ATI Beaver Creek Spill
Natural Resource Damage Assessment
and Restoration Summary

July 2004

INTRODUCTION

On 4 March 1999, a tanker truck overturned on Highway 26 and released approximately 6,000 gallons of gasoline into Beaver Butte Creek, located on the Warm Springs Reservation, resulting in significant natural resource impacts. Separate from response actions taken to control and cleanup the spill, a Natural Resource Damage Assessment (NRDA) was initiated under the authority of the Oil Pollution Act. The natural resource trustees designated for the spill included the Confederated Tribes of the Warm Springs, the Department of Commerce (National Marine Fisheries Service) and the Department of Interior (U.S. Fish and Wildlife Service, Bureau of Indian Affairs).

As agreed to in earlier meetings between ATI=s representatives (the Responsible Party) and the Trustees, efforts have been made to simplify the potentially long-term and expensive NRDA process by delaying, and possibly avoiding additional field studies that would be used to measure impacts to trust resources. Instead, the Trustees have agreed to use currently available information to prepare a document summarizing the trust resource impacts associated with the ATI gasoline spill. This plan seeks to compensate for the natural resource service losses that occurred using appropriate restoration actions. Restoration under this plan is intended to make the public whole for injuries or losses resulting from the spill by ensuring that injured natural resources or services return to baseline or pre-spill conditions, and by providing for restoration or replacement of resources or resource services to compensate for interim losses of resources or resource services caused by the spill.

This document presents estimated impacts to anadromous fishes, including Chinook salmon (hatchery and wild populations), and steelhead. A habitat restoration proposal for compensating anadromous fish losses is included.. A variety of other natural resources and resource services were potentially injured as the result of the spill (e.g. surface water, benthic macroinvertebrates in Beaver Creek, resident fishes and amphibians in Beaver Creek, riparian vegetation, cultural resources, loss of recreational fishing opportunity for adult salmon, ceremonial and subsistence loss due to reduced adult returns to river and hatchery, etc.) The Trustees reserve the right to perform more comprehensive assessment studies to document impacts, if a settlement agreement that compensates for anadromous fish losses cannot be reached.

RESOURCE: <u>Spring Chinook Salmon from Warm Springs National Fish Hatchery</u>

<u>Impacts</u>

Two broods of fish required unusual treatment due to the ATI gasoline spill upstream of the hatchery, the 1997 brood year fingerlings and the 1998 brood sub-yearling fingerlings. The U.S.

Fish and Wildlife Service was required to release the 811,570 1997 brood fingerling Chinook from the Warm Springs hatchery in order to avoid the possibility of fish mortality and chemical contamination of the hatchery. These fingerlings were released 47 days prior to normal release time. Based on size and release investigations at the hatchery (Cates 1992, Olson 1997) and policy guidelines in IHOT (1995) and NMFS (1999), the Trustees estimate that a substantial increase in mortality to the fingerlings occurred as a result of the early release due to the spill. An additional 825,000 1998 brood sub-yearling Chinook were transported to a State hatchery to avoid potential chemical exposure and mortality. Trustee records indicate that 40,000 fish were lost during this process, as a result of shipping and screen failures at the state hatchery.

The impact of the 40,000 juvenile fish lost from brood year 1998 is estimated to result in a loss of approximately 120 to 400 adult fish, assuming juvenile to adult survival rates of 0.3% to 1.0%. The impact of the brood year 1997 early hatchery release as a result of the gas spill can be analyzed by examining the adult return of four year old adult fish in 2001. A run summary was completed using standard methodology (Gauvin and Olson 2002). This summary was finalized after all spring Chinook completed their return in 2001.

Evidence of the increased mortality in the 1997 brood fish is demonstrated by the returns from the group of fish released early due to the spill. The Warm Springs hatchery return of four year old fish to the Deschutes River in 2001 was 4,362 fish. The return in 2000 totaled 9,209 adult size fish, including 9,168 age four fish. The returns in 2001 for Columbia River spring Chinook salmon destined upstream of Bonneville Dam was the highest since records have been kept, due to excellent rearing, outmigrant passage, and ocean conditions for the juveniles, all promoting outstanding survival rates. However, the returns of age four fish to the Deschutes River from Warm Springs hatchery fish released in response to the gasoline spill was half the return observed in 2000. Compared to two other federal hatcheries nearby to Warm Springs hatchery, the returns in 2001 should have been similar to, or larger than that observed in 2000. The table below shows the relative survival rates from the other two federal hatcheries in comparison to Warm Springs hatchery.

Return to the hatchery plus tributary fisheries for three Columbia River spring Chinook programs, including both age four and age five adult size fish.

Hatchery	Year 2000 Return	Year 2001 Return	Factor Increased
Carson (federal)	21,500	25,600	X 1.19
Little White (federal)	11,900	14,300	X 1.20
Warm Springs (federal)	9,209	4,362[1]	X 0.47

[1] Adult return in 2001 includes only age four fish.

Since Warm Springs is a federal hatchery, it is appropriate to compare survival factors from the other two nearby federal hatcheries which also produce spring Chinook salmon. Doing this, the average expected return of adult fish in 2001 would have been 1.2 times higher than the 2000 return or about 11,051 fish (9,209 X 1.2 = 11,051) in 2001 compared to 9,209 in 2000. With an estimated return of 170 five year old fish expected in 2002, the adult return from the 1997 brood year release is calculated at 4,532. This calculates as a loss of 6,519 adult fish (11,051 - 4,532 = 6,519).

Loss to the Fishery and Tribes**:** On average, 40% of the return is harvested with the remaining 60% returning to the hatchery. The recreational portion is typically 75% of the catch and the tribal fishery 25% (Olson et al. 1995). The adults returning to the hatchery are used as brood (630) with the remainder provided to the tribes for ceremonial or subsistence use.

Of the 6,519 calculated adult fish loss from brood year 1997, an estimated 2,608 adult fish would be lost to the fishery. After considering the fishery and survival rates, an additional 3,911 fish could have returned to the hatchery. Fish returning to the hatchery in excess of brood requirements were to be distributed to the tribal ceremonial and subsistence program.

Reduced adult returns associated with the 40,000 1998 brood year juveniles lost during transport result in the loss of additional 48 to 160 fish to the fishery, and 72 to 240 fish to the hatchery.

Tribal and recreational fishery losses are expected to be compensated for over time through increased adult returns resulting from the increased system carrying capacity associated with habitat restoration actions required for juvenile salmonid losses.

Calculation of equivalent juvenile losses.

The estimated loss from the early release is calculated from the difference between actual returns to the hatchery and expected returns. Based on a comparison of 2000 and 2001 returns from other federal hatcheries in the area, the predicted return to the Warm Springs hatchery from the release of 811,570 smolts is 11,051 fish. Overall survival from this release, based on actual and predicted returns, is 4,828 (296 age three jacks in 2000, 4,362 age four adults in 2001, and an estimated 170 age five adults in 2002). The reduction in the expected adult return represents a 56.3% loss of production, representing an equivalent loss of 456,914 smolts in 1999 due to the early release of 1997 brood year smolts.

The equivalent smolt loss associated with the 40,000 1998 brood year juvenile mortality may be estimated by using the expected sub-yearling to smolt survival rate at the hatchery. With a 95% expected survival of subyearlings to smolt stage (personal communication from Doug Olson, U.S. Fish and Wildlife Service), the equivalent loss is 38,000 smolts in 2000.

The total estimated loss as a result of the spill is 494,914 hatchery spring Chinook salmon migrants.

RESOURCE: Wild Spring Chinook

Impacts

The spill resulted in direct impacts to Chinook salmon redds and Chinook salmon yearlings in Beaver Creek, indirect impacts to Chinook salmon yearlings in the lower Warm Springs and Deschutes rivers associated with the release of hatchery fish, indirect impacts to juvenile Chinook salmon due to reduced quality of rearing habitat, and indirect impacts due to loss of production from future generations. The losses affect potential production from the 1997 through 2004 brood years. Since 1986, only wild spring Chinook salmon have been allowed upstream of the Warm Springs National Fish Hatchery (ODFW, 1997), so the fish losses represent a resource of significant value.

Life History Assumptions

Eggs per redd/eggs per female: Average number of eggs/female in the Warm Springs River ranges from 3,360 - 3,647 (mean of 3,470) (Howell et al., 1985)

Egg to migrant survival: Data from 1975 - 1981 show an egg to migrant ranging from 2.3% to 10.0% (mean of 4.81%) (Salmon and Steelhead Production Plan, 1990)

Migrant to adult return: Warm Springs River natural spring Chinook smolt to adult return rates ranged from 1.03% to 5.45% (mean of 3.07%) between 1977 and 1990 (personal communication from Earl Weber, Columbia River Intertribal Fish Commission, 05/19/99). Wild adult spring Chinook salmon return to the Warm Springs River system predominantly as 4-year old fish (77%), and the majority of the return in 2001 will consist of fish outmigrating in 1999. Because of outmigration conditions in 1999, and a favorable ocean rearing environment, a higher than average survival occurred and spring Chinook adult returns in 2001 are at record levels. Given this situation, the highest recorded migrant to adult return rate (5.45%) is used to calculate the loss of adults from juvenile migrants affected in 1999. Mean survival (3.07%) is used for later year classes.

Adult returns: Spring Chinook salmon return to the Warm Springs River as 3, 4, and 5 year old fish. The age composition of returning adults, based on 1975-1995 data (Olson, 1995), was 5% 3-year olds, 77% 4-year olds, and 18% 5-year olds.

Redds. 1998 index area redd counts indicate that 42 Chinook salmon redds were located in Beaver Creek (Stream Net, 1998). Of these, 11 were in the reach most heavily affected by the spill (from above Robinson Park to Dahl Pine). The toxicity of petroleum products to salmonid embryos is dependent upon their developmental stage, with decreasing tolerance from egg to emergent fry (Moles et al., 1979). Chinook emergence in the Warm Springs system begins in mid-March (Howell et al., 1985), so the redds impacted by the spill likely contained late stage alevins. The estimate of potential effects on Chinook redds is based on the extent of benthic macroinvertebrate mortality, and areas where dead fish were recovered. The most severely impacted area appears to extend somewhere between 2.5 and 5.0 km downstream of the spill (Polaris Applied Sciences, Inc. 1999). 100% mortality of Chinook embryos is assumed in the one redd located above Robinson Park. The exact locations of redds in the reach between Robinson Park and Dahl Pine is unknown and based on the assumption of a uniform distribution in the reach, we estimate 100% mortality of Chinook embryos in five of the redds and 50% mortality of Chinook embryos in the remaining five redds. Using the assumptions above, 1,419 potential migrants will be lost, equivalent to a potential loss of 44 returning adult wild Chinook salmon (1998 year class).

<u>Yearlings in Beaver Creek</u>. In the days following the spill, 404 dead juvenile spring Chinook salmon (yearlings) were recovered in the reach immediately downstream of the spill (CTWSRO, 1999). Since the efficiency of collection depends on factors such as timing, stream conditions, flow, how long it takes fish to die, carcass predation, etc., it is generally recognized that carcass recoveries represent only a portion of the fish that die. The observation of distressed fish near the Dahl Pine bridge several hours after the spill, with no fish recoveries from the area later that day (personal communication from Steve Priybl, Oregon Dept. of Fish and Wildlife) is a relevant example. The number of dead fish recovered represents some (unknown) percentage of the number actually killed and is useful primarily as evidence that fish were killed. Production is estimated in the reach to determine the number of fish potentially affected by the spill. In 1997, 37 redds were counted in the reach of Beaver Creek above Dahl Pine (Stream Net, 1998). Using an estimate of 3,470 eggs per redd and a 4.81% egg to migrant survival, 6,176 juveniles were produced in this reach. A percentage of spring Chinook juveniles move downstream in the fall as subyearlings and overwinter in lower river reaches. The percentage that emigrate is dependent on habitat conditions and varies from year to year (Howell et. al., 1985; Fritsch, 1995). Assuming that 50% of the production left during the subyearling migration, 3,088 could have been in the vicinity of the spill in March, 1999. Habitat information for Beaver Creek indicates that higher quality rearing habitat exists in the approximate 8.8 km reach between Beaver Butte and Coyote creeks (NWPPC 1990). Beaver Creek habitat downstream of Coyote Creek is in poor condition and it is more likely than not that juvenile Chinook would have remained in the upstream reach. Based on observations of dead fish and macroinvertebrate mortalities, we estimate that at least half of this higher quality habitat reach was impacted, and that 50% of the fish in the reach may have been killed (1,544 fish). Using a 5.45% smolt to adult return, this represents a potential loss of 84 adult wild Chinook salmon (1997 year class).

<u>Yearlings in the Deschutes River</u>. Fish released from hatcheries may influence premature migratory behavior of wild fish and at Warm Springs Hatchery attempts are made to minimize this possibility by timing releases to overlap with wild salmon and steelhead (Olson et al., 1995).

Steward and Bjornn (1990) cite references indicating that hatchery smolts may Apull@ wild fish with them during their downstream migration. In a study on the Wenatchee River, Hillman and Mullan (1989) documented that wild Chinook salmon aggregated with a release of hatchery Chinook and began drifting downstream, moving into areas that wild fish did not normally use. They also reported that predatory fish appeared to prey preferentially on wild fish within the downstream moving group of hatchery fish (wild fish were smaller than hatchery fingerlings). Displacing wild juvenile Chinook salmon from the system before they are physiolgically prepared to leave, especially during a time when the Columbia River projects are not being operated for safe fish passage, will result in increased mortality. The loss associated with this action is assumed to be at least comparable to that associated with the early release of the hatchery Chinook (50%). In 1997, 362 Chinook redds were counted in the Warm Springs system (Stream Net, 1998). The number of juveniles potentially affected by displacement is the approximate 50% of production (noted in preceding section) that would have migrated downstream into the Deschutes River in the fall of 1998. With eggs per redd and egg to migrant survival above, 60,420 juveniles would have been produced, and 30,210 would be expected to move downstream in the fall of 1998. Lindsay et al. (1989) indicate that fall migrants from the Warm Springs River overwinter in the Deschutes or Columbia River before entering the ocean as yearlings. They also estimated that approximately 52% of the fall migrants from the Warm Springs River survived through winter. With these assumptions, 15,709 juvenile Chinook would have remained to overwinter in freshwater, and may have been affected by the early release of hatchery fish. Assuming a 50% reduction in survival results in the loss of 7,855 juveniles. With an estimated 5.45% smolt to adult return, this represents a loss of 428 adult wild spring Chinook salmon (1997 year class).

<u>Reduced quality of rearing habitat</u>. Data on spawning adult-recruitment, egg-migrant, and migrant-adult relationships suggests some density-dependent survival in the Warm Springs system (Lindsay et al., 1989) indicating that habitat quality may be a limiting factor. Several physical and biological attributes are important for successful juvenile rearing. Aquatic macroinvertebrates are important intermediaries in the utilization of plant material and recycling of nutrients in aquatic environments and are a major food source for fish. Toxic effects on the macroinvertebrate community extended between 2.5 and 5.0 km downstream of the spill (Polaris Applied Sciences, Inc. 1999). Although recolonization of affected sites may begin rapidly, the literature suggests that full recovery may not occur for 24 months (Taylor et al., 1995). Based on the potential habitat limitation resulting from the reduced aquatic macroinvertebrate community, and the potential recovery, we assume a 50% reduction in habitat quality for the first year following the spill. Given that the higher quality rearing habitat in Beaver Creek exists in the approximate 8.8 km reach downstream of Beaver Butte Creek (2.5 to 5.0 km of which is affected by the spill), and that habitat availability may limit survival, we express this reduction in habitat quality as reduced juvenile survival. Survival data are not broken down to enable separate calculations of eggs to fry to parr to migrants. Losses are estimated based on the egg to migrant survival rate, and assumed that losses to a brood year occurred only during the year following spawning. Estimating juvenile production from 1998 brood year redds in this reach not directly

impacted by the spill (50% survival of expected progeny from 5 redds in the Robinson Park to Dahl Pine segment, and 100% survival of expected progeny from 18 redds in the Dahl Pine to Canyon segment, 3,470 eggs per redd, 4.81% egg to migrant survival) results in the potential production of 3,421 juvenile Chinook salmon in the reach in 1999. A 50% reduction in habitat quality, with a consequent 50% reduction in survival results in the loss of 1,711 juvenile Chinook salmon from the 1998 spawning migration. The equivalent adult production losses from the 1998 year class is 53 fish (3.07% smolt to adult return).

Multigeneration effects. The reduced adult returns related to the juvenile losses (609 adults) will result in additional losses through the elimination of migrant production from future generations. Fish populations have the ability to recover from stochastic events provided that the mortality event is below a threshold level for population elimination. Survival in the Warm Springs system appears to be density dependent (i.e. there is an inverse relationship in the number of migrants produced and the subsequent survival to adults) and it is likely that compensatory survival will return the population to an expected baseline within one additional generation. Because only a portion of each year=s return is affected, and we do not carry the loss past one generation, we use a simple linear accumulation of losses for each generation, rather than attempting to quantify multigenerational effects using spawner-recruitment curves developed for the system. Based on the distribution of 3-, 4-, and 5-year old fish, the 609 adults expected to return would be distributed:

Year class	Adult return year			
	2000	2001	2002	2003
1997 (512 adults)	26 (jacks)	394	92	
1998 (97 adults)		5 (jacks)	75	17
Total spawners		394	167	17
Redd loss		131	56	6
migrant loss		21,865	9,346	1,001

Assuming three adult fish per redd (1986 - 1998 average, excluding 1992 count of six per redd) (CTWSR, 1998), and that all of the returning fish spawn, the number of potential redds in the Warm Springs system will be reduced by 131, 56, and 6, in 2001, 2002, and 2003. Using the fecundity and egg-migrant relationships mentioned above, the reduction in spawners over the 3-year period results in a loss of 32,212 migrants.

Summary: Spill-related losses of wild spring Chinook salmon are:

> 1,419 migrants (1998 brood year) due to direct mortality of Chinook alevins in redds (equivalent to 44 adults),
>
> 1,544 migrants (1997 brood year) due to direct mortality of yearlings (equivalent to 84 adults),
>
> 7,855 migrants (1997 brood year) related to indirect mortality of juveniles due to premature displacement (equivalent to 428 adults),
>
> 1,711 migrants (1998 brood year) as a result of degraded habitat quality (equivalent to 53 adults).
>
> 32,212 migrants (2001 - 2003 brood years) as a result of loss of production from future generations.

The total estimated loss as a result of the spill is 44,741 wild spring Chinook salmon migrants.

RESOURCE: Wild Summer Steelhead

Impacts

The spill resulted in direct impacts to summer steelhead juveniles in Beaver Creek, indirect impacts to juvenile steelhead due to reduced quality of rearing habitat, and indirect impacts due to loss of production from future generations. The Warm Springs River is of particular value as a refuge for wild summer steelhead since all hatchery marked or suspected hatchery origin steelhead are not allowed to pass the barrier dam at Warm Springs National Fish Hatchery. Wild steelhead in the Warm Springs system are included in the Middle Columbia ESU, listed as a threatened species under the Endangered Species Act on March 25, 1999 (64 FR 14517).

Juveniles. Juvenile steelhead in the Deschutes River system rear for 1 to 4 years before

migrating to the ocean (ODFW, 1997) and may exist as age 0+, 1+ and 2+ and older fish in Beaver Creek. Partial emigration from tributaries occurs in the spring at age 0 to age 3, with many continuing to rear in the lower Deschutes River before smolting. Outmigration occurs from April through June so it is probable that all age classes were present in Beaver Creek during the spill. Because of the existence of several age classes, the lack of data regarding the numbers of particular age classes that outmigrate and survival from hatch to 1+ or 2+, it is not possible to calculate potential production from prior year redd counts. Surveys following the spill recovered 338 dead juvenile steelhead/rainbow. Using the ratio of actual recoveries to estimated production for juvenile Chinook (404 dead Chinook/3,088 estimated production), and the same habitat assumptions, we assume that the number of dead steelhead collected represented 13% of the fish that were in the stream reach prior to the spill (2,600 juvenile steelhead/rainbow trout). Assuming that 50% of the fish may have been killed results in a loss estimate of 1,300 juvenile steelhead/rainbow trout. Non-anadromous rainbow trout co-occur with steelhead in Beaver Creek. However, the recovered carcasses have not been examined to determine the relative proportions of the populations and we assume the loss represents juvenile steelhead. No age class distribution information has been determined from the carcasses and we assume an even distribution of 0+, 1+, and 2+ fish. The estimated wild smolt to adult survival rate is 6%
(ODFW, 1997). Scale patterns from wild adult steelhead indicate that smolts enter the ocean from age 1 to age 4. With no data to estimate year to year juvenile survival, we assume a linear survival and use 1%, 3%, and 6% (3.33% average) to project juvenile to adult survival for the 0+, 1+, and 2+ juveniles, respectively, and estimate the potential loss of 43 adult fish.

<u>Reduced quality of rearing habitat</u>. There is less information available on steelhead than Chinook salmon but it is assumed that habitat availability also affects survival of juvenile steelhead. Based on the same information used for Chinook salmon, we assume a 50% reduction in habitat quality in the first year following the spill. This reduction in quality is expressed as reduced juvenile survival. The loss estimate is based on the number of steelhead redds expected in Beaver Creek, and assume that the loss occurs during the year of spawning (steelhead fry emerge in early summer) and results in a overall decrease in survival to the smolt stage. Annual steelhead redd counts over the past 10 years in the segments of Beaver Creek between Beaver Butte Creek to Canyon range from 4 (1994) to 45 (1998) (CTWSR, 1998). Wild summer steelhead typically return after 1 or 2 years in the ocean. There is little information regarding age composition except for a sampling conducted in 1971 and 1972 reporting that one- and two-salt fish returned in about equal proportions (Howell et al.,1985). Average fecundity is 4,680 eggs per female for one-salt fish, and 5,930 eggs per female for 2-salt fish (ODFW, 1997).

Using a 10-year average (15) to predict the number of redds in 1999, an equal distribution of one-and two-salt fish, their respective fecundities, a 0.75% egg to smolt survival (ODFW, 1997), and a 50% reduction in survival due to degraded habitat, we estimate a loss of 298 smolts from the 1999 brood year. Based on an estimated wild smolt to adult survival rate of 6%, this results in the projected loss of 18 adults from the 1999 brood year.

<u>Multigeneration effects</u>. To simplify the analysis, we assume that the mixed age classes of juvenile steelhead killed by the spill would emigrate to the ocean in 1999, with the 44 adults that would have been produced returning in 2000 (1-salt) and 2001 (2-salt). Juveniles for the 1999 brood year are assumed to outmigrate the year following spawning, with the 18 adults that would have come from the 1999 brood year returning in 2001 and 2002. Losses are not projected past one generation. Using an equal distribution of one-and two-salt fish, their respective fecundities, a 50:50 male:female ratio, one female per redd, and a 0.75% egg to smolt survival rate (ODFW, 1997), we estimate expected juvenile losses:

	Adult return year		
	2000	2001	2002
brood years 1996, 1997, 1998	22 (1-salt)	21 (2-salt)	
brood year 1999		9 (1-salt)	9 (2-salt)
redds	11	14	4
Eggs	51,480	78,020	23,720
Migrant loss	386	585	178

<u>Summary</u>: Spill-related losses of wild summer steelhead are:

> 1,300 migrants (1996, 1997, 1998 brood years) due to direct mortality in Beaver Creek (equivalent to 43 adults).
>
> 298 migrants (1999 brood year) as a result of degraded habitat quality (equivalent to 18 adults).
>
> 1,149 migrants as a result of loss of production from future generations.

The total estimated loss resulting from the spill is 2,747 wild summer steelhead migrants.

RESTORATION SCALING

CONFIDENTIAL

Anadromous Fishes (wild and hatchery spring Chinook salmon, wild summer steelhead)

The Trustees= proposal for compensating for anadromous fish losses is based on using smolt/migrant production as a metric and determining, through a habitat equivalency analysis (HEA), how much habitat restoration is needed to resolve the natural resource damage liability associated with the spill. HEA equates the losses resulting from the injuries and the amount of restoration necessary to compensate for the losses by using some aspect of the affected environment as a metric. Because of the emphasis on increasing natural production in the Deschutes River subbasin, the Trustees decided to emphasize habitat restoration as the mechanism for compensating anadromous fish losses, for both wild and hatchery fish. HEA is used to adjust the size of restoration actions to ensure that the value of gains associated with a project equals the value of the losses. Compensation requirements are defined as the amount of spawning and rearing habitat restoration necessary to increase smolt/migrant production to a level that equals the losses. While no quantitative mortality estimates were made, the spill resulted in injuries to other aquatic species in Beaver Butte and Beaver creeks (CTWSRO, 1999). Trustees chose anadromous fish smolts/migrant as an indicator of restoration success based on an assumption of a correlation between salmonid habitat vitality and overall ecosystem health, so that as salmonid habitat is restored, other resources will be restored as well.

Production information developed for the Northwest Power Planning Council=s subbasin planning process (NWPPC, 1990) is used to scale restoration projects. A Smolt Density Model was included in the NWPPC process that determined smolt production potential of Columbia River subbasins, using the EPA river reach system, reach length, estimated reach width, the anadromous species presence/absence percentage in the reach, habitat quality evaluation (excellent to poor), and an evaluation of primary anadromous species use. Based on these data and a set of density values for each stock in each production category, a smolt production estimate was calculated. Smolt density estimates (smolts/m^2) used in the model for the species of concern in Beaver Creek are:

Species	Habitat quality (density in smolts/m^2)			
(spawning and rearing)	excellent	good	fair	poor
spring Chinook	0.90	0.64	0.37	0.10
summer steelhead	0.10	0.07	0.05	0.03

Species	Habitat quality (density in smolts/m^2)			

(rearing only)	excellent	good	fair	poor
spring Chinook	0.40	0.27	0.15	0.03
summer steelhead	0.04	0.03	0.02	0.01

It is acknowledged that the NWPPC values are generic smolt density estimates that do not account for differences in carrying capacity among different stream types in the basin, water quality conditions, differences in run sizes, etc. However, no site-specific density data for the Warm Springs River system are available for comparison. For the purpose of restoration scaling, if we can accept that excellent habitat will support twice as many fish as fair habitat(summer steelhead rearing), or that good habitat can support six times as many fish as poor habitat (spring Chinook spawning and rearing), the relative production values provided in the Smolt Density Model are an acceptable assumption.

Information on the Warm Springs River system suggests that anadromous fish production is limited by spawning and rearing habitat quality (Lindsay et al., 1989; Olson et al.; 1995 ODFW, 1997) and potential projects are intended to focus on improving spawning and rearing conditions. Given that some of the problems in the drainage are associated with watershed scale attributes (high water temperature, sedimentation, streamband degradation, gravel quality) habitat improvements are expected to proceed slowly and a 15 year time frame is used for projects to achieve full benefits.

Losses are expressed in smolts/migrants and the restoration plan is based on habitat improvements that compensate for the number of smolts lost. With the nature of the problems, restoration actions such as livestock exclusion fencing, establishing riparian vegetation, protecting streambanks and floodplains, increasing stream canopy, eradicating sediment generating roads, and other types of actions that will promote natural recovery of the ecosystem are preferred over approaches involving instream structures, channel modifications, etc. Compensation requirements are, therefore, calculated in miles of stream for which habitat improvements are necessary, rather than as specific restoration projects.

HEA assumptions are:

Injury year. 1999

Current year. 2003

Compensation projects begin. 2004

Distribution of fish losses (expressed as smolts/migrants).

Chinook steelhead

1999	469,443 (456,914 hatchery, 12,529 wild)	1,598
2000	38,000 (hatchery)	386
2001	21,865 (wild)	585
2002	9,346 (wild)	178
2003	1,001 (wild)	0

Habitat improvement potential. Potential restoration actions are assumed to result in a two step habitat quality increase (e.g. poor to good). Spawning and rearing values from the Smolt Density Model are used (0.27 smolts/m^2 and 0.02 smolts/m^2 increase per step for Chinook and steelhead, respectively).

Time for restoration to achieve full functional value. 15 years.

Creek width. 7.5 meters (based on average Beaver Creek stream width as reported in Fritsch 1995)

Square meters of wetted area per stream mile. 12,070

Using the above assumptions, compensation requirements are 40,915m^2 (5.45 km or 3.38 miles) for spring Chinook salmon and 5,299 m^2 (0.69 km or 0.43 miles) for steelhead. While juvenile steelhead and Chinook do have some differences in habitat requirements, improving overall stream quality will benefit both, so the requirements are not additive and compensation is based on the larger Chinook requirement. Stream segments in the drainage with the potential for improvement, totaling 3.38 miles, will be selected, and restoration actions implemented, including a combination fencing for livestock exclusion, riparian planting, culvert replacement, bank stabilization, etc. that are expected to effect an overall habitat quality improvement. Monitoring will be incorporated to monitor progress and success, and determine the need for corrective action.

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