11
LARGE TREES	33
INSTREAM COVER-OVERALL	
PROPORTION	4
DOMINANT	A
SUB-DOMINANT	H
MEAN BANKFULL WIDTH	105
MEAN BANKFULL DEPTH	9
EMBEDDEDNESS- % YES	
POOLS	100
RIFFLES	23
OVERALL	80
RIPARIAN COVER	
PROPORTION	4
DOMINANT	T
SUB-DOMINANT	S
BANK GROUND COVER	4
PERCENT CANOPY	3

Table G. Survey data for the proposed inundation zone in Charley Creek.

DATE OF SURVEY: AUG 21 1991 SURVEY DIRECTION: UPSTREAM
NOTE: NSO 11 IS CONFLUENCE OF STREAM 0202

								-WEIGHTING- OVERALL (%)		AREA BY HABITAT TYPE (%)						SUB.		# LWD			INSTR. COV.						RIP. COVER				
NSO	HT	HN	HL	HW	HA	PA	RA	LEN.	AREA	POOL	RIFF.	MD	MDP	MDR	PC	DO	SD	B	S	L	PR	DO	SD	BFW	BFD	EMB	PR	DO	SD	GCO	CAN.
1	R	1	55	30	1650	0	1650	5	5	0	8	1.8	0	1.8		SB	CO	0	0	0	4	S	T	62	5	N	3	T	S	4	1
2	P	1	27-	22	594	594	0	2	2	6	0	2.1	2.1	0	1	SB	CO	0	0	0	4	S	T	46	5	N	4	S	T	4	1
3	R	2	56	55	3080	0	3080	5	10	0	15	2.2	0	2.2		CO	SB	0	0	1	4	S	T	62	5	N	4	S	T	4	1
4	P	2	43	16	688	688	0	4	2	7	0	2.7	2.7	0	1	BR	SB	0	0	0	4	S	T			N	1			4	1
5	P	3	88	26	2288	2288	0	8	7	23	0	3.7	3.7	0	1	BR	CO	0	0	2	4	D	S	62	8	N	3	S	T	4	1
6	R	3	90	30	2700	0	2700	8	9	0	13	2.1	0	2.1		SB	CO	0	2	0	4	T	S	62	5	N	4	T	S	4	2
7	P	4	79	25	1975	1975	0	7	6	20	0	8	8	0	1	BR	GR	0	0	0	4	D	S	62	13	N	4	T	S	4	1
8	R	4	176	34	5984	0	5984	15	19	0	29	1.5	0	1.5		SB	CO	0	0	2	4	T	S	79	5	N	4	T	S	4	1
9	P	5	89	16	1424	1424	0	8	5	14	0	4.3	4.3	0	1	BR	SB	0	0	0	4	D	S	32	9	N	4	T	S	4	1
10	R	5	39	25	975	0	975	3	3	0	5	1.6	0	1.6		SB	LB	0	0	0	4	T	S	57	6	N	4	T	S	4	2
*11	P	6	67	21	1407	1407	0	6	5	14	0	2.9	2.9	0	1	CO	LB	0	0	0	4	S	T	57	7	N	4	T	S	4	1
12	R	6	167	24	4008	0	4008	14	13	0	19	2.6	0	2.6		SB	CO	0	0	1	4	T	S	55	5	N	4	T	S	4	2
13	R	6	85	20	1700	0	1700	7	5	0	8	2.7	0	2.7		SB	CO	0	0	0	4	S	T	55	5	N	4	T	S	4	2
14	P	7	53	30	1590	1590	0	5	5	16	0	1.8	1.8	0	3	GR	SA	0	0	2	3	S	U	50	5	Y	4	T	S	4	2
15	R	8	38	23	874	0	874	3	3	0	4	1.4	0	1.4		CO	SB	0	0	0	4	T	S	50	5	Y	4	T	S	4	2
SIDE CHANNELS:																															
4	R	1	43	11	473	0	473	-	2	0	-	1.4	0	1.4		SB	CO	0	0	0	4	S	T			N	4	S		4	1
12	R	1	167	24	4008	0	4008	-	19	0	-	2.6	0	2.6		SB	CO	0	0	1	4	T	S	55	5	N	4	T	S	4	4
ADDED HABITAT AREA:					4481	0	4481																								

-SUMMARY-
(EXCLUSIVE OF SIDE CHANNELS, EXCEPT AS NOTED)

THALWEG LENGTH	1152	SUBSTRATE-OVERALL	
HORIZ. LENGTH	1151	DOMINANT	SB
GRADIENT %	3.13	SUB-DOMINANT	CO
POOL AREA	9966	PIECES LWD	
RIFFLE AREA	20971	BRUSH	0
POOL/RIFFLE	0.32	SMALL TREES	2
TOTAL HABITAT AREA	30937	LARGE TREES	8
TOTAL HABITAT AREA (W/SIDE CHANNELS)	35418	INSTREAM COVER-OVERALL	
AV MAX POOL DEPTH	3.6	PROPORTION	4
AV MAX RIFFLE DEPTH	2.0	DOMINANT	T
AV STREAM WIDTH	27	SUB-DOMINANT	S
AV MAX STREAM DEPTH	2.8	MEAN BANKFULL WIDTH	53
POOL CLASSES		MEAN BANKFULL DEPTH	6
% FIRST CLASS	86	EMBEDDEDNESS- % YES	
% SECOND CLASS	0	POOLS	16
% THIRD CLASS	14	RIFFLES	4
SUBSTRATE-POOLS		OVERALL	8
DOMINANT	BR	RIPARIAN COVER	
SUB-DOMINANT	CO	PROPORTION	4
SUBSTRATE-RIFFLES		DOMINANT	T
DOMINANT	SB	SUB-DOMINANT	S
SUB-DOMINANT	CO	BANK GROUND COVER	4
		PERCENT CANOPY	1
		MEAN SPRING WIDTH (FIELD NOTES)	35
		MEAN SPRING THALWEG DEPTH	2

Table H. Survey data for the proposed inundation zone in Gale Creek.

DATE OF SURVEY: AUG 28 1991 SURVEY DIRECTION- UPSTREAM

NSO	HT	HN	HL	HW	HA	PA	RA	-WEIGHTING- OVERALL (%) LEN.	AREA	AREA BY HABITAT TYPE (%) POOL	RIFF.	MD	MDP	MDR	PC	SUB. DO	SUB. SD	# LWD B	S	L	INSTR. COV. PR	DO	SD	BFW	BFD	EMB	RIP. COVER PR	DO	SD	GCO	CAN.
1	P	1	55	16	880	880	0	3	2	5	0	3.4	3.4	0	2	GR	SA	1	2	3	3	U	W	100	10	Y	4	T	S	4	1
2	R	1	50	17	850	0	850	2	2	0	3	0.9	0	0.9		GR	SA	0	0	0	4	T	S	100	9	N	4	T	S	4	1
3	P	2	75	20	1500	1500	0	4	3	8	0	3.2	3.2	0	3	SA	GR	1	2	2	4	W	U	100	9	Y	4	T	S	4	2
4	R	2	240	20	4800	0	4800	12	10	0	18	1.5	0	1.5		GR	SA	2	2	1	4	T	S	125	8	N	4	T	S	4	3
5	P	3	49	15	735	735	0	2	2	4	0	1.3	1.3	0	3	GR	SA	3	1	3	4	W	S	89	10	Y	4	S	T	4	3
6	R	3	37	14	518	0	518	2	1	0	2	0.9	0	0.9		GR	CO	0	0	0	4	T	S	79	8	N	4	T	S	3	1
7	P	4	70	18	1260	1260	0	3	3	6	0	1.4	1.4	0	2	GR	SA	0	0	1	4	H	S	80	8	Y	4	T	S	4	3
8	R	4	75	20	1500	0	1500	4	3	0	6	1.5	0	1.5		GR	CO	1	2	1	4	T	S	90	9	N	4	S	T	4	2
9	P	5	43	14	602	602	0	2	1	3	0	3.6	3.6	0	1	GR	SA	1	1	4	4	W	U	90	10	Y	4	S	T	4	3
10	R	5	50	25	1250	0	1250	2	3	0	5	1.3	0	1.3		GR	SA	0	0	0	4	T	S	100	10	N	4	S	T	4	2
11	P	6	114	26	2964	2964	0	5	6	15	0	1.3	1.3	0	1	GR	SA	1	1	1	3	W	T	110	9	Y	4	T	S	4	2
12	R	6	41	20	820	0	820	2	2	0	3	1.4	0	1.4		GR	CO	0	0	0	4	T	S	105	8	N	4	T	S	4	1
13	P	7	63	21	1323	1323	0	3	3	7	0	2.5	2.5	0	1	GR	SA	1	0	0	4	U	S	100	8	Y	4	T	S	4	2
14	R	7	26	19	494	0	494	1	1	0	2	1.5	0	1.5		GR	CO	1	2	1	4	T	S	100	8	N	4	T	S	4	1
15	P	8	30	30	900	900	0	1	2	5	0	5	5	0	1	SA	GR	0	3	4	4	D	W	101	15	Y	3	T	S	4	1
16	R	8	61	16	976	0	976	3	2	0	4	1	0	1		GR	CO	1	0	0	3	T	S	100	8	N	4	S	T	3	1
17	P	9	95	20	1900	1900	0	5	4	10	0	3	3	0	1	SA	GR	8	4	8	4	D	W	98	14	Y	4	S	T	4	3
18	R	9	250	22	5500	0	5500	12	12	0	21	1	0	1		GR	CO	3	5	7	4	T	S	95	13	N	3	S	T	3	2
19	P	10	98	40	3920	3920	0	5	9	20	0	3	3	0	1	GR	SA	10	10	15	4	W	S	120	12	Y	2	S	T	3	4
20	R	10	90	35	3150	0	3150	4	7	0	12	2	0	2		GR	SA	1	1	2	4	T	S	95	10	N	4	T	S	4	3
21	R	11	250	20	5000	0	5000	12	11	0	19	3	0	3		SA	GR	0	1	2	3	S	U	90	11	Y	4	S	T	4	1
22	P	11	94	30	2820	2820	0	5	6	15	0	3	3	0	1	SA	GR	1	2	2	4	W	U	80	10	Y	4	S	T	4	1
23	R	12	83	18	1494	0	1494	4	3	0	6	2	0	2		GR	CO	0	0	1	4	S	T	80	10	N	4	T	S	4	4
24	P	12	44	14	616	616	0	2	1	3	0	2.1	2.1	0	2	CO	SA	0	0	2	3	T	S	75	12	Y	4	S	T	4	1

-SUMMARY-

THALWEG LENGTH	2083
HORIZ. LENGTH	2083
GRADIENT %	1.73
POOL AREA	19420
RIFFLE AREA	26352
POOL/RIFFLE	0.42
TOTAL HABITAT AREA	45772
TOTAL HABITAT AREA (W/SIDE CHANNELS)	N/A
AV MAX POOL DEPTH	2.7
AV MAX RIFFLE DEPTH	1.5
AV STREAM WIDTH	22
AV MAX STREAM DEPTH	2.1
POOL CLASSES	
% FIRST CLASS	58
% SECOND CLASS	25
% THIRD CLASS	17
SUBSTRATE-POOLS	
DOMINANT	GR
SUB-DOMINANT	SA
SUBSTRATE-RIFFLES	
DOMINANT	GR
SUB-DOMINANT	CO

SUBSTRATE-OVERALL	
DOMINANT	GR
SUB-DOMINANT	SA
PIECES LWD	
BRUSH	36
SMALL TREES	39
LARGE TREES	60
INSTREAM COVER-OVERALL	
PROPORTION	4
DOMINANT	T
SUB-DOMINANT	S
MEAN BANKFULL WIDTH	96
MEAN BANKFULL DEPTH	10
EMBEDDEDNESS- % YES	
POOLS	100
RIFFLES	19
OVERALL	53
RIPARIAN COVER	
PROPORTION	4
DOMINANT	S
SUB-DOMINANT	T
BANK GROUND COVER	4
PERCENT CANOPY	2
MEAN SPRING WIDTH (FIELD NOTES)	30
MEAN SPRING THALWEG DEPTH	2.5

Table I. Survey data for the proposed inundation zone in Cottonwood Creek (0197).

DATE OF SURVEY: AUG 29 1991

SURVEY DIRECTION: DOWNSTREAM

NOTE: NSO #1 ABOVE CULVERT DRY AT SURVEY;BELOW #8 ALL DRY

NOTE: NSO #2 IS CULVERT WITHOUT FLOW

								-WEIGHTING- OVERALL (%)		AREA BY HABITAT TYPE (%)						SUB.		# LWD			INSTR. COV.						RIP. COVER				
NSO	HT	HN	HL	HW	HA	PA	RA	LEN.	AREA	POOL	RIFF.	MD	MDP	MDR	PC	DO	SD	B	S	L	PR	DO	SD	BFW	BFD	EMB	PR	DO	SD	GCO	CAN.
*1	R	1	245	0	0	0	0	20	0	0	0	0	0	0		GR	CO	3	1	1				90	5	Y	3	S	T	4	2
*2	R	2	60	0	0	0	0	5	0	0	0	0	0	0																	
3	P	1	19	20	380	380	0	2	24	55	0	3.8	3.8	0	1	SA	GR	1	1	0	3	D	H	31	10	Y	3	S	T	4	3
4	R	3	115	3	345	0	345	9	21	0	38	0.5	0	0.5		GR	CO	2	3	5	2	T	S	45	9	N	3	S	T	3	2
5	P	2	33	3	99	99	0	3	6	14	0	1.1	1.1	0	3	GR	SA	1	1	3	3	W	U	29	9	Y	4	S	T	4	4
6	R	4	98	5	490	0	490	8	30	0	53	0.9	0	0.9		GR	CO	0	1	1	2	S		35	6	N	4	S	T	4	2
7	P	3	36	6	216	216	0	3	13	31	0	1.2	1.2	0	3	SA	GR	0	2	2	3	W	U	29	5	Y	4	S	T	4	4
8	R	5	28	3	84	0	84	2	5	0	9	0.4	0	0.4		GR	CO	0	0	1	3	T	S	25	5	N	4	S		4	3
*9	P	4	28	0	0	0	0	2	0	0	0	0	0	0		SA	GR	1	0	2				26	5	N	4	S	T	4	2
10	R	6	29	0	0	0	0	2	0	0	0	0	0	0		GR	CO	1	2	1				26	5	N	4	S	T	4	2
11	P	4	15	0	0	0	0	1	0	0	0	0	0	0		GR	SA	0	1	0				25	5	Y	4	S		4	1
12	R	7	31	0	0	0	0	3	0	0	0	0	0	0		GR	SA	1	1	1				35	6	N	4	S	T	4	3
13	P	5	26	0	0	0	0	2	0	0	0	0	0	0		GR	SA	1	1	2				40	7	Y	4	S	T	3	4
14	R	8	82	0	0	0	0	7	0	0	0	0	0	0		GR	CO	2	1	3				41	6	N	3	S	T	4	4
15	R	9	15	0	0	0	0	1	0	0	0	0	0	0		GR	SA	2	3	5				40	7	Y	4	S	T	4	4
16	P	6	90	0	0	0	0	7	0	0	0	0	0	0		GR	CO	1	1	2				43	7	Y	4	S	T	3	4
17	R	10	49	0	0	0	0	4	0	0	0	0	0	0		GR	CO	0	0	1				40	6	N	4	S	T	3	2
18	P	7	84	0	0	0	0	7	0	0	0	0	0	0		SA	GR	2	3	4				43	8	Y	4	S	T	4	3
19	R	11	109	0	0	0	0	9	0	0	0	0	0	0		GR	CO	2	1	3				40	8	N	4	S	T	4	4
20	P	8	26	0	0	0	0	2	0	0	0	0	0	0		GR		0	1	1				45	7	N	4	S	T	4	2

-SUMMARY-

THALWEG LENGTH	1218
HORIZ. LENGTH	1217
GRADIENT %	2.96
POOL AREA	695
RIFFLE AREA	919
POOL/RIFFLE	0.43
TOTAL HABITAT AREA	1614
TOTAL HABITAT AREA (W/SIDE CHANNELS)	N/A
AV MAX POOL DEPTH	2.0
AV MAX RIFFLE DEPTH	0.6
AV STREAM WIDTH (WETTED AREA)	7
AV MAX STREAM DEPTH	0.4
POOL CLASSES	
% FIRST CLASS	33
% SECOND CLASS	0
% THIRD CLASS	67
SUBSTRATE-POOLS	
DOMINANT	SA
SUB-DOMINANT	GR
SUBSTRATE-RIFFLES	
DOMINANT	GR
SUB-DOMINANT	CO

SUBSTRATE-OVERALL	
DOMINANT	GR
SUB-DOMINANT	CO
PIECES LWD	
BRUSH	20
SMALL TREES	24
LARGE TREES	38
INSTREAM COVER-OVERALL	
PROPORTION	2
DOMINANT	S
SUB-DOMINANT	H
MEAN BANKFULL WIDTH	38
MEAN BANKFULL DEPTH	7
EMBEDDEDNESS- % YES (WETTED AREAS)	
POOLS	100
RIFFLES	0
OVERALL	43
RIPARIAN COVER	
PROPORTION	4
DOMINANT	S
SUB-DOMINANT	T
BANK GROUND COVER	4
PERCENT CANOPY	3
MEAN SPRING WIDTH (FIELD NOTES)	20
MEAN SPRING THALWEG DEPTH	0.5

Table J. Survey data for the proposed inundation zone in Piling Creek.

DATE OF SURVEY: AUG 29 1991 SURVEY DIRECTION- DOWNSTREAM

								-WEIGHTING-																							
								OVERALL (%)		AREA BY HABITAT TYPE (%)						SUB.		# LWD			INSTR. COV.						RIP. COVER				
NSO	HT	HN	HL	HW	HA	PA	RA	LENGTH	AREA	POOL	RIFFLE	MD	MDP	MDR	PC	DO	SD	B	S	L	PR	DO	SD	BFW	BFD	EMB	PR	DO	SD	GCO	CAN.
1	P	1	22	12	264	264	0	3	4	9	0	1.7	1.7	0	2	SB	CO	0	0	0	4	S	T	21	7	N	3	S	T	3	1
2	R	1	20	12	240	0	240	3	4	0	7	1.6	0	1.6		SB	CO	0	0	1	4	S	T	20	7	N	3	T	S	3	1
3	P	2	29-	12	348	348	0	5	5	12	0	1.8	1.8	0	2	SB	CO	0	0	2	4	S	T	20	7	N	3	T	S	3	1
4	R	2	26	10	260	0	260	4	4	0	7	1.1	0	1.1		SB	CO	0	1	1	4	T	S	21	7	N	2	T	S	3	1
5	P	3	27	14	378	378	0	4	6	13	0	1.5	1.5	0	3	SB	CO	0	1	0	4	S	U	20	7	N	2	S	T	3	1
6	R	3	15	5	75	0	75	2	1	0	2	0.6	0	0.6		SB	CO	0	0	0	4	S	W	21	7	N	2	S	T	3	1
7	P	4	35	5	175	175	0	6	3	6	0	1.3	1.3	0	3	SB	CO	1	2	0	4	S	W	21	7	N	2	S	T	2	1
8	R	4	36	10	360	0	360	6	6	0	10	1	0	1		SB	CO	2	3	2	4	S	T	35	8	N	2	S	T	4	1
9	P	5	51	9	459	459	0	8	7	15	0	1.3	1.3	0	3	SB	CO	1	2	3	4	S	W	30	7	N	2	S	T	4	2
10	R	5	56	11	616	0	616	9	9	0	18	0.8	0	0.8		BR	SB	1	1	0	3	S	T	30	6	N	2	S	T	4	1
11	P	6	87	10	870	870	0	14	13	29	0	0.9	0.9	0	3	BR	SB	0	0	1	3	S	T	29	6	N	2	S	T	4	1
12	R	6	49	11	539	0	539	8	8	0	15	0.8	0	0.8		BR	SB	0	0	0	2	S	M	41	5	N	2	S	T	4	1
13	P	7	36	10	360	360	0	6	6	12	0	1.2	1.2	0	3	BR	SB	0	0	0	2	S	M	39	5	N	2	S	T	4	1
14	R	7	25	10	250	0	250	4	4	0	7	0.6	0	0.6		BR	SB	0	0	1	3	S	M	35	5	N	2	S	T	4	3
15	P	8	14	10	140	140	0	2	2	5	0	2.2	2.2	0	2	BR	SB	0	0	0	3	S	M	30	6	N	2	S	T	4	3
16	R	8	105	11	1155	0	1155	17	18	0	33	1	0	1		BR	LB	5	6	4	3	T	S	65	6	N	4	T	S	4	3

-SUMMARY-

THALWEG LENGTH	633
HORIZ. LENGTH	632
GRADIENT %	5.7
POOL AREA	2994
RIFFLE AREA	3495
POOL/RIFFLE	0.46
TOTAL HABITAT AREA	6489
AV MAX POOL DEPTH	1.5
AV MAX RIFFLE DEPTH	0.9
AV STREAM WIDTH	10
AV MAX STREAM DEPTH	1.2
POOL CLASSES	
% FIRST CLASS	0
% SECOND CLASS	38
% THIRD CLASS	62
SUBSTRATE-POOLS	
DOMINANT	SB
SUB-DOMINANT	CO
SUBSTRATE-RIFFLES	
DOMINANT	BR
SUB-DOMINANT	SB

SUBSTRATE-OVERALL	
DOMINANT	BR
SUB-DOMINANT	SB
PIECES LARGE WOODY DEBRIS	
BRUSH	10
SMALL TREES	16
LARGE TREES	15
INSTREAM COVER-OVERALL	
PROPORTION	3
DOMINANT	S
SUB-DOMINANT	T
MEAN BANKFULL WIDTH	30
MEAN BANKFULL DEPTH	6
EMBEDDEDNESS- % YES	
POOLS	0
RIFFLES	0
OVERALL	0
RIPARIAN COVER	
PROPORTION	2
DOMINANT	S
SUB-DOMINANT	T
BANK GROUND COVER	4
PERCENT CANOPY	2
MEAN SPRING WIDTH (FIELD NOTES)	12
MEAN SPRING THALWEG DEPTH	1

Table K. Survey data for the proposed inundation zone in stream 0202.

DATE OF SURVEY: AUG 29 1991
NOTE: ONLY 14.5 FT ELEVATION GAIN
NOTE: NSO 7 IS CULVERT (89 FT X 2 FT, 0.4 FT DEPTH)

SURVEY DIRECTION- UPSTREAM

								-WEIGHTING- OVERALL (%)		AREA BY HABITAT TYPE (%)						SUB.		# LWD			INSTR. COV.						RIP. COVER				
NSO	HT	HN	HL	HW	HA	PA	RA	LEN.	AREA	POOL	RIFF.	MD	MDP	MDR	PC	DO	SD	B	S	L	PR	DO	SD	BFW	BFD	EMB	PR	DO	SD	GCO	CAN.
1	R	1	8	10	80	0	80	3	4	0	7	0.5	0	0.5		CO	SB	0	0	0	3	T	S	60	5	N	2	T	S	4	2
2	P	1	15	5	75	75	0	6	4	9	0	1.3	1.3	0	3	CO	SB	0	0	0	3	S	T	60	5	N	2	T	S	4	2
3	R	2	30	13	390	0	390	11	19	0	32	0.8	0	0.8		CO	SB	0	0	0	3	T	S	48	5	N	2	T	S	4	2
4	P	2	14	10	140	140	0	5	7	17	0	1.6	1.6	0	2	SB	LB	0	0	0	4	S	T	47	5	N	2	T	S	4	3
5	R	3	13	8	104	0	104	5	5	0	9	1	0	1		SB	LB	0	1	0	4	T	S	40	5	N	2	T	S	3	3
6	P	3	19	18	342	342	0	7	17	40	0	3.9	3.9	0	1	CO	SA	1	2	2	4	D	W	30	10	Y	1	T	S	4	3
*7	R	4	89	2	178	0	178	34	9	0	15	0.4	0	0.4																	
8	R	5	27	13	351	0	351	10	17	0	29	1.1	0	1.1		CO	SB	0	0	0	4	T	S	32	10	N	2	S	T	3	2
9	P	4	16	12	192	192	0	6	9	23	0	1.6	1.6	0	3	CO	SB	1	1	0	3	S	T	30	10	N	2	S	T	3	3
10	R	6	14	8	112	0	112	5	5	0	9	0.9	0	0.9		CO	SB	0	0	0	3	T	S	45	9	N	2	S	T	4	3
11	P	5	16	6	96	96	0	6	5	11	0	1	1	0	3	CO	SB	0	1	0	4	T	S	50	9	N	2	S	T	3	3

-SUMMARY-

THALWEG LENGTH	261
HORIZ. LENGTH	261
GRADIENT %	5.56
POOL AREA	845
RIFFLE AREA	1215
POOL/RIFFLE	0.41
TOTAL HABITAT AREA	2060
TOTAL HABITAT AREA (W/SIDE CHANNELS)	N/A
AV MAX POOL DEPTH	1.9
AV MAX RIFFLE DEPTH	0.8
AV STREAM WIDTH	8
AV MAX STREAM DEPTH	1.3
POOL CLASSES	
% FIRST CLASS	20
% SECOND CLASS	20
% THIRD CLASS	60
SUBSTRATE-POOLS	
DOMINANT	CO
SUB-DOMINANT	SB
SUBSTRATE-RIFFLES	
DOMINANT	CO
SUB-DOMINANT	SB

SUBSTRATE-OVERALL	
DOMINANT	CO
SUB-DOMINANT	SB
PIECES LWD	
BRUSH	2
SMALL TREES	5
LARGE TREES	2
INSTREAM COVER-OVERALL	
PROPORTION	3
DOMINANT	T
SUB-DOMINANT	S
MEAN BANKFULL WIDTH	40
MEAN BANKFULL DEPTH	7
EMBEDDEDNESS- % YES	
POOLS	40
RIFFLES	0
OVERALL	17
RIPARIAN COVER	
PROPORTION	2
DOMINANT	T
SUB-DOMINANT	S
BANK GROUND COVER	3
PERCENT CANOPY	3
MEAN SPRING WIDTH (FIELD NOTES)	12
MEAN SPRING THALWEG DEPTH	0.5

Table L. Survey data for the proposed inundation zone in stream 0212.

DATE OF SURVEY: SEP 3 1991 SURVEY DIRECTION: UPSTREAM

								-WEIGHTING- OVERALL (%)		AREA BY HABITAT TYPE (%)						SUB.		# LWD			INSTR. COV.						RIP. COVER				
NSO	HT	HN	HL	HW	HA	PA	RA	LEN.	AREA	POOL	RIFF.	MD	MDP	MDR	PC	DO	SD	B	S	L	PR	DO	SD	BFW	BFD	EMB	PR	DO	SD	GCO	CAN.
1	R	1	13	3	39	0	39	4	3	0	5	0.4	0	0.4		GR	SA	20	16	7	2	W	S	70	10	Y	2	T	S	4	3
2	P	1	21	3	63	63	0	6	4	9	0	0.3	0.3	0	3	GR	CO	10	10	3	4	W	U	46	6	Y	3	S	T	4	3
3	R	2	28	6	168	0	168	9	12	0	23	0.5	0	0.5		GR	SA	10	5	1	4	W	U	47	5	Y	3	S	T	3	3
4	P	2	16	4	64	64	0	5	4	9	0	0.7	0.7	0	3	GR	SA	5	2	0	4	W	H	47	5	Y	4	S	T	4	3
5	R	3	28	4	112	0	112	9	8	0	15	0.5	0	0.5		GR	SA	0	1	0	3	W	H	30	5	Y	4	S	T	4	3
6	P	3	34	4	136	136	0	10	9	19	0	1	1	0	2	GR	SA	3	2	0	4	W	U	30	5	Y	4	S	T	4	3
7	R	4	28	3	84	0	84	9	6	0	11	0.4	0	0.4		GR	CO	0	0	0	3	S	H	30	5	Y	4	S	T	4	3
8	P	4	49	6	294	294	0	15	20	42	0	1.1	1.1	0	1	CO	GR	3	2	3	4	W	U	28	6	N	4	S	T	4	4
9	R	5	9	5	45	0	45	3	3	0	6	0.7	0	0.7		GR	CO	1	1	2	3	W	H	29	5	N	4	S	T	4	3
10	P	5	13	6	78	78	0	4	5	11	0	0.7	0.7	0	3	GR	CO	2	2	0	3	W	U	29	5	N	4	S	T	4	3
11	R	6	16	4	64	0	64	5	4	0	9	0.4	0	0.4		CO	GR	0	0	0	3	T	S	29	5	N	4	S	T	4	4
12	P	6	17	4	68	68	0	5	5	10	0	1	1	0	2	CO	SB	0	0	2	3	W	S	30	5	N	4	S	T	4	2
13	R	7	55	4	220	0	220	17	15	0	30	0.7	0	0.7		CO	SB	1	0	0	3	T	S	32	6	N	3	S	T	4	3

-SUMMARY-

THALWEG LENGTH	327
HORIZ. LENGTH	325
GRADIENT %	11.08
POOL AREA	703
RIFFLE AREA	732
POOL/RIFFLE	0.49
TOTAL HABITAT AREA	1435
TOTAL HABITAT AREA (W/SIDE CHANNELS)	N/A
AV MAX POOL DEPTH	0.8
AV MAX RIFFLE DEPTH	0.5
AV STREAM WIDTH	4
AV MAX STREAM DEPTH	0.6
POOL CLASSES	
% FIRST CLASS	17
% SECOND CLASS	33
% THIRD CLASS	50
SUBSTRATE-POOLS	
DOMINANT	CO
SUB-DOMINANT	GR
SUBSTRATE-RIFFLES	
DOMINANT	GR
SUB-DOMINANT	SA

SUBSTRATE-OVERALL	
DOMINANT	GR
SUB-DOMINANT	SA
PIECES LWD	
BRUSH	55
SMALL TREES	41
LARGE TREES	18
INSTREAM COVER-OVERALL	
PROPORTION	3
DOMINANT	W
SUB-DOMINANT	U
MEAN BANKFULL WIDTH	37
MEAN BANKFULL DEPTH	6
EMBEDDEDNESS- % YES	
POOLS	37
RIFFLES	55
OVERALL	46
RIPARIAN COVER	
PROPORTION	4
DOMINANT	S
SUB-DOMINANT	T
BANK GROUND COVER	4
PERCENT CANOPY	3
MEAN SPRING WIDTH (FIELD NOTES)	5
MEAN SPRING THALWEG DEPTH	1

Table #. Survey data for the proposed inundation zone in stream 0215.

DATE OF SURVEY: AUG 28 1991 SURVEY DIRECTION: UPSTREAM

								-WEIGHTING- OVERALL (%)		AREA BY HABITAT TYPE (%)						SUB.		# LWD			INSTR. COV.						RIP. COVER				
NSO	HT	HN	HL	HW	HA	PA	RA	LEN.	AREA	POOL	RIFF.	MD	MDP	MDR	PC	DO	SD	B	S	L	PR	DO	SD	BFW	BFD	EMB	PR	DO	SD	GCO	CAN.
1	P	1	25	6	150	150	0	3	4	13	0	1.1	1.1	0	3	SA	GR	1	2	2	3	W	U	30	6	Y	4	T	S	4	3
2	R	1	88	6	528	0	528	12	15	0	22	1.6	0	1.6		SA	GR	1	0	0	3	U	T	30	6	Y	4	S	T	4	3
3	P	2	66	5	330	330	0	9	9	29	0	2.3	2.3	0	2	SA	GR	1	0	0	3	U	W	28	5	Y	4	S	T	4	3
4	R	2	18	5	90	0	90	2	3	0	4	0.4	0	0.4		GR	SA	1	1	0	3	T	U	27	6	Y	3	S	T	4	2
5	P	3	29	5	145	145	0	4	4	13	0	1.2	1.2	0	3	SA	GR	0	1	1	3	T	W	30	6	Y	3	S	T	3	4
6	R	3	36	5	180	0	180	5	5	0	7	1	0	1		GR	SA	1	0	1	4	H	U	30	7	Y	3	S		4	4
7	P	4	12	5	60	60	0	2	2	5	0	1.1	1.1	0	3	SA	GR	1	0	0	3	H	W	25	6	Y	4	S		4	3
8	R	4	58	5	290	0	290	8	8	0	12	0.9	0	0.9		GR	SA	1	1	1	4	H	U	26	6	Y	4	S		4	4
9	P	5	13	4	52	52	0	2	1	5	0	1.1	1.1	0	3	SA		2	1	0	3	H	W	27	7	Y	4	S		4	4
10	R	5	82	4	328	0	328	11	9	0	13	0.9	0	0.9		GR	SA	5	4	4	4	T	H	30	7	Y	4	S		4	4
11	P	6	18	5	90	90	0	2	3	8	0	1.1	1.1	0	3	SA		1	0	0	4	H	W	28	6	Y	4	S	T	4	4
12	R	6	80	6	480	0	480	11	13	0	20	0.9	0	0.9		GR	SA	6	5	5	4	H	W	31	5	Y	4	S	T	4	4
13	P	7	37	5	185	185	0	5	5	16	0	1.3	1.3	0	3	SA	GR	3	1	1	4	H	W	30	5	Y	4	S		3	4
14	R	7	45	4	180	0	180	6	5	0	7	0.7	0	0.7		GR	SA	3	2	1	4	H	W	31	4	Y	4	S		3	4
15	P	8	14	4	56	56	0	2	2	5	0	0.8	0.8	0	3	SA		1	1	1	4	H	W	30	5	Y	4	S	T	4	4
16	R	8	90	4	360	0	360	12	10	0	15	0.5	0	0.5		GR	SA	1	0	0	4	H	T	28	6	Y	3	S		3	4
17	P	9	21	4	84	84	0	3	2	7	0	1	1	0	3	SA		0	0	0	4	H	U	25	5	Y	3	S	T	4	4

-SUMMARY-

THALWEG LENGTH	732
HORIZ. LENGTH	731
GRADIENT %	4.92
POOL AREA	1152
RIFFLE AREA	2436
POOL/RIFFLE	0.32
TOTAL HABITAT AREA	3588
TOTAL HABITAT AREA (W/SIDE CHANNELS)	N/A
AV MAX POOL DEPTH	1.2
AV MAX RIFFLE DEPTH	0.9
AV STREAM WIDTH	5
AV MAX STREAM DEPTH	1.1
POOL CLASSES	
% FIRST CLASS	0
% SECOND CLASS	11
% THIRD CLASS	89
SUBSTRATE-POOLS	
DOMINANT	SA
SUB-DOMINANT	GR
SUBSTRATE-RIFFLES	
DOMINANT	GR
SUB-DOMINANT	SA

SUBSTRATE-OVERALL	
DOMINANT	GR
SUB-DOMINANT	SA
PIECES LWD	
BRUSH	29
SMALL TREES	19
LARGE TREES	17
INSTREAM COVER-OVERALL	
PROPORTION	4
DOMINANT	H
SUB-DOMINANT	W
MEAN BANKFULL WIDTH	29
MEAN BANKFULL DEPTH	6
EMBEDDEDNESS- % YES	
POOLS	100
RIFFLES	100
OVERALL	100
RIPARIAN COVER	
PROPORTION	4
DOMINANT	S
SUB-DOMINANT	T
BANK GROUND COVER	4
PERCENT CANOPY	4
MEAN SPRING WIDTH (FIELD NOTES)	5
MEAN SPRING THALWEG DEPTH	0.5

Table N. Survey data for the existing inundation zone (upper 30 feet of elevation) of the Green River mainstem.

DATES OF SURVEY:
NSO 1-10: SEP 26 1991
NSO 11-20: OCT 15 1991

SURVEY DIRECTION: DOWNSTREAM

NSO	HT	HN	HL	HW	HA	PA	RA	-WEIGHTING- OVERALL (%) LEN.	AREA	AREA BY HABITAT TYPE (%) POOL	RIFF.	MD	MDP	MDR	PC	SUB. DO	SUB. SD	# LWD B	S	L	INSTR. COV. PR	DO	SD	BFW	BFD	EMB	RIP. COVER PR	DO	SD	GCO	CAN.
1	P	1	510	87	44370	44370	0	8	9	27	0	18	18	0	1	GR	CO	0	0	0	4	D	U	315	30	Y	3	T	S	4	1
2	R	1	200	108	21600	0	21600	3	4	0	6	1	0	1		CO	SB	0	0	1	3	S	T	350	20	Y	3	T	S	4	1
3	R	2	240	57	13680	0	13680	4	3	0	4	12	0	1.5		CO	SB	0	0	0	4	T	S	225	15	Y	3	T	S	2	1
4	P	2	445	47	20915	20915	0	7	4	13	0	20	20	0	1	BR	SA	0	0	1	4	D	U	320	10	Y	2	T	S	4	1
5	P	3	450	79	35550	35550	0	7	7	22	0	4	4	0	1	CO	SB	0	1	1	4	S	D	420	10	Y	2	T	S	2	1
6	R	3	573	97	55581	0	55581	9	11	0	16	1.2	0	1.2		CO	SB	0	1	1	3	T	S	275	8	Y	3	T	S	4	1
7	P	4	415	83	34445	34445	0	6	7	21	0	2.5	2.5	0	2	CO	SB	0	3	5	3	S	W	400	10	Y	2	T	S	2	1
8	R	4	282	63	17766	0	17766	4	3	0	5	1.5	0	1.5		CO	GR	0	8	1	3	T	S	460	12	Y	2	S	T	2	1
9	P	5	140	59	8260	8260	0	2	2	5	0	10	10	0	1	CO	GR	0	5	3	4	D	W	450	12	Y	2	S	G	2	1
10	R	5	1470	120	176400	0	176400	23	35	0	51	2.5	0	2.5		CO	GR	0	10	25	3	T	S	N/A	N/A	Y	1	G		3	1
11	P	6	84	27	2268	2268	0	1	0	1	0	4.5	4.5	0	1	CO	SB	0	2	2	4	D	W	N/A	N/A	Y	1	G		2	1
12	P	7	175	62	10850	10850	0	3	2	7	0	1.5	1.5	0	3	GR	CO	2	0	1	3	S		N/A	N/A	Y	1	G		2	1
13	R	6	75	69	5175	0	5175	1	1	0	1	0.5	0	0.5		CO	SB	0	1	0	3	S		N/A	N/A	Y	1	G		2	1
14	P	8	135	51	6885	6885	0	2	1	4	0	2	2	0	3	CO	SB	0	2	2	3	W	S	N/A	N/A	Y	1	G		2	1
15	R	7	311	73	20915	0	20915	5	4	0	6	0.5	0	0.5		CO	GR	0	0	3	2	T		N/A	N/A	Y	1	G		2	1
16	P	9	78	20	1560	1560	0	1	0	1	0	2	2	0	2	GR	CO	3	0	0	2	W		N/A	N/A	Y	1	G		2	1
17	R	8	155	37	5735	0	5735	2	1	0	2	1.5	0	1.5		CO	SB	1	0	0	3	S		N/A	N/A	Y	1	G		2	1
18	R	9	120	38	4560	0	4560	2	1	0	1	1.5	0	1.5		CO	SB	0	0	0	2	S		N/A	N/A	Y	1	G		2	1
19	R	10	155	52	8060	0	8060	2	2	0	2	0.9	0	0.9		CO	SB	0	0	2	4	T	S	N/A	N/A	Y	1			4	1
20	R	11	410	38	15580	0	15580	6	3	0	5	1	0	1		CO	SB	0	0	1	3	T	S	N/A	N/A	Y	1			4	1

-SUMMARY-

THALWEG LENGTH	6423
HORIZ. LENGTH	6423
GRADIENT %	0.47
POOL AREA	165103
RIFFLE AREA	345052
POOL/RIFFLE	0.32
TOTAL HABITAT AREA	510155
TOTAL HABITAT AREA (W/SIDE CHANNELS)	N/A
AV MAX POOL DEPTH	7
AV MAX RIFFLE DEPTH	1
AV STREAM WIDTH	80
AV MAX STREAM DEPTH	4.4
POOL CLASSES	
% FIRST CLASS	56
% SECOND CLASS	22
% THIRD CLASS	22
SUBSTRATE-POOLS	
DOMINANT	CO
SUB-DOMINANT	SB
SUBSTRATE-RIFFLES	
DOMINANT	CO
SUB-DOMINANT	GR

SUBSTRATE-OVERALL	
DOMINANT	CO
SUB-DOMINANT	GR
PIECES LWD	
BRUSH	6
SMALL TREES	33
LARGE TREES	49
INSTREAM COVER-OVERALL	
PROPORTION	3
DOMINANT	D
SUB-DOMINANT	S
MEAN BANKFULL WIDTH	N/A
MEAN BANKFULL DEPTH	N/A
EMBEDDEDNESS- % YES	
POOLS	100
RIFFLES	100
OVERALL	100
RIPARIAN COVER	
PROPORTION	1
DOMINANT	G
SUB-DOMINANT	S
BANK GROUND COVER	2
PERCENT CANOPY	1

Table 0. Survey data for the existing inundation zone (upper 30 feet of elevation) in the North Fork of the Green River.

DATE OF SURVEY: OCT 15 1991

SURVEY DIRECTION- DOWNSTREAM

								-WEIGHTING- OVERALL (%)		AREA BY HABITAT TYPE (%)						SUB.		# LWD			INSTR. COV.						RIP. COVER				
NSO	HT	HN	HL	HW	HA	PA	RA	LENGTH	AREA	POOL	RIFFLE	MD	MDP	MDR	PC	DO	SD	B	S	L	PR	DO	SD	BFW	BFD	EMB	PR	DO	SD	GCO	CAN.
1	R	1	192	34	6528	0	6528	9	8	0	10	1.5	0	1.5		SB	LB	3	0	3	4	T	S	135	8	Y	4	S	T	4	2
2	P	1	49	32	1568	1568	0	2	2	16	0	1.6	1.6	0	2	CO	SB	1	0	0	2	T		194	8	Y	4	T	S	4	1
3	R	2	128	38	4864	0	4864	6	6	0	7	0.6	0	0.6		CO	SB	6	0	0	4	T	S	190	8	Y	4	S	T	4	1
4	P	2	176	25	4400	4400	0	8	6	45	0	2.5	2.5	0	2	CO	SB	2	2	3	4	W	S	190	8	Y	4	S	T	2	1
5	R	3	165	30	4950	0	4950	8	6	0	7	0.9	0	0.9		CO	SB	0	0	0	4	T	S	175	10	Y	2	T	G	3	1
6	P	3	140	27	3780	3780	0	7	5	39	0	2.5	2.5	0	2	CO	SB	0	0	0	3	S		175	10	Y	2	G		2	1
7	R	4	404	33	13332	0	13332	19	17	0	20	2	0	2		CO	SB	0	0	0	4	T	S	N/A	N/A	Y	2	G		2	1
8	R	5	835	45	37575	0	37575	40	49	0	56	1.5	0	1.5		CO	GR	2	0	0	3	T	S	N/A	N/A	Y	1			1	1

-SUMMARY-

THALWEG LENGTH	2089
HORIZ. LENGTH	2089
GRADIENT %	1.4
POOL AREA	9748
RIFFLE AREA	67249
POOL/RIFFLE	0.13
TOTAL HABITAT AREA	76997
AV MAX POOL DEPTH	2.2
AV MAX RIFFLE DEPTH	1.3
AV STREAM WIDTH	37
AV MAX STREAM DEPTH	1.6
POOL CLASSES	
% FIRST CLASS	0
% SECOND CLASS	100
% THIRD CLASS	0
SUBSTRATE-POOLS	
DOMINANT	CO
SUB-DOMINANT	SB
SUBSTRATE-RIFFLES	
DOMINANT	CO
SUB-DOMINANT	GR

SUBSTRATE-OVERALL	
DOMINANT	CO
SUB-DOMINANT	GR
PIECES LARGE WOODY DEBRIS	
BRUSH	14
SMALL TREES	2
LARGE TREES	6
INSTREAM COVER-OVERALL	
PROPORTION	2
DOMINANT	T
SUB-DOMINANT	S
MEAN BANKFULL WIDTH	N/A
MEAN BANKFULL DEPTH	N/A
EMBEDDEDNESS- % YES	
POOLS	100
RIFFLES	100
OVERALL	100
RIPARIAN COVER	
PROPORTION	2
DOMINANT	G
SUB-DOMINANT	T
BANK GROUND COVER	1
PERCENT CANOPY	1

Table P. Survey data for the existing inundation zone (upper 30 feet of elevation) in Charley Creek.

DATE OF SURVEY: OCT 15 1991

SURVEY DIRECTION- DOWNSTREAM

								-WEIGHTING- OVERALL (%)		AREA BY HABITAT TYPE (%)						SUB.		# LWD			INSTR. COV.						RIP. COVER				
NSO	HT	HN	HL	HW	HA	PA	RA	LENGTH	AREA	POOL	RIFFLE	MD	MDP	MDR	PC	DO	SD	B	S	L	PR	DO	SD	BFW	BFD	EMB	PR	DO	SD	GCO	CAN.
1	R	1	519-	37	19203	0	19203	44	49	0	53	2	0	2		LB	SB	11	13	12	4	T	S	98	10	N	4	T	S	3	2
2	P	1	59	24	1416	1416	0	5	4	46	0	2.5	2.5	0	2	LB	SB	1	1	2	4	S	T	107	15	N	4	T	S	4	2
3	R	2	186	52	9672	0	9672	16	25	0	27	2.1	0	2.1		LB	SB	10	8	5	4	T	S	150	15	N	4	T	S	4	2
4	P	2	33	26	858	858	0	3	2	28	0	4	4	0	2	LB	BR	0	0	0	3	D	S	150	15	N	3	T	S	4	1
5	R	3	230	24	5520	0	5520	19	14	0	15	1.9	0	1.9		LB	SB	3	2	8	4	T	S	140	15	N	1			1	1
6	P	3	68	12	816	816	0	6	2	26	0	3	3	0	2	BR	LB	0	0	0	4	D	U	140	18	N	1			1	1
7	R	4	86	21	1806	0	1806	7	5	0	5	2	0	2		LB	SB	0	0	1	4	T	S	140	18	N	1			1	1

-SUMMARY-

THALWEG LENGTH	1181
HORIZ. LENGTH	1181
GRADIENT %	2.5
POOL AREA	3090
RIFFLE AREA	36201
POOL/RIFFLE	0.08
TOTAL HABITAT AREA	39291
AV MAX POOL DEPTH	3.2
AV MAX RIFFLE DEPTH	2.0
AV STREAM WIDTH	31
AV MAX STREAM DEPTH	2.5
POOL CLASSES	
% FIRST CLASS	0
% SECOND CLASS	100
% THIRD CLASS	0
SUBSTRATE-POOLS	
DOMINANT	LB
SUB-DOMINANT	SB
SUBSTRATE-RIFFLES	
DOMINANT	LB
SUB-DOMINANT	SB

SUBSTRATE-OVERALL	
DOMINANT	LB
SUB-DOMINANT	SB
PIECES LARGE WOODY DEBRIS	
BRUSH	25
SMALL TREES	24
LARGE TREES	28
INSTREAM COVER-OVERALL	
PROPORTION	4
DOMINANT	T
SUB-DOMINANT	S
MEAN BANKFULL WIDTH	132
MEAN BANKFULL DEPTH	15
EMBEDDEDNESS- % YES	
POOLS	0
RIFFLES	0
OVERALL	0
RIPARIAN COVER	
PROPORTION	3
DOMINANT	T
SUB-DOMINANT	S
BANK GROUND COVER	2
PERCENT CANOPY	1

Table Q. Survey data for the existing inundation zone (approximately upper 22 feet of elevation) in Gale Creek.

DATES OF SURVEY:
NSO 1-3: OCT 15 1991
NSO 4-10: SEP 26 1991
NOTE: JOINS MAINSTEM BELOW NSO 10

SURVEY DIRECTION- UPSTREAM

								-WEIGHTING- OVERALL (%)		AREA BY HABITAT TYPE (%)						SUB.		# LWD			INSTR. COV.						RIP. COVER				
NSO	HT	HN	HL	HW	HA	PA	RA	LEN.	AREA	POOL	RIFF.	MD	MDP	MDR	PC	DO	SD	B	S	L	PR	DO	SD	BFW	BFD	EMB	PR	DO	SD	GCO	CAN.
1	R	1	85	40	3400	0	3400	5	12	0	18	0.5	0	0.5		CO	GR	0	0	0	3	T	S			Y	1			1	1
2	P	1	130	41	5330	5330	0	8	19	64	0	1	1	0	3	CO	GR	0	0	0	2	S				Y	1			1	1
3	R	2	75	15	1125	0	1125	5	4	0	6	1.1	0	1.1		CO	GR	0	0	0	3	T	S			Y	1			1	2
4	R	3	145	20	2900	0	2900	9	11	0	15	0.4	0	0.4		CO	GR	0	0	0	2	S				Y	1			4	1
5	P	2	62	22	1364	1364	0	4	5	16	0	2	2	0	3	GR	CO	0	1	0	1	S				Y	2	G		1	3
6	R	4	430	13	5590	0	5590	27	20	0	29	0.4	0	0.4		GR	CO	0	0	0	1	S		205	10	Y	2	G		1	1
7	P	3	130	8	1040	1040	0	8	4	12	0	2.5	2.5	0	3	GR	SA	0	0	0	2	U		205	10	Y	2	G		1	1
8	R	5	390	11	4290	0	4290	25	16	0	22	0.6	0	0.6		CO	GR	0	0	0	2	S		210	10	Y	1	G		3	1
9	P	4	37	16	592	592	0	2	2	7	0	2.7	2.7	0	1	CO	GR	3	0	2	4	W	S	109	12	Y	3	T	S	2	1
10	R	6	100	18	1800	0	1800	6	7	0	9	0.8	0	0.8		CO	SB	0	2	4	4	T	S	58	8	Y	4	T	S	4	2

-SUMMARY-

THALWEG LENGTH	1584
HORIZ. LENGTH	1584
GRADIENT %	1.39
POOL AREA	8326
RIFFLE AREA	19105
POOL/RIFFLE	0.30
TOTAL HABITAT AREA	27431
TOTAL HABITAT AREA (W/SIDE CHANNELS)	N/A
AV MAX POOL DEPTH	2.0
AV MAX RIFFLE DEPTH	0.6
AV STREAM WIDTH	17
AV MAX STREAM DEPTH	1.2
POOL CLASSES	
% FIRST CLASS	25
% SECOND CLASS	0
% THIRD CLASS	75
SUBSTRATE-POOLS	
DOMINANT	CO
SUB-DOMINANT	GR
SUBSTRATE-RIFFLES	
DOMINANT	CO
SUB-DOMINANT	GR

SUBSTRATE-OVERALL	
DOMINANT	CO
SUB-DOMINANT	GR
PIECES LWD	
BRUSH	3
SMALL TREES	3
LARGE TREES	6
INSTREAM COVER-OVERALL	
PROPORTION	2
DOMINANT	S
SUB-DOMINANT	
MEAN BANKFULL WIDTH	N/A
MEAN BANKFULL DEPTH	N/A
EMBEDDEDNESS- % YES	
POOLS	100
RIFFLES	100
OVERALL	100
RIPARIAN COVER	
PROPORTION	1
DOMINANT	G
SUB-DOMINANT	S
BANK GROUND COVER	1
PERCENT CANOPY	1

Table R. Survey data for the existing inundation zone (upper 30 feet of elevation) in stream 0215.

DATE OF SURVEY: OCT 16 1991

SURVEY DIRECTION: DOWNSTREAM

								-WEIGHTING- OVERALL (%)		AREA BY HABITAT TYPE (%)						SUB.		# LWD			INSTR. COV.						RIP. COVER				
NSO	HT	HN	HL	HW	HA	PA	RA	LEN.	AREA	POOL	RIFF.	MD	MDP	MDR	PC	DO	SD	B	S	L	PR	DO	SD	BFW	BFD	EMB	PR	DO	SD	GCO	CAN.
1	R	1	140	4	560	0	560	10	8	0	8	0.6	0	0.6		SA	GR	5	1	0	3	U	W	250	5	Y	4	T	S	4	4
2	P	1	55	5	275	275	0	4	4	73	0	2	2	0	2	SA	GR	2	0	0	3	U		290	5	Y	4	T	S	4	4
3	R	2	65	4	260	0	260	4	4	0	4	0.6	0	0.6		SA	GR	1	0	0	3	T	U	N/A	N/A	Y	4	T	S	4	4
4	P	2	25	4	100	100	0	2	1	27	0	1	1	0	2	SA	GR	1	1	0	3	U		N/A	N/A	Y	4	T		4	4
5	R	3	1180	5	5900	0	5900	81	83	0	88	1	0	1		SA		0	0	0	3	U		N/A	N/A	Y	1	G		2	1

-SUMMARY-

THALWEG LENGTH	1465
HORIZ. LENGTH	1465
GRADIENT %	2.05
POOL AREA	375
RIFFLE AREA	6720
POOL/RIFFLE	0.05
TOTAL HABITAT AREA	7095
TOTAL HABITAT AREA (W/SIDE CHANNELS)	N/A
AV MAX POOL DEPTH	1.5
AV MAX RIFFLE DEPTH	0.7
AV STREAM WIDTH	5
AV MAX STREAM DEPTH	1.0
POOL CLASSES	
% FIRST CLASS	0
% SECOND CLASS	100
% THIRD CLASS	0
SUBSTRATE-POOLS	
DOMINANT	SA
SUB-DOMINANT	GR
SUBSTRATE-RIFFLES	
DOMINANT	SA
SUB-DOMINANT	

SUBSTRATE-OVERALL	
DOMINANT	SA
SUB-DOMINANT	
PIECES LWD	
BRUSH	9
SMALL TREES	2
LARGE TREES	0
INSTREAM COVER-OVERALL	
PROPORTION	3
DOMINANT	U
SUB-DOMINANT	
MEAN BANKFULL WIDTH	N/A
MEAN BANKFULL DEPTH	N/A
EMBEDDEDNESS- % YES	
POOLS	100
RIFFLES	100
OVERALL	100
RIPARIAN COVER	
PROPORTION	1
DOMINANT	G
SUB-DOMINANT	
BANK GROUND COVER	2
PERCENT CANOPY	1