HABITAT LIMITING FACTORS

YAKIMA RIVER WATERSHED

WATER RESOURCE INVENTORY AREAS 37 - 39

FINAL REPORT

WASHINGTON STATE
CONSERVATION COMMISSION

Donald Haring

December 2001

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ACRONYMS AND ABBREVIATIONS USED IN THIS REPORT

The following list provides a guide to acronyms or abbreviations used in this report:

BPA	Bonneville Power Administration
BOR	U.S. Bureau of Reclamation
CBSP	Columbia Basin Systems Planning (the 1990 Yakima Subbasin Plan)
cfs	cubic feet per second (a measure of water flow)
CWA	Clean Water Act
EF	East Fork
ESA	Endangered Species Act
IFIM	Instream Flow Incremental Methodology
KCCD	Kittitas County Conservation District
KID	Kennewick Irrigation District
KRD	Kittitas Reclamation District
LWD	Large Woody Debris
m	meter
mg/L	milligrams/Liter
mi	mile
mi^2	square miles
MF	Middle Fork
NF	North Fork
NWIFC	Northwest Indian Fisheries Commission
NYCD	North Yakima Conservation District
RM	River Mile
RID	Roza Irrigation District
SASSI	Salmon and Steelhead Stock Inventory
SF	South Fork
SSHIAP	Salmon and Steelhead Habitat Inventory Assessment Project
SSI	Salmonid Stock Inventory
SVID	Sunnyside Valley Irrigation District
TAG	Technical Advisory Group
USFWS	U.S. Fish and Wildlife Service
WDF	Washington Department of Fisheries
WDFW	Washington Department of Fish and Wildlife
WF	West Fork
WRIA	Water Resource Inventory Area
YKFP	Yakima/Klickitat Fisheries Project
YN	Yakama Nation
yr	year

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EXECUTIVE SUMMARY

> *Key physical components of a functioning aquatic ecosystem include complex habitats consisting of floodplains, streambanks, channel structure, and water flows. Habitat complexity is created and maintained by rocks, sediment, large wood, and favorable water quantity and quality. Upland and riparian areas influence aquatic ecosystems by supplying sediment, large wood, and water. Disturbance processes such as landslides and floods are important mechanisms for delivery of wood and bedload to streams. Streams are disturbance dependent systems, and in order to maintain aquatic ecosystems, natural disturbance regimes must be maintained. The natural function of aquatic ecosystems in the Yakima watershed has been affected by intense forest, agricultural, and water management.* (excerpted from USFS 1997)

Section 10 of Engrossed Substitute House Bill 2496 (Salmon Recovery Act of 1998), directs the Washington State Conservation Commission, in consultation with local government and treaty tribes to invite private, federal, state, tribal, and local government personnel with appropriate expertise to convene as a Technical Advisory Group (TAG). The purpose of the TAG is to identify limiting factors for salmonids. Limiting factors are defined as "conditions that limit the ability of habitat to fully sustain populations of salmon, including all species of the family Salmonidae." Although the report is titled as a habitat limiting factors analysis (per the legislation), it is important to note that the charge to the Conservation Commission in ESHB 2496 does not constitute a full limiting factors analysis in the true scientific sense. A full habitat limiting factors analysis would require extensive additional scientific studies for each of the subwatersheds in the Yakima Basin (Water Resource Inventory Areas (WRIA) 37-39 (see location in Figure 1)). Analysis of hatchery, hydro, and harvest impacts would also be part of a comprehensive limiting factors analysis; these elements are not addressed in this report, but are being considered in other forums.

The upper Yakima River watershed originates near the crest of the Cascade Range upstream of Keechelus Lake on Snoqualmie Pass, the Naches River watershed originates near the crest at Chinook and White passes, and the Satus/Toppenish River drainages originate in the Simcoe Mountains east of Mt. Adams (see Figure 1). The Yakima River flows 344 km (214 miles) southeastward from Keechelus Dam to its confluence with the Columbia River at RM 335.2. The Yakima Basin drains an area of 15,900 square km (6,155 square miles) and contains about 3058 km (1,900 river miles) of perennial streams (YSS 2001 DRAFT).

The Yakima Basin was historically one of the primary anadromous salmonid production areas within the Columbia River Basin (Tuck 1993). The Yakima Basin currently supports spring chinook, fall chinook, coho, summer steelhead, bull trout, other resident salmonids, and other non-salmonid fish species. Summer chinook and anadromous sockeye were historically numerous, but have been extirpated from the watershed. Coho were extirpated in the Yakima Basin, but are currently being reintroduced. Known, presumed, and historic/potential distribution of anadromous salmonids and bull trout are shown on the individual species maps included in the separate Maps file included with this report, and supporting data in Appendix A.

The status of identified salmon, steelhead, and bull trout stocks in the Yakima Basin is shown in Table 1. Of the estimated 1,900 miles of perennial streams in the Yakima Basin, anadromous

Figure 1: Location of the Yakima River watershed (WRIAs 37-39) in Washington State

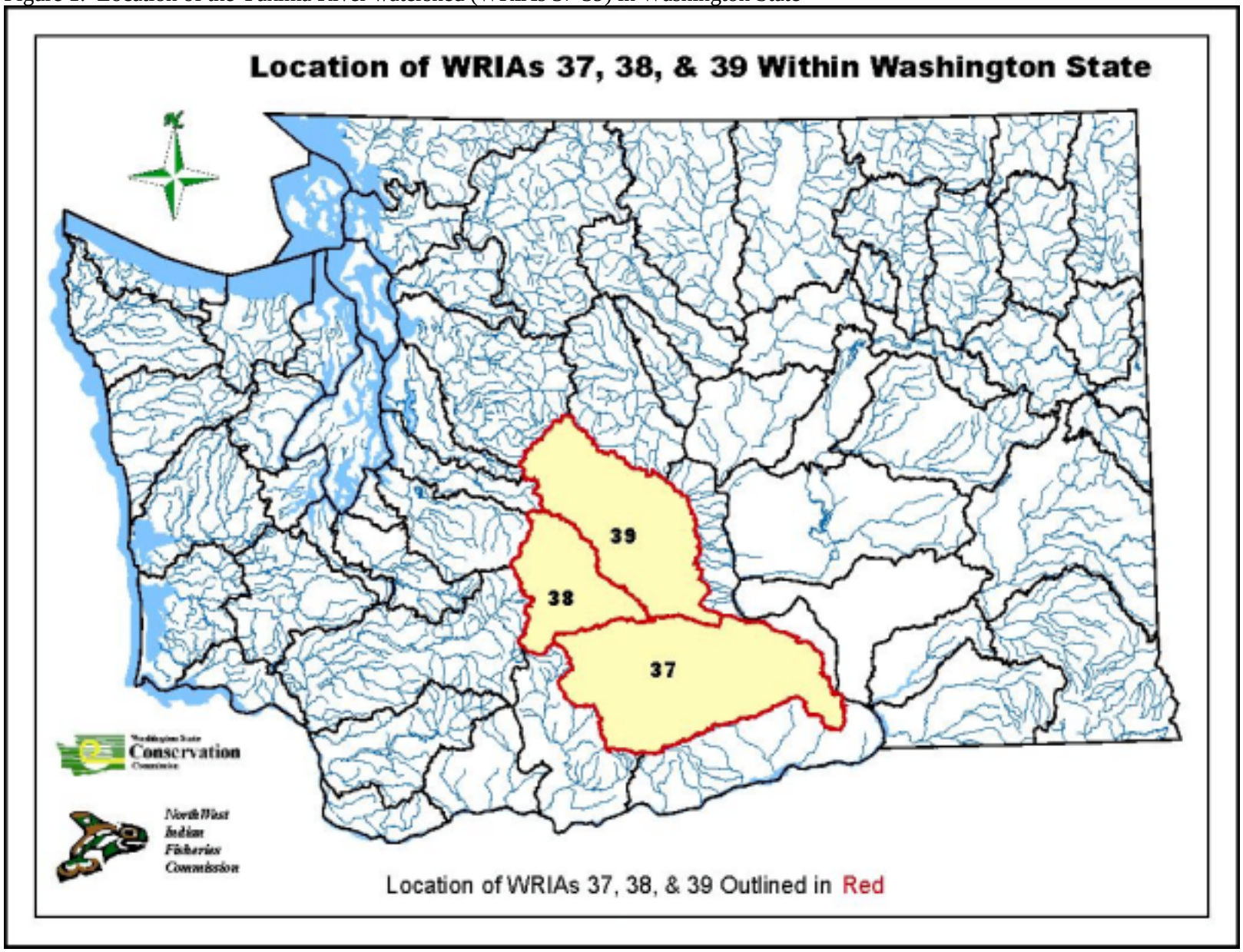


Table 1: Yakima Basin Salmon, Steelhead, and Bull Trout Stock Designations and Associated Status		
Stock	**SASSI Status**	**ESA Listing Status**
Upper Yakima spring chinook, and the stocks	Depressed	Not warranted
Naches spring chinook	Depressed	Not warranted
American River spring chinook	Depressed	Not warranted
Yakima summer chinook	Extirpated	Not recognized
Yakima upriver bright fall chinook	Healthy	Not warranted
Marion Drain fall chinook	Healthy	Not warranted
Yakima sockeye (upper Yakima and Bumping River)	Extirpated	Not recognized
Yakima coho	Extirpated but being reintroduced	Not recognized
Yakima summer steelhead	Depressed	Threatened
Yakima bull trout/dolly varden	Critical	Threatened
Ahtanum Creek bull trout/dolly varden	Critical	Threatened
Naches bull trout/dolly varden	Critical	Threatened
Rimrock Lake bull trout/dolly varden	Healthy	Threatened
Bumping Lake bull trout/dolly varden	Depressed	Threatened
NF Teanaway bull trout/dolly varden	Critical	Threatened
Cle Elum/Waptus lakes bull trout/dolly varden	Unknown	Threatened
Kachess Lake bull trout/dolly varden	Critical	Threatened
Keechelus Lake bull trout/dolly varden	Critical	Threatened

Table 2: Salmonid habitat utilization in the Yakima River watershed (distances in river miles)						
Species	Known Presence	Known/ Presumed Presence	Presumed Presence	Potential/ Historic Presence	Total Current/ Potential/Historic Habitat	Percent of Total Potential/Historic Habitat Currently Occupied
Spring Chinook	467		55	393	915	57%
Fall Chinook	172		42	Unknown	214	Unknown
Coho	335			1017	1352	25%
Summer Steelhead		1024		356	1380	74%

salmonids currently occupy or historically occupied nearly 1,400 miles (Table 2), with additional areas occupied by bull trout. Anadromous salmonids returning to the upper Yakima River (Easton reach) migrate nearly 550 miles from the mouth of the Columbia River upstream to their spawning grounds.

Suitable gradients for salmonids exist in many streams nearly to the headwaters, with suitable gradient extending nearly to the cascade crest in many streams. Vegetative cover in the Yakima Basin ranges from coniferous forest in the upper elevations to shrub-steppe in the lower

watershed; annual precipitation ranges from 80 inches to 140 inches in the upper portions of the watershed to 10 inches or less in the lower watershed (YSS 2001 DRAFT). Peak flows are typically associated with snowmelt runoff in the spring and early summer, although storm related peak flows also are common through the winter months. Natural low flows are common in late-summer/early-fall, although the natural hydrology in many of the streams is profoundly affected by irrigation storage and delivery throughout the watershed.

Of particular note in the Yakima Basin are the scale, extent, and timing of reductions in anadromous salmonid production. Although it seems to be a common view that the dramatic decline in anadromous salmon is the result of fisheries and Columbia River hydropower operations, the declines actually preceded these impacts. Original runs of salmon and steelhead in the Yakima Basin have been estimated at approximately 800,000 retuning adults (Northwest Power Planning Council 1989). By 1900, it is estimated that the number of returning adults had been reduced by 90%, compared to the historic runs (Davidson 1965, as cited in Tuck 1993). The Salmon and steelhead runs continued to decline, and by 1920 only 11,000 adults are estimated to have returned to the Yakima River Basin (BOR 1979, as cited in Tuck 1993), a reduction of >98% of the historic run. The first hydropower dam on the Columbia River that could have adversely affected Yakima River salmon and steelhead was Bonneville Dam, constructed in 1938 (Tuck 1993). Obviously, the dramatic decline occurred prior to hydropower impacts. Other than the screening of one small irrigation diversion on the Naches River in 1928, none of the hundreds of diversions in the Yakima watershed were screened until the Works Progress Administration (WPA) program of 1934-1940, under President Franklin Roosevelt's "New Deal" (Tuck 1995, as cited in YSS 2001 DRAFT). The probability that a smolt could survive emigration from the Yakima River or its tributaries was extremely small, and the bulk of the initial decline can be attributed primarily to smolt entrainment in irrigation diversions (Tuck 1993; Earnest Brannon Sr. 1929, as referred by Easterbrooks). Although the Columbia River commercial fisheries in the late-1800s/early-1900s likely contributed in part to the decline of Yakima River salmon and steelhead, the peak harvest in the Columbia River occurred in 1911, and large harvests continued until 1920 (Craig and Hacker 1940, as cited in Tuck 1993), all well after the observed collapse of adult returns to the Yakima River (90% reductions by 1900, as noted above). The high harvests of the early 1900s appear to have been supported by Columbia River tributary watersheds other than the Yakima. The peak harvest of coho in the lower Columbia River occurred in 1925, by which time only a remnant coho run existed in the Yakima River Basin (Tuck 1993). It is apparent that the collapse of anadromous salmonid production in the Yakima Basin preceded the construction of hydropower dams, and was associated with factors other than harvest, although harvest likely also contributed to some extent.

Salmonid habitat conditions and productivity have been impacted by a variety of land and water use actions in the watershed. These land and water uses contributed to the development of the important agricultural, forestry, and mining industries in the Yakima Basin, but historical watershed modifications were often implemented with little/limited consideration of impacts to salmonid resources. The dramatic decline in salmon and steelhead production in the Yakima Basin is most likely associated with the combination of habitat-related impacts in the late-1800s/early 1900s, including:

- Irrigation development – irrigation diversions were constructed on the mainstem Yakima and many of the tributaries, most of which were constructed without upstream fish passage facilities or downstream juvenile fish screening, and many that dewatered reaches downstream of the diversion
- Construction of irrigation storage reservoirs – dams at the outlets of Keechelus Lake, Kachess Lake, Cle Elum Lake, and Bumping Lake were built without upstream fish passage, precluding access and anadromous salmonid production from approximately 70

miles of highly productive fish habitat upstream of the dams (construction of these dams resulted in extirpation of sockeye in the Yakima Basin); Tieton dam at the outlet to Rimrock Reservoir blocked upstream access to approximately 43 miles of upstream habitat, including inundation of the highly productive historic floodplain complex at McCallister Meadows on the Tieton River

- Splash damming (log drives) – from 1879 through approximately 1915, splash dams were constructed on tributaries in the upper Yakima (Cle Elum and Teanaway rivers), and the channels cleared in order to drive large lografts downriver to lumber mills, resulting in a significant decline in suitable salmonid habitat in those basins.
- Mining – discovery of gold in Swauk Creek in the 1870s led to extensive placer mining that created extensive alteration of the channel, substrate, and banks, and caused extensive turbidity that affected salmonid production in Swauk Creek, and likely downstream in the Yakima River
- Removal of beaver – beaver dams were historically common throughout the watershed; beaver trapping in the mid-1800s resulted in a loss of beaver dams that helped maintain hydrology during dry periods, resulting in an associated loss of valuable juvenile salmonid rearing habitat, and possibly creating additional impairments to upstream fish passage
- Grazing – extensive grazing occurred in the late 1800s, particularly in higher elevation subwatersheds

The largest of these impacts was likely associated with early irrigation development. Adverse habitat impacts associated with transportation development (railroad, highways, roads), urbanization, and other agricultural and logging activities have also occurred in the watershed, but many of these occurred after the period of severe decline in salmonid abundance.

Data included in this report include formal habitat inventories or studies specifically directed at evaluating fish habitat, other watershed data not specifically associated with fish habitat evaluation, and personal experience and observations of the watershed experts that participated in the TAG. The analysis of habitat conditions in the Yakima Basin (WRIAs 37-39) and associated action recommendations is based on these data. Although many of the habitat data/observations in this report may not meet the highest scientific standard of peer reviewed literature, they should nevertheless be considered as valid, as they are based on the collective experience of the watershed experts that are actively working in these drainages. Although there are a significant number of past studies and reports on these watersheds, a large number of salmonid habitat "data gaps" remain, which will require additional specific watershed research or evaluation. The most critical data gap needs are identified in the Data Gaps chapter of this report.

Although some of the historic actions that led to the dramatic decline in salmonid presence in the Yakima Basin have ceased or been reduced, and significant restoration efforts have been implemented to address some of these elements, there are numerous habitat-related problems remaining through the Yakima Basin that continue to limit salmonid productivity potential. These impacts include:

- Fish Access – Adult and juvenile salmonids have been precluded from historic spawning and rearing habitats. Significant progress has been made in providing fish passage and juvenile screening at the major mainstem irrigation diversions, however, there remain a large number of irrigation diversions (primarily on tributaries) and other structures (e.g., culverts, dams) that preclude (either due to the structure or lack of flow downstream) upstream adult and/or juvenile salmonid access, and which may preclude access to suitable habitat downstream of the barrier (e.g, reservoir dams)(historic/potential habitat that is not currently accessible is indicated on the species distribution maps in the

separate Maps file included with this report). The lack of upstream fish passage facilities at the major storage reservoirs has precluded anadromous salmonid presence from approximately 113 miles of highly productive historic habitat (Bumping–12 miles; Rimrock–43 miles; Cle Elum-35 miles; Kachess-14 miles; Keechelus-9 miles). There are ongoing efforts to address upstream fish passage and screening on culvert and irrigation barriers in the tributaries. In addition, access to productive side-channel rearing habitats is precluded by structures that constrict the floodplain or activities that have eliminated previously connected surficial aquifers. Bull trout access to spawning streams is impeded or blocked during periods of drought due to a combination of low stream flows and extreme reservoir drawdown.

- Floodplain Modifications – Salmonid access to productive floodplain side-channel habitats has been lost and the productivity of floodplain areas has been reduced as a result of floodplain constrictions. Natural floodplain function has been impaired through much of the watershed by structures (dikes, levees, roads, railroads) that restrict floodplain extent, by channel incision that disconnects the channel from the floodplain, by extensive mining within the floodplain, and by channelization and construction of drains that eliminate or interrupt hyporheic or surficial side-channel flow.
- Channel Conditions – The loss of channel complexity, cover, bank stability, and presence of pools has adversely affected spawning and rearing habitat. Channel condition and complexity has been dramatically altered through most of the watershed by channelization, loss of large woody debris (LWD) and pools, and by loss of bank stability and channel complexity due to a variety of land use practices.
- Substrate Conditions – Gravel substrate quality has been adversely affected by increased presence of fines (<0.85mm) and loss of suitable gravels; these impacts affect spawning and rearingsuccess and benthic productivity. Gravel substrates are impaired in many areas of the watershed by significant presence of fine sediments, and in other areas by loss of suitable spawning and rearing substrate due to altered hydrology (e.g., Tieton River) and channel simplification. Channel and substrate stability have also been affected by altered hydrology from land uses in the watersheds. The severe reductions in returning adult spawners also has implications to substrate conditions, as spawners have been shown to maintain their own habitat by flushing fine sediments from the gravels as they create redds, and actually maintaining or increasing the wetted perimeter as they spawn on the fringe of the wetted channel.
- Riparian Conditions – Impaired riparian function has resulted in increased water temperature, loss of bank stability, loss of instream cover, and loss of LWD recruitment to streams. Riparian function has been severely impaired through much of the basin by removal of riparian vegetation; by structures (dikes, roads, railroads, etc.) that preclude riparian vegetation growth; by channel incision, drains, and channelization that lower the water table in riparian areas; and by altered hydrology that either dewaters riparian zones or excess flows/altered timing of peak flows that preclude natural regeneration of woody riparian vegetation (e.g., cottonwoods).
- Water Quality – Salmonids require cool, clean water for effective spawning and rearing; cold water temperatures are particularly critical to maintaining bull trout populations. Water temperatures naturally rise in many streams/rivers in the watershed in late-summer, potentially to levels that may impair habitat suitability. Naturally elevated water temperatures may be further exacerbated by human induced impacts, including loss of riparian function, altered hydrology, and increased erosion/fine sediment delivery. Increased water temperatures in the mainstem and many tributaries affect habitat suitability for spawning and rearing, and also increase suitability for predator species that are known to predate on juvenile salmonids. High presence of toxic substances (e.g.,

pesticides) has been detected in sediment and fish tissue samples, particularly in mainstem and tributary areas with agricultural return flows. Significant recent progress has been made in reducing turbidity and associated presence of toxics in irrigation return flows, but beneficial effects to instream habitat and fish health have not yet been assessed.

- Water Quantity – Salmonids require suitable instream flows at specific times of the year for effective spawning, incubation, and rearing; they have adapted over history to the natural flow regime within the Yakima Basin. However, the natural hydrologic regime in the Yakima Basin has been extensively altered by irrigation delivery. Instream flows are eliminated or reduced downstream of irrigation diversions throughout the basin, and during periods where instream flow is reduced to achieve desired irrigation storage, impairing salmonid spawning and rearing. Much higher than normal flows occur in the Yakima and Naches rivers during summer/early-fall, affecting newly-emerged salmonids and riparian regeneration potential. Although the hourly/daily instream flow variation associated with irrigation storage releases has been significantly improved, there is still potential to strand juvenile salmonids in side-channels and pockets on the channel fringe. The flip-flop water management scheme, designed specifically to protect spawning spring chinook in the upper Yakima River (Keechelus-Easton reaches), may have significant unintended consequences to other species and watersheds; review of the implications of this strategy is warranted. In addition, upper Yakima River water is directly conveyed through many streams and drains either for irrigation delivery, or as operational or tailwater spill from the large irrigation canals, resulting in false attraction of adult spawners that would otherwise likely be returning to the upper watershed. False attraction to lower watershed streams is of particular concern, as habitat conditions are typically poor in these streams and resulting production from spawning in these areas is thought to be very low.
- Lakes – The historic large natural glacial lakes, and their associated tributaries, were important contributors to total salmonid production in the Yakima Basin. Anadromous salmonid production has been eliminated from approximately 113 miles (Bumping–12 miles; Rimrock–43 miles; Cle Elum-35 miles; Kachess-14 miles; Keechelus-9 miles) of highly productive habitat upstream of the major storage reservoirs, resulting in the extirpation of anadromous sockeye, and significantly affecting total production of the other anadromous species and bull trout. Water level fluctuation in the major storage reservoirs in the watershed affects the productivity within the reservoir, and potentially in the watershed downstream of the reservoirs. Fluctuating reservoir levels have also resulted in altered characteristics of the delta fan at the mouths of tributaries to the reservoirs, creating fish passage difficulties for adult bull trout and other species attempting to migrate into the tributaries to spawn.
- Biological Processes – The return of marine-derived nutrients (particularly nitrogen and phosphorous) from salmon carcasses provides an important nutrient source to the oligotrophic waters and riparian areas in the higher elevations of the watershed. The loss of marine-derived nutrients, in conjunction with impairment of floodplain, channel, substrate, and riparian functions adversely affects the productivity of aquatic invertebrates that form the base for the freshwater food web. These in turn limit the salmonid production potential of streams within the basin. Surplus hatchery salmon carcasses are being placed in some of the headwater streams to provide an enhanced nutrient base; although this effort does enhance productivity of certain streams, it does not duplicate the distribution and benefits that would be achieved through natural spawning.

Habitat condition has been rated (good, fair, poor, data gap) for each of these habitat elements for mainstem reaches and tributaries in the Yakima Basin, generally using the Habitat Rating

Standards in Appendix C. The habitat condition rating summary is presented in the Assessment of Habitat Limiting Factors chapter.

The most critical habitat concerns (unranked) by WRIA appear to be:

WRIA 37

- Altered hydrograph, resulting in lower flows than normal through the irrigation period; lack of instream flow downstream of Prosser
- High water temperatures and associated high predation rates on juvenile salmonids in the lower Yakima River
- High fine sediment delivery, and associated toxics, primarily from irrigation return flows (significant reductions in fine sediment delivery have been achieved in recent years)
- Fish passage barriers associated with irrigation diversions (particularly in Toppenish and Ahtanum creeks) and lack of screening
- Lack of habitat complexity (little LWD, channel simplification, lack of pools)
- Loss of floodplain function through the Wapato reach and through Yakima-Union Gap
- Impaired riparian function due to land use impacts and altered hydrology that impairs riparian regeneration
- False attraction due to irrigation operational spills and return flows

WRIA 38

- Impaired habitat quality and rearing utilization resulting from altered hydrology effects (from flip-flop) on the Tieton River and lower Naches River
- Impaired instream flow in the reach downstream of the Wapatox diversion dam
- Lack of anadromous fish passage at Tieton and Bumping dams
- Impaired floodplain and riparian function on the Naches River and several tributaries
- Lack of habitat complexity (little LWD, channel simplification, lack of pools)

WRIA 39

- Fish passage barriers (lack of instream flow, lack of fish passage) and lack of screening associated with irrigation diversions, impairing fish passage into suitable habitat in upper portions of tributaries
- Impaired floodplain function on Yakima River and many tributaries
- Altered hydrology, resulting in unnaturally high flows through the irrigation season, and substantially reduced spring runoff in most years
- Impaired riparian function on many tributaries
- Lack of habitat complexity (lack of LWD, channel simplification, lack of pools)
- High fine sediment delivery, and associated toxics, primarily from irrigation return flows (significant reductions in fine sediment delivery have been achieved in recent years)
- Lack of anadromous fish passage at Cle Elum, Keechelus, and Kachess dams

However, the salmonid production potential from the Yakima Basin is not nearly as bleak as the information above might indicate. The watershed has existing production potential, and significant habitat restoration potential. There are still areas with highly productive habitat conditions (e.g., American River, the Keechelus and Easton reaches of the upper Yakima River, etc.), and other areas where high quality habitat exists upstream of existing fish passage barriers (e.g., Ahtanum Creek, Big Creek, etc.). Efforts to provide upstream fish passage and juvenile screening at irrigation diversions, and recent efforts to reduce the delivery of fine sediment from

irrigation return flows have improved spawning access, juvenile salmonid survival, and quality of rearing habitat. Reductions in flow variation over short periods of time downstream of the storage reservoirs and diversion dams has reduced the potential for stranding and associated mortality of juvenile salmonids; however, the potential for stranding and associated mortality still exists. Stream corridor acquisitions and voluntary actions have led to improved channel and riparian condition. These collective efforts, in conjunction with enhancement efforts through the Yakima/Klickitat Fisheries Project, have contributed to significant increases in adult returns in the last few years. These increased returns clearly show the benefits of efforts to date, and should provide incentive to increase habitat protection and restoration efforts throughout the watershed. There is extensive salmonid habitat restoration potential and opportunity remaining. Yakima Basin salmon recovery efforts have achieved excellent benefits to date, but there is much progress still to be achieved.

Prioritized habitat action recommendations are provided for each stream in which salmonid presence has been identified, following the discussion of identified salmonid habitat concerns. Those action recommendations at the top of the list are considered to provide greater restoration benefit potential than those towards the bottom of the list, or those on the top of the list may need to be done first to better ensure the effectiveness of those further down the list. The TAG did not prioritize or rank between watersheds on the basis of salmonid productivity potential resulting from habitat restoration. Cross-watershed prioritization should be addressed through Lead Entity development of salmon restoration strategies for the Yakima Basin. There is general support for the tenets of 1) protect the best remaining habitat, 2) restore those habitat areas that are still functioning, and 3) restore severely impaired non-functioning habitat where feasible. Habitat restoration projects should be reviewed on their own merits, and should be prioritized/ranked on the basis of their anticipated benefit to protecting/restoring salmonid production. Habitat protection/restoration project proposal ranking should consider whether the project addresses the cause of an identified habitat limiting factor, where the habitat need addressed by the project ranks in the prioritized action recommendations list for that stream, how the project complements other protection/restoration actions, and how the project complements identified habitats needing protection. Project ranking should also consider projects where willing landowners and partnerships can increase the effectiveness/efficiency of the restoration project. Habitat conditions vary between different reaches of a stream; restoration proposals should consider the potential benefits of the proposal in relation to habitat conditions likely to be encountered elsewhere in the watershed.

Protection/restoration of salmonid resources cannot be accomplished by watershed habitat restoration projects alone. It is unlikely that we will be able to resolve the salmon predicament using the same land management approaches that got us into it. We will need to look at the watershed with a clear new vision. Salmonid recovery will require a combination of efforts, including:

- land use regulations alone will not be effective, habitat restoration and resource protection will also require landowner commitment, participation, and stewardship
- revision, implementation, and enforcement of land use ordinances that provide protection for natural ecological processes in the instream, and riparian corridors
- protection of instream and riparian habitat that is currently functioning, particularly key habitat areas, and
- restoration of natural instream and riparian ecological processes where they have been impaired.

This report represents a “snapshot-in-time” portrayal of salmonid habitat conditions. This information can and should be used by the Lead Entity (HB2496) and the Watershed Planning Unit (HB 2514) in the development of salmonid habitat protection and restoration strategies. It should be considered a living document, updated periodically with additional habitat assessment data and habitat restoration successes, as information becomes available.

BACKGROUND

The successful recovery of naturally spawning salmon populations depends upon directing actions simultaneously at harvest, hatcheries, habitat and hydroelectric dams, the 4-H's. The 1998 state Legislature produced a number of bills aimed at salmon recovery. Engrossed Substitute House Bill (ESHB) 2496 is a key piece of the Legislature's salmon recovery effort, with the focus directed at salmon habitat issues.

Engrossed Substitute House Bill (ESHB) 2496 in part:

- directs the Conservation Commission in consultation with local government and the tribes to invite private, federal, state, tribal and local government personnel with appropriate expertise to act as a technical advisory group;
- directs the technical advisory group to identify limiting factors for salmonids;
- defines limiting factors as "conditions that limit the ability of habitat to fully sustain populations of salmon;"
- defines salmon as all members of the family salmonidae, which are capable of self-sustaining, natural production.

The overall goal of the Conservation Commission's limiting factors project is to identify habitat factors limiting production of salmon in the state. In waters shared by salmon, steelhead, and bull trout, the report will include all three.

It is important to note that the responsibilities given to the Conservation Commission in ESHB 2496 do not constitute a full limiting factors analysis. The hatchery, hydropower, and harvest limiting factors are being dealt with in other forums.

THE RELATIVE ROLE OF HABITAT IN HEALTHY POPULATIONS OF NATURAL SPAWNING SALMON

(Chapter Author – Carol Smith, PHD)

During the last 10,000 years, Washington State anadromous salmonid populations have evolved in their specific habitats (Miller 1965). Water chemistry, flow, and the physical stream components unique to each stream have helped shaped the characteristics of every salmon population. These unique physical attributes have resulted in a wide variety of distinct salmon stocks for each salmon species throughout the State. Within a given species, stocks are population units that do not extensively interbreed because returning adults rely on a stream's unique chemical and physical characteristics to guide them to their natal grounds to spawn. This maintains the separation of stocks during reproduction, thus preserving the distinctiveness of each stock.

Throughout the salmon's life cycle, the dependence between the stream and a stock continues. Adults spawn in areas near their own origin because survival favors those that do. The timing of juveniles leaving the river and entering the estuary is tied to high natural river flows. It has been theorized that the faster speed during out-migration reduces predation on the young salmon and perhaps is coincident to favorable feeding conditions in the estuary (Wetherall 1971). These are a few examples that illustrate how a salmon stock and its environment are intertwined throughout the entire life cycle.

Salmon habitat includes the physical, chemical and biological components of the environment that support salmon. Within freshwater and estuarine environments, these components include water quality, water quantity or flows, stream and river physical features, riparian zones, upland terrestrial conditions, and ecosystem interactions as they pertain to habitat. However, these components closely intertwine. Low stream flows can alter water quality by increasing temperatures and decreasing the amount of available dissolved oxygen, while concentrating toxic materials. Water quality can impact stream conditions through heavy sediment loads, which result in a corresponding increase in channel instability and decrease in spawning success. The riparian zone interacts with the stream environment, providing nutrients and a food web base, woody debris for habitat and flow control (stream features), filtering runoff prior to surface water entry (water quality), and providing shade to aid in water temperature control.

Salmon habitat includes clean, cool, well-oxygenated water flowing at a normal (natural) rate for all stages of freshwater life. In addition, salmon survival depends upon specific habitat needs for egg incubation, juvenile rearing, migration of juveniles to saltwater, estuary rearing, ocean rearing, adult migration to spawning areas, and spawning. These specific needs can vary by species and even by stock.

When adults return to spawn, they not only need adequate flows and water quality, but also unimpeded passage to their natal grounds. They need deep pools with vegetative cover and instream structures such as root wads for resting and shelter from predators. Successful spawning and incubation depend on sufficient gravel of the right size for that particular population, in addition to the constant need of adequate flows and water quality, all in unison at the necessary location. Also, delayed upstream migration can be critical. After entering freshwater, most salmon have a limited time to migrate and spawn, in some cases, as little as 2-3 weeks. Delays can results in pre-spawning mortality, or spawning in a sub-optimum location.

After spawning, the eggs need stable gravel that is not choked with sediment. River channel stability is vital at this life history stage. Floods have their greatest impact to salmon populations during incubation, and flood impacts are worsened by human activities. In a natural river system, the upland areas are forested, and the trees and their roots store precipitation, which slows the rate of storm water into the stream. The natural, healthy river is sinuous and contains large pieces of wood contributed by an intact,

mature riparian zone. Both slow the speed of water downstream. Natural systems have floodplains that are connected directly to the river at many points, allowing wetlands to store flood water and later discharge this storage back to the river during lower flows. In a healthy river, erosion or sediment input is great enough to provide new gravel for spawning and incubation, but does not overwhelm the system, raising the riverbed and increasing channel instability. A stable incubation environment is essential for salmon, but is a complex function of nearly all habitat components contained within that river ecosystem.

Once the young fry emerge from the gravel nests, certain species such as chum, pink, and some chinook salmon quickly migrate downstream to the estuary. Other species, such as coho, steelhead, bulltrout, and chinook, will search for suitable rearing habitat within the side sloughs and channels, tributaries, and spring-fed "seep" areas, as well as the outer edges of the stream. These quiet-water side margin and off channel slough areas are vital for early juvenile habitat. The presence of woody debris and overhead cover aid in food and nutrient inputs as well as provide protection from predators. For most of these species, juveniles use this type of habitat in the spring. Most sockeye populations migrate from their gravel nests quickly to larger lake environments where they have unique habitat requirements. These include water quality sufficient to produce the necessary complex food web to support one to three years of salmon growth in that lake habitat prior to outmigration to the estuary.

As growth continues, the juvenile salmon (parr) move away from the quiet shallow areas to deeper, faster areas of the stream. These include coho, steelhead, bulltrout, and certain chinook. For some of these species, this movement is coincident with the summer low flows. Low flows constrain salmon production for stocks that rear within the stream. In non-glacial streams, summer flows are maintained by precipitation, connectivity to wetland discharges, and groundwater inputs. Reductions in these inputs will reduce that amount of habitat; hence the number of salmon dependent on adequate summer flows.

In the fall, juvenile salmon that remain in freshwater begin to move out of the mainstems, and again, off-channel habitat becomes important. During the winter, coho, steelhead, bulltrout, and remaining chinook parr require habitat to sustain their growth and protect them from predators and winter flows. Wetlands, stream habitat protected from the effects of high flows, and pools with overhead are important habitat components during this time.

Except for bulltrout and resident steelhead, juvenile parr convert to smolts as they migrate downstream towards the estuary. Again, flows are critical, and food and shelter are necessary. The natural flow regime in each river is unique, and has shaped the population's characteristics through adaptation over the last 10,000 years. Because of the close inter-relationship between a salmon stock and its stream, survival of the stock depends heavily on natural flow patterns.

The estuary provides an ideal area for rapid growth, and some salmon species are heavily dependent on estuaries, particularly chinook, chum, and to a lesser extent, pink salmon. Estuaries contain new food sources to support the rapid growth of salmon smolts, but adequate natural habitat must exist to support the detritus-based food web, such as eelgrass beds, mudflats, and salt marshes. Also, the processes that contribute nutrients and woody debris to these environments must be maintained to provide cover from predators and to sustain the food web. Common disruptions to these habitats include dikes, bulkheads, dredging and filling activities, pollution, and alteration of downstream components such as lack of woody debris and sediment transport.

All salmonid species need adequate flow and water quality, spawning riffles and pools, a functional riparian zone, and upland conditions that favor stability, but some of these specific needs vary by species, such as preferred spawning areas and gravel. Although some overlap occurs, different salmon species within a river are often staggered in their use of a particular type of habitat. Some are staggered in time, and others are separated by distance.

Chum and pink salmon use the streams the least amount of time. Washington adult pink salmon typically begin to enter the rivers in August and spawn in September and October, although Dungeness summer pinks enter and spawn a month earlier (WDFW and WWTIT 1994). During these times, low flows and associated high temperatures and low dissolved oxygen can be problems. Other disrupted habitat components, such as less frequent and shallow pools from sediment inputs and lack of canopy from an altered riparian zone or widened river channel, can worsen these flow and water quality problems because there are fewer refuges for the adults to hold prior to spawning.

Pink salmon fry emerge from their gravel nests around March and migrate downstream to the estuary within a month. After a limited rearing time in the estuary, pink salmon migrate to the ocean for a little over a year, until the next spawning cycle. Most pink salmon stocks in Washington return to the rivers only in odd years. The exception is the Snohomish Basin, which supports both even- and odd-year pink salmon stocks.

In Washington, adult chum salmon (3-5 years old) have three major run types. Summer chum adults enter the rivers in August and September, and spawn in September and October. Fall chum adults enter the rivers in late October through November, and spawn in November and December. Winter chum adults enter from December through January and spawn from January through February. Chum salmon fry emerge from the nests in March and April, and quickly outmigrate to the estuary for rearing. In the estuary, juvenile chum follow prey availability. In Hood Canal, juveniles that arrive in the estuary in February and March migrate rapidly offshore. This migration rate decreases in May and June as levels of zooplankton increase. Later as the food supply dwindles, chum move offshore and switch diets (Simenstad and Salo 1982). Both chum and pink salmon have similar habitat needs such as unimpeded access to spawning habitat, a stable incubation environment, favorable downstream migration conditions (adequate flows in the spring), and because they rely heavily on the estuary for growth, good estuary habitat is essential.

Chinook salmon have three major run types in Washington State. Spring chinook are generally in their natal rivers throughout the calendar year. Adults begin river entry as early as February in the Chehalis, but in Puget Sound, entry doesn't begin until April or May. Spring chinook spawn from July through September and typically spawn in the headwater areas where higher gradient habitat exists. Incubation continues throughout the autumn and winter, and generally requires more time for the eggs to develop into fry because of the colder temperatures in the headwater areas. Fry begin to leave the gravel nests in February through early March. After a short rearing period in the shallow side margins and sloughs, all Puget Sound and coastal spring chinook stocks have juveniles that begin to leave the rivers to the estuary throughout spring and into summer (August). Within a given Puget Sound stock, it is not uncommon for other chinook juveniles to remain in the river for another year before leaving as yearlings, so that a wide variety of outmigration strategies are used by these stocks. Spring chinook salmon juveniles in the Columbia Basin exhibit some distinct life history characteristics. Generally, these stocks remain in the basin for a full year. However, some stocks migrate downstream from their natal tributaries in the fall and early winter into larger rivers, including the Columbia River, where they are believed to over-winter prior to outmigration the next spring as yearling smolts.

Adult summer chinook begin river entry as early as June in the Columbia, but not until August in Puget Sound. They generally spawn in September and/or October. Fall chinook stocks range in spawn timing from late September through December. All Washington summer and fall chinook stocks have juveniles that incubate in the gravel until January through early March, and outmigration downstream to the estuaries occurs over a broad time period (January through August). A few of these stocks have a component of juveniles that remain in freshwater for a full year after emerging from the gravel nests.

While some emerging chinook salmon fry outmigrate quickly, most inhabit the shallow side margins and side sloughs for up to two months. Then, some gradually move into the faster water areas of the stream to rear, while others outmigrate to the estuary. Most summer and fall chinook outmigrate within their first year of life, but a few stocks (Snohomish summer chinook, Snohomish fall chinook, and upper Columbia summer chinook) have juveniles that remain in the river for an additional year, similar to many spring chinook (Marshall et al. 1995). However, those in the upper Columbia, have scale patterns that suggest that they rear in a reservoir-like environment (mainstem Columbia upstream from a dam) rather than in their natal streams and it is unknown whether this is a result of dam influence or whether it is a natural pattern.

The onset of coho salmon spawning is tied to the first significant fall freshet. They typically enter freshwater from September to early December, but has been observed as early as late July and as late as mid-January (WDF et al. 1993). They often mill near the river mouths or in lower river pools until freshets occur. Spawning usually occurs between November and early February, but is sometimes as early as mid-October and can extend into March. Spawning typically occurs in tributaries and sedimentation in these tributaries can be a problem, suffocating eggs. As chinook salmon fry exit the shallow low-velocity rearing areas, coho fry enter the same areas for the same purpose. As they grow, juveniles move into faster water and disperse into tributaries and areas which adults cannot access (Neave 1949). Pool habitat is important not only for returning adults, but for all stages of juvenile development. Preferred pool habitat includes deep pools with riparian cover and woody debris.

All coho juveniles remain in the river for a full year after leaving the gravel nests, but during the summer after early rearing, low flows can lead to problems such as a physical reduction of available habitat, increased stranding, decreased dissolved oxygen, increased temperature, and increased predation. Juvenile coho are highly territorial and can occupy the same area for a long period of time (Hoar 1958). The abundance of coho can be limited by the number of suitable territories available (Larkin 1977). Streams with more structure (logs, undercut banks, etc.) support more coho (Scrivener and Andersen 1982), not only because they provide more territories (useable habitat), but they also provide more food and cover. There is a positive correlation between their primary diet of insect material in stomachs and the extent the stream was overgrown with vegetation (Chapman 1965). In addition, the leaf litter in the fall contributes to aquatic insect production (Meehan et al. 1977).

In the autumn as the temperatures decrease, juvenile coho move into deeper pools, hide under logs, tree roots, and undercut banks (Hartman 1965). The fall freshets redistribute them (Scarlett and Cederholm 1984), and over-wintering generally occurs in available side channels, spring-fed ponds, and other off-channel sites to avoid winter floods (Peterson 1980). The lack of side channels and small tributaries may limit coho survival (Cederholm and Scarlett 1981). As coho juveniles grow into yearlings, they become more predatory on other salmonids. Coho begin to leave the river a full year after emerging from their gravel nests with the peak outmigration occurring in early May. Coho use estuaries primarily for interim food while they adjust physiologically to saltwater.

Sockeye salmon have a wide variety of life history patterns, including landlocked populations of kokanee, which never enter saltwater. Of the populations that migrate to sea, adult freshwater entry varies from spring for the Quinault stock, summer for Ozette, to summer for Columbia River stocks, and summer and fall for Puget Sound stocks. Spawning ranges from September through February, depending on the stock.

After fry emerge from the gravel, most migrate to a lake for rearing, although some types of fry migrate to the sea. Lake rearing ranges from 1-3 years. In the spring after lake rearing is completed, juveniles enter the ocean where more growth occurs prior to adult return for spawning.

Sockeye spawning habitat varies widely. Some populations spawn in rivers (Cedar River) while other populations spawn along the beaches of their natal lake (Ozette), typically in areas of upwelling groundwater. Sockeye also spawn in side channels and spring-fed ponds. The spawning beaches along lakes provide a unique habitat that is often altered by human activities, such as pier and dock construction, dredging, and weed control.

Steelhead have the most complex life history patterns of any Pacific salmonid species (Shapovalov and Taft 1954). In Washington, there are two major run types, winter and summer steelhead. Winter steelhead adults begin river entry in a mature reproductive state in December and generally spawn from February through May. Summer steelhead adults enter the river from about May through October with spawning from about February through April. They enter the river in an immature state and require several months to mature (Burgner et al 1992). Summer steelhead usually spawn farther upstream than winter stocks (Withler 1966) and dominate inland areas such as the Columbia Basin. However, the coastal streams support more winter steelhead populations.

Juvenile steelhead can either migrate to sea or remain in freshwater as rainbow or redband trout. In Washington, those that are anadromous usually spend 1-3 years in freshwater, with the greatest proportion spending two years (Busby et al. 1996). Because of this, steelhead rely heavily on the freshwater habitat and are present in streams all year long.

Bulltrout/Dolly Varden stocks are also very dependent on the freshwater environment, where they reproduce only in clean, cold, relatively pristine streams. Within a given stock, some adults remain in freshwater their entire lives, while others migrate to the estuary where they stay during the spring and summer. They then return upstream to spawn in late summer. Those that remain in freshwater either stay near their spawning areas as residents, or migrate upstream throughout the winter, spring, and early summer, residing in pools. They return to spawning areas in late summer. In some stocks juveniles migrate downstream in spring, over-winter in the lower river, then enter the estuary and Puget Sound the following late winter to early spring (WDFW 1998). Because these life history types have different habitat characteristics and requirements, bulltrout are generally recognized as a sensitive species by natural resource management agencies. Reductions in their abundance or distribution are inferred to represent strong evidence of habitat degradation.

In addition to the above-described relationships between various salmon species and their habitats, there are also interactions between the species that have evolved over the last 10,000 years such that the survival of one species might be enhanced or impacted by the presence of another. Pink and chum salmon fry are frequently food items of coho smolts, Dolly Varden char, and steelhead (Hunter 1959). Chum fry have decreased feeding and growth rates when pink salmon juveniles are abundant (Ivankov and Andreyev 1971), probably the result of occupying the same habitat at the same time (competition). These are just a few examples.

Most streams in Washington are home to several salmonid species, which together, rely upon freshwater and estuary habitat the entire calendar year. As the habitat and salmon review indicated, there are complex interactions between different habitat components, between salmon and their habitat, and between different species of salmon. For just as habitat dictates salmon types and production, salmon contribute to habitat and to other species.

INTRODUCTION

The quantity and quality of aquatic habitat present in any stream, river, lake or estuary is a reflection of the existing physical habitat characteristics (e.g. depth, structure, gradient, etc) as well as the water quality (e.g. temperature and suspended sediment load). There are a number of processes that create and maintain these features of aquatic habitat. In general, the key processes regulating the condition of aquatic habitats are the delivery and routing of water (and its associated constituents such as nutrients), sediment, and large woody debris (LWD). These processes operate over the terrestrial and aquatic landscape. For example, climatic conditions operating over very large scales can drive many habitat forming processes while the position of a fish in the stream channel can depend upon delivery of wood from forest adjacent to the stream. In addition, ecological processes operate at various spatial and temporal scales and have components that are lateral (e.g., floodplain), longitudinal (e.g., landslides in upstream areas) and vertical (e.g., riparian forest).

The effect of each process on habitat characteristics is a function of variations in local geomorphology, climatic gradients, spatial and temporal scales of natural disturbance, and terrestrial and aquatic vegetation. For example, wood is a more critical component of stream habitat than in lakes, where it is primarily an element of littoral habitats. In stream systems, the routing of water is primarily via the stream channel and subsurface routes whereas in lakes, water is routed by circulation patterns resulting from inflow, outflow and climatic conditions.

Human activities degrade and eliminate aquatic habitats by altering the key natural processes described above. This can occur by disrupting the lateral, longitudinal, and vertical connections of system components as well as altering spatial and temporal variability of the components. In addition, humans have further altered habitats by creating new processes such as the actions of exotic species. The following sections identify and describe the major alterations of aquatic habitat that have occurred and why they have occurred. These alterations are discussed as limiting factors.

Discussion of Habitat Limiting Factor Elements

Fish Passage Barriers

Salmon are limited to certain spawning and rearing locations by natural features of the landscape. These features include channel gradient and the presence of physical features of the landscape (e.g. logjams). Flow can affect the ability of some landscape features to function as barriers. For example, some falls may be impassable at low flows, but then become passable at higher flows. In some cases flows themselves can present a barrier, such as when extreme low flows occur in some channels; at higher flows fish are not blocked. Flow conditions may also allow accessibility to some anadromous salmonid species, while precluding access to others.

Throughout Washington, barriers have been constructed that have restricted or prevented juvenile and adult fish from gaining access to formerly accessible habitat. The most obvious of these barriers are dams and diversions with no passage facilities that prevent adult salmon from accessing historically used spawning grounds. Culverts are often full or partial fish passage barriers; delayed fish passage during certain flow conditions can be equally as detrimental as a total fish passage barrier. In addition, in recent years it has become increasingly clear that we have also constructed barriers that prevent juveniles from accessing rearing habitat. For example, dikes and levees have blocked off historically accessible side-channel rearing areas, and poorly designed culverts in streams have impacted the ability of juvenile salmonids to move upstream into rearing areas.

Within the Yakima River watershed, there are five major storage reservoirs and hundreds of surface water diversions. These diversions create a variety of migration barriers to anadromous and resident salmonids. As noted above, most of the diversions include a dam that blocks and ponds stream flow. Although many of the diversions have been fitted with upstream fish passage facilities, few of the diversions had fish passage from their initial construction (late 1800s, early 1900s) until construction of fish passage beginning in the mid-1900s. The major reservoirs and many of the smaller diversions still do not have upstream fish passage. In addition, all or most of the instream flow is diverted from the channel at many diversions, eliminating or severely reducing instream flow downstream of the diversion, resulting in a barrier to upstream/downstream passage or impaired passage conditions. Water diversions can also entrain downstream-migrating juvenile salmonids. These fish are then routed into irrigation delivery canals, where they perish. This is of particular concern in watersheds with extensive irrigation, such as the Yakima. Although there were some limited efforts to screen some diversions in the early 1900s, significant screening of water diversions did not occur until the 1950s-1960s, and revision of screening criteria to current standards did not occur until the 1990s. Although almost all of the major diversions are now screened, there are hundreds of smaller water diversions on the tributaries that have yet to be screened.

Functions of Floodplains

Floodplains are portions of a watershed that are periodically flooded by the lateral overflow of rivers and streams. In general, most floodplain areas are located in lowland areas of river basins and are associated with higher order streams. Floodplains are typically structurally complex, and are characterized by a great deal of lateral, aquatic connectivity by way of distributaries, sloughs, backwaters, side-channels, oxbows, and lakes. Often, floodplain channels can be highly braided (multiple parallel channels).

One of the functions of floodplains is to provide aquatic habitat. Aquatic habitats in floodplain areas can be very important for some species and life stages such as spring chinook and coho salmon juveniles that often use the sloughs and backwaters of floodplains to over-winter since this provides a refuge from high flows. Floodplains also help dissipate water energy during floods by allowing water to escape the channel and inundate the terrestrial landscape, lessening the impact of floods on incubating salmon eggs. Floodplains also provide coarse beds of alluvial sediments through which subsurface flow passes. This acts as a filter of nutrients and other chemicals to maintain high water quality. Floodplains also provide an area for sediment deposition and storage, particularly for fine sediment, outside of the river channel, reducing the effects of sediment deposition and instability in the river channel.

Impairment of Floodplains by Human Activities

Large portions of the floodplains of many Washington rivers, especially those in the western part of the state, have been converted to urban and agricultural land uses. Much of the urban areas of the state are located in lowland floodplains, while land used for agricultural purposes is often located in floodplains because of the flat topography and rich soils deposited by the flooding rivers.

There are two major types of human impacts to floodplain functions. First, channels are disconnected from their floodplain. This occurs both laterally as a result of the construction of dikes and levees, which often occur simultaneously with the construction of roads, and longitudinally as a result of the construction of road crossings. This has: 1) eliminated off-channel habitats such as sloughs and side channels; 2) increased flow velocity during flood events due to the constriction of the channel; 3) reduced subsurface flows and groundwater contribution to the stream; and 4) simplified channels since LWD is lost and channels are often straightened when levees are constructed. Channels can also become

disconnected from their floodplains as a result of down-cutting and incision of the channel from losses of LWD, decreased sediment supplies, and increased high flow events.

The second major type of impact is loss of natural riparian and upland vegetation. Natural riparian vegetation in floodplain areas in the Yakima River watershed ranged from coniferous forest at the higher/wetter elevations, to cottonwoods/willows with fewer coniferous trees in the mid-elevation watersheds, to willows/shrubs in the lower/drier elevations of the watershed. Conversion of coniferous riparian forests to deciduous trees, and conversion of wooded riparian areas to impervious surfaces, meadows, grasslands, and farmed fields has occurred as floodplains have been converted to urban and agricultural uses. Riparian forests are typically reduced or eliminated as levees and dikes are constructed. Loss of vegetation on the floodplain reduces shading of water in floodplain channels, eliminates LWD contribution, reduces filtering of sediments, nutrients and toxics, and results in increased water energy and loss of bank stability during flood flows.

Elimination of off-channel habitats results in the loss of important habitats for juvenile salmonids. Sloughs and backwaters that are protected from flood flow impacts function as prime spawning habitat for chum, pink, and coho, and rearing and over-wintering habitat for spring chinook and coho juveniles. The loss of LWD from channels reduces the amount of rearing habitat available for chinook juveniles. Disconnection of the stream channels from their floodplain due to levee and dike construction increases water velocities, which in turn increases scour of the streambed. Salmon that spawn in these areas may have reduced egg to fry survival due to the scour. Removal of mature native vegetation from riparian zones can increase stream temperatures in channels, which can stress both adult and juvenile salmon. Sufficiently high temperatures can increase mortality.

Streambed Sediment

The sediments present in an ecologically healthy stream channel are naturally dynamic and are a function of a number of processes that input, store, and transport the materials. Processes naturally vary spatially and temporally and depend upon a number of features of the landscape such as stream order, gradient, stream size, basin size, geomorphic context, and hydrological regime. In forested mountain basins, sediment enters stream channels from natural mass wasting events (e.g. landslides and debris flows), channel bank erosion (particularly in glacial deposits), surface erosion, and soil creep. Natural input of sediment to stream channels in these types of basins occurs periodically during extreme climatic events such as floods (increasing erosion) and mass wasting. In lowland, or higher order streams, lateral erosion is the major natural sediment source. Inputs of sediment in these basins tend to be steadier in geologic time.

Once sediment enters a stream channel it can be stored or transported depending upon particle size, stream gradient, hydrological conditions, availability of storage sites, and channel type or morphology. Finer sediments tend to be transported through the system as wash load or suspended load, and have relatively little effect on channel morphology. Coarser sediments (>2 mm diameter) tend to travel as bedload, and can have larger effects on channel morphology as they move downstream, depositing through the channel network.

Some parts of the channel network are more effective at storing sediment, while other parts of the network are more effective at transporting material. There are also strong temporal components to sediment storage and transport, such as seasonal floods, which tend to transport more material. One channel segment may function as a storage site during one time of year and a transport reach at other times. In general, the coarsest sediments are found in upper watersheds while the finest materials are found in the lower reaches of a watershed. Storage sites include various types of channel bars, floodplain areas, and associated with LWD.

Effects of Human Actions on Sediment Processes

Changes in the supply, transport, and storage of sediments can occur as the direct result of human activities. Human actions can result in increases or decreases in the supply of sediments to a stream. Increases in sediment deposition in the channel result from increased erosion due to land use practices or isolation of the channel from the floodplain (due to presence of dikes or roads), eliminating important off-channel storage areas for sediment and increasing the sediment load beyond the transport capacity of the stream. In addition, actions that destabilize the landscape in high slope areas such as logging or road construction increase the frequency and severity of mass wasting events. Finally, increases in the frequency and magnitude of flood flows, and/or loss of floodplain vegetation, increase erosion. Increased erosion fills pools and aggrades the channel, resulting in reduced habitat complexity and reduced rearing capacity for some salmonids. Increased total sediment supply to a channel increases the proportion of fine sediments in the bed, which can reduce the survival of incubating eggs in the gravel and change benthic invertebrate production.

Decreases in sediment supply occur in some streams, primarily as a result of disconnecting the channel from the floodplain. Dams typically block the supply of sediment from upper watershed areas while levees typically isolate the stream from natural upland sources of sediment. In addition, gravels are removed from streambeds to increase flow capacity (dredging) or for mineral extraction purposes. Reduction in sediment supply can alter the streambed composition, which can coarsen the substrate and reduce the amount of gravel substrate suitable for spawning.

In addition to affecting sediment supply, human activities can also affect the storage and movement of sediment in a stream. An understanding of how sediment moves through a system is important for determining where sediment will have the greatest effect on salmonid habitat and for determining which areas will have the greatest likelihood of altering habitats. In general, transport of sediment changes as a result of gradient, hydrology changes (water removal, increased peak flows, or altered timing and magnitude of peak flows), and isolation of the channel from its floodplain. This increases in the magnitude and frequency of flood flows. Larger and more frequent flood flows move larger and greater amounts of material more frequently. This can increase bed scour and bank erosion, alter channel morphology, and ultimately degrade the quality of spawning and rearing habitat. Unstable channels become very dynamic and unpredictable compared to the relatively stable channels characteristic of undeveloped areas. Additional reductions in the levels of instream LWD can greatly alter sediment storage and processing patterns, resulting in increased levels of fines in gravels and reduced organic material storage and nutrient cycling.

Riparian Zone Functions

Stream riparian zones include the area of living and dead vegetative material adjacent to a stream. They extend from the edge of the ordinary high water mark of the wetted channel, upland to a point where the zone ceases to have an influence on the stream channel. Riparian forest characteristics in ecologically healthy watersheds are strongly influenced by climate, channel geomorphology, and where the channel is located in the drainage network. Large-scale natural disturbances (fires, severe windstorms, and debris flows) can dramatically alter riparian characteristics. These natural events are typically infrequent, with recovery to healthy riparian conditions for extended periods of time following the disturbance event. The width of the riparian zone and the extent of the riparian zone's influence on the stream are strongly related to stream size and drainage basin morphology. In a basin un-impacted by humans, the riparian zone would exist as a mosaic of tree stands of different acreage, ages (e.g. sizes), and species.

Functions of riparian zones include providing hydraulic diversity, adding structural complexity, buffering the energy of runoff events and erosive forces, moderating temperatures, protecting water quality, and providing a source of food and nutrients. They are especially important as the source of LWD in streams, which directly influences several habitat attributes important to anadromous species. In particular, LWD helps form and maintain the pool structure in streams, and provides a mechanism for sediment and organics sorting and storage upstream and adjacent to LWD formations. Pools provide a refuge from predators and high-flow events for juvenile salmon, especially coho that rear for extended periods in streams.

Effects of Human Activities on Riparian Zones

Riparian zones are impacted by all types of land use practices. In general, riparian forests can be completely removed, broken longitudinally by roads and laterally by bridges and culverts, and their widths can be reduced by land use practices. Further, species composition can be dramatically altered when native, coniferous trees are replaced by exotic species, shrubs, and deciduous species. Deciduous trees are typically of smaller diameter than coniferous trees and decompose faster than conifers, so they do not persist as long in streams and are vulnerable to washing out from lower magnitude floods. Once impacted, the recovery of a riparian zone can take many decades as the forest cover regrows, and coniferous species colonize.

Changes to riparian zones affect many attributes of stream ecosystems. For example, stream temperatures can increase due to the loss of shade, while streambanks become more prone to erosion due to elimination of the trees and their associated roots. Perhaps the most important impact of riparian alteration is a decline in the frequency, volume, and quantity of LWD due to reduced recruitment from forested areas. Loss of LWD results in a significant reduction in the complexity of stream channels including a decline of pool habitat, which reduces the number of rearing salmonids. Loss of LWD affects the amount of both over-wintering and low flow rearing habitat, as well as providing a variety of other ecological functions in the channel.

Water Quantity

The hydrologic regime of a drainage basin refers to how water is collected, moved and stored. The frequency and magnitude of floods are especially important since floods are the primary source of disturbance in streams and thus play a key role in how channels are structured and function. In ecologically healthy systems, the physical and biotic changes caused by natural disturbances are not usually sustained, and recovery is rapid to pre-disturbance levels. If the magnitude of change is sufficiently large, however, permanent impacts can occur.

Alterations in basin hydrology are caused by changes in soils, decreases in the amount of forest cover, increases in impervious surfaces, elimination of riparian and headwater wetlands, and changes in landscape context. Hydrologic impacts to stream channels occur even at low levels of development (<2% impervious area) and generally increase in severity as more of the landscape is converted to from natural forest cover to more developed land uses.

Salmonid production is profoundly affected by water withdrawals for irrigation, industrial, and domestic use, including water transfers between basins. Removal of water, either directly from the stream channel or from wells that are in hydraulic continuity with stream flows, reduces the amount of instream flow and useable wetted area remaining for support of adult salmonid spawning and juvenile rearing. Reduction of instream flows also typically results in increased water temperature, often to levels that impair salmonid productivity. The relationship between the useable wetted area of a stream and stream flow varies

between species and life stages. For example, juvenile coho prefer quiet water in pools for rearing, whereas juvenile steelhead prefer areas of faster water (Hiss and Lichatowich 1990). Streamflow limitations are typically greatest during the dry summer and early fall months when stream flows are lowest. In other instances stream flows may actually increase due to direct or indirect (irrigation ground water return flows) water transfers from other basins. In some instances peak flood flows may be transferred to basins that would otherwise not be affected by flood flows. These situations may increase the stream flow and useable wetted area for fish use, but the increased hydrology may cause channel bedload movement, bank erosion, loss of LWD, and other adverse habitat impacts that would not be experienced under the natural hydrology regime to which the channel is adapted.

Irrigation water storage and delivery also affects the flow timing regime and transfers flow into streams that otherwise would not naturally have flow. In the Yakima watershed, normal peak flows occur during spring runoff. Much of the spring runoff is stored for irrigation delivery through the summer and early fall. Steelhead that emerge in early summer, and have adapted to low flows in their post-emergence phase, are exposed to peak flows that extend throughout the summer. Anadromous salmonid adults migrating to the upper watershed may be falsely attracted into lower watershed streams that are carrying operational spills or irrigation return flows of upper Yakima water that has been conveyed through the irrigation delivery network to the lower watershed. These fish may spawn in streams where habitat conditions are not suitable for egg incubation or for successful early rearing after emergence.

Water Quality

Water quality affects productivity and survival of salmonids. There are several water quality parameters that affect salmonids, including water temperature, pH, dissolved oxygen, turbidity, nutrients, and toxics. Water temperature increases are typically associated with increased ambient air temperature along the stream corridor, loss of mature riparian vegetation, reduced instream flows during late summer resulting from water withdrawals, or from increased solar exposure to water impounded behind dams. Egg incubation and rearing can be affected by increased icing due to loss of riparian vegetation and reduced instream flows during the dry winter months. Dissolved oxygen levels are directly associated with water temperature, with saturation being higher in colder water. Turbidity refers to the presence of suspended sediment in the water column that may affect survival of eggs or fish. Stormwater runoff (particularly from roads), surface erosion, and increased streambank erosion are the main contributors of turbidity. Natural stream nutrient regimes have been altered. Natural nutrient cycling has been affected by low numbers of salmon carcasses due to reduced numbers of spawners returning to streams; by removal or alteration of riparian vegetation that reduces the entry of litter fall and invertebrates; by the lack of LWD in streams that slows the loss of nutrient sources from the stream; and by stormwater flows that flush available nutrients from the streams. Nutrient level increases result from stormwater runoff that has high levels of nitrogen and phosphorous, and by failing septics and sewage treatment plant outfalls. Public health districts regularly monitor for presence of fecal coliform; presence of elevated levels of fecal coliform may result in closure of marine shellfish beds to harvest, but fecal coliform are not known to affect salmonid health or survival. However, elevated fecal coliform counts may be an indicator of other salmonid habitat problems (elevated nutrient levels, low dissolved oxygen, unrestricted domestic livestock access to streams, high concentration of wildlife in a particular reach in a particular season, etc.) in the watershed. There is far less water quality monitoring for presence of toxics. Sources of toxics of concern include toxic spills (e.g., oil, paint, pesticides, etc.), runoff from roads/parking lots, exposure of the stream or marine water to treated wood, leaching of pesticides, and leaching of heavy metals.

Washington State water temperature standards are identified in Chapter 173-201A WAC. Water temperature standards differ for Class AA (extraordinary) and Class A (excellent) freshwater areas; water temperatures are not to exceed 16°C (Class AA) or 18°C, due to human activities. There are a number of streams in the Yakima Basin that are listed on the CWA 303(d) list for temperature, but it is difficult to

determine to what extent temperature exceedances are the result of natural conditions vs human activities (Creech). When natural conditions exceed water temperature standards, the WAC states that "no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3°C." Although salmonids are known to exist in streams and lakes where a portion of the watershed exceeds state water quality standards, human-induced water temperature increases may impair/preclude salmonid habitat use in those stream segments during the period that state standards are exceeded. Comprehensive efforts to restore habitat function may lower water temperatures during late-summer periods, possibly allowing salmonid utilization of habitat year-round, or at least for a longer portion of the year.

Estuarine Habitat

Anadromous salmonids are affected by the freshwater habitat conditions described above, but are also affected by habitat conditions in the estuary, as well as in the ocean. Worldwide, few other habitats are so valuable for fish production and yet are so imperiled as estuaries. Estuaries include the area from the uppermost extent of tidal influence within the stream to the upper intertidal line on the delta face. Their abundant food supply, wide salinity gradients, and diverse habitats make these areas particularly valuable to anadromous fish for rearing, feeding, and osmoregulatory acclimation during transition between fresh water and marine habitats (Macdonald et al 1987). The vital role estuaries play in chum salmon ecology is well documented (Walters et al. 1978; Healy 1980A, Levy and Northcote 1982). Other species of salmonids that also inhabit estuaries, sometimes in high densities, include coho (Tschaplinski 1982, Mason 1974, Miller and Simenstad 1997, Nielsen 1994, Hiss 1994), sockeye (Healy 1980A), pinks (Hiss 1994), and chinook (Levy and Northcote 1982, Healy 1980A, Healy 1980B, Congleton et al 1981, Shreffler et al 1992). According to Levy and Northcote (1982), significant estuary rearing by chum and chinook fry on the Fraser River Delta extends even into tidal channels that are dewatered during normal low tides. In the Skagit River estuary, Beamer and LaRock (1998) found high densities of chinook, chum, and smelt inhabiting a salt marsh tidal channel (Browns Slough) that was not associated with any freshwater stream. Also found in Browns Slough were coho smolts and adult cutthroat trout engorged on smelt. Juvenile chinook have been documented in at least two Puget Sound estuarine salt marshes not associated with chinook spawning streams - Shine Creek on the Olympic Peninsula (Lichatowich 1993) and Seabeck Creek on the Kitsap Peninsula (Hirschi, personal communication). The spawning of Pacific herring, an important forage fish for salmonids, has been documented in Willapa Bay and Grays Harbor estuarine salt marshes, but the presence or importance of Pacific herring has not been assessed in Strait of Juan de Fuca estuaries

WATERSHED DESCRIPTION

(the majority of this chapter is excerpted directly from the YSS 2001 DRAFT)

Location

The Yakima River Subbasin is located in south central Washington (Figure 2). The city of Yakima is the largest city and is centrally located in the subbasin. The basin or subbasin includes most of Yakima and Kittitas counties as well as small portions of Benton and Klickitat counties. Most of the Yakima Nation Reservation is located within the subbasin.

Figure 2: Map showing the location of the Yakima subbasin (from YSS 2001 DRAFT)

Drainage Area

The Yakima River drains an area of 15,900 square km (6,155 square miles) and contains about 3058 km (1,900 river miles) of perennial streams. Originating near the crest of the Cascade Range above Keechelus Lake (Figure 2), the Yakima River flows 344 km (214 miles) southeastward to its confluence with the Columbia River at RM 335.2.

Major tributaries include the Kachess, Cle Elum and Teanaway rivers in the northern part of the subbasin, and the Naches River in the west. The Naches has four major tributaries, the Bumping, American, Tieton and Little Naches rivers. Ahtanum, Toppenish and Satus creeks join the Yakima in the lower subbasin. Figure 1 shows the basin's major rivers. Six major reservoirs are located in the subbasin and form the storage component of the federal Yakima Project, managed by the Bureau of Reclamation. The Yakima River flows out of Keechelus Lake (157,800 acre feet), the Kachess River from Kachess Lake (239,000 acre feet), the Cle Elum River from Cle Elum Lake (436,900 acre feet), the Tieton from Rimrock Lake (198,000 acre feet), and the Bumping from Bumping Lake (33,700 acre feet). The North Fork of the Tieton River connects Clear Lake (5,300 acre feet) with Rimrock Lake. All reservoirs except Rimrock and Clear Lake were natural lakes before impoundment. The non-federal Wenas Dam stores irrigation water for use in the lower Wenas Valley in the middle subbasin.

Climate

The climate of the Yakima Subbasin ranges from cool and moist in the mountains to warm and dry in the valleys. Annual precipitation near the Cascade crest ranges from 80 inches to 140 inches, whereas the lower elevations in the eastern part of the subbasin receive 10 inches or less. Summer temperatures average 55º F in the mountains, and 82º F in the valleys. Winter temperatures are fairly moderate. The Selkirk Mountains in Idaho and the Rocky Mountains in British Columbia shield the area from the very cold air masses that sweep down from Canada into the Great Plains. The predominantly westerly winds in the winter allow the area to benefit from the coastal maritime influence. Average maximum winter temperatures range from 25º to 40º F, while average minimum winter temperatures range from 15º to 25ºF. Minimum temperatures of minus 20º to minus 25º F have been recorded in most areas.

A sharp precipitation gradient in the subbasin falls off in a generally southeasterly direction. Orographic cooling of moist maritime air passing over the Cascades results in heavy precipitation on the windward slope and near the crest, and a rain shadow to the east. In a distance of 10 miles, annual precipitation falls from 100 inches or more at the crest of the Cascades to 48 inches at Bumping Lake and to 26 inches at Rimrock Dam. Within the next 15 to 20 miles, precipitation decreases to 8 to 10 inches on the valley floor. Virtually all of the streams in the subbasin originate at higher elevations where annual precipitation is 30 inches or more (note Satus~30", Toppenish~45", etc.).

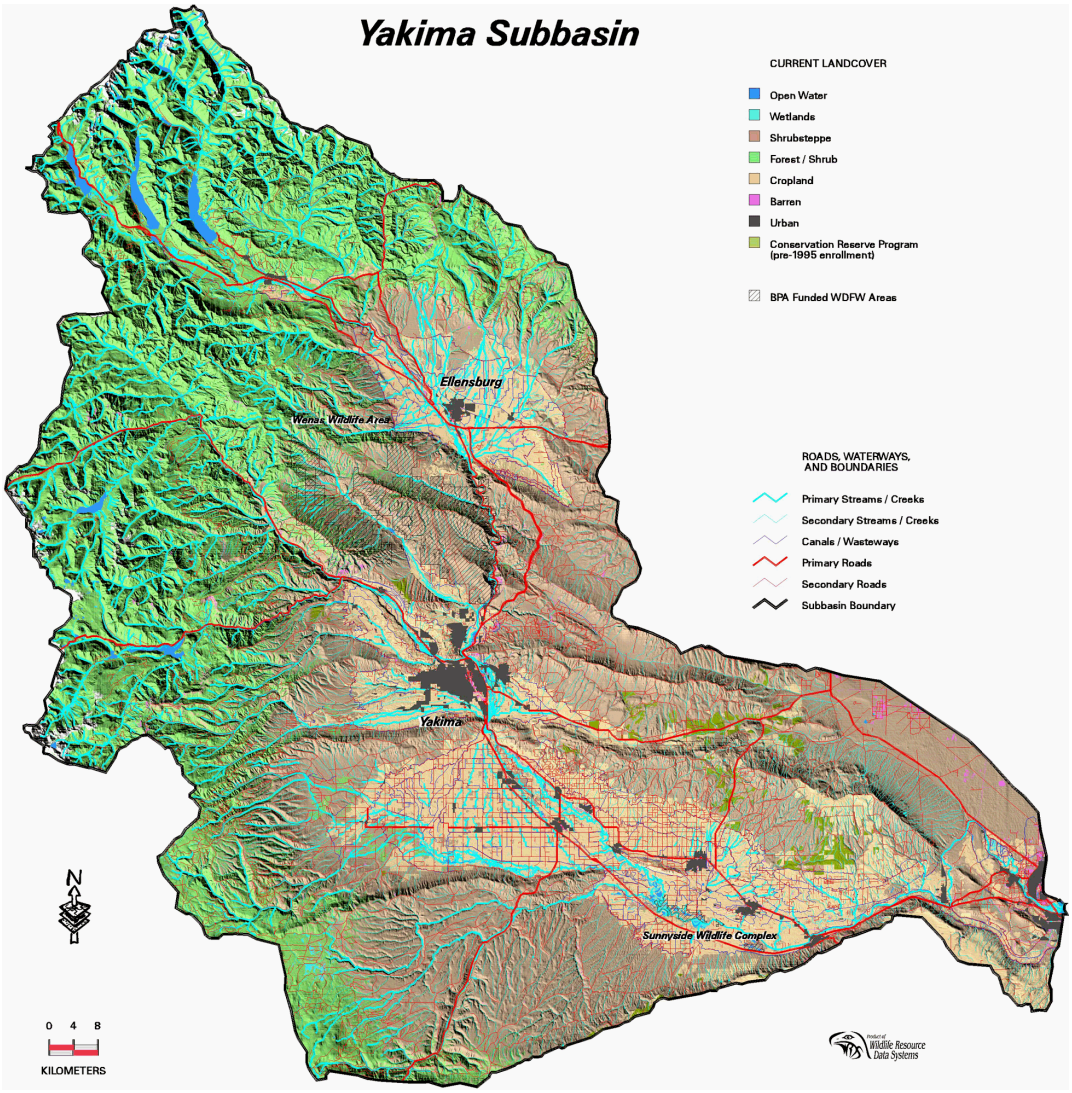
The rainy season in the valleys occurs during November through January, when about half the annual precipitation occurs. Snowfall in the valleys ranges from 20 to 25 inches, and from 75 inches at 2,500 feet to over 500 inches at the summit of the Cascades. It is this mountain snow pack that provides most of the water for irrigated agriculture and streamflow.

Topography

The topography of the Yakima River Subbasin includes a variety of land forms and land cover (Figure 3). In the higher elevations of the Cascade Mountains there are glaciated peaks and deep u-shaped valleys. The upper mainstem Yakima and Naches River and several tributaries occupy broad valleys excavated by

alpine glaciers. Typical lowland landforms associated with the Columbia Plateau are found along the lower half of the Yakima River (TriCounty Water Resource Agency et al., 2000). Elevations in the subbasin range from over 2,438 m (8,000 feet) in the Cascades, above Keechelus Lake where the river originates, to about 104 m (340 feet) at the confluence of the Yakima and Columbia rivers (Rinella, et al. 1992).

Figure 3: Current land cover in the Yakima subbasin (from YSS 2001 DRAFT)



Topography in the subbasin is characterized by a series of long ridges extending eastward from the Cascades and encircling flat valley areas. The ridges rise 1,000 to 3,000 feet above the adjacent valley floors (Tri-County Water Resource Agency et al. 2000).

Geology

The Yakima River Subbasin straddles two very different physiographic and geologic provinces, the Cascade Mountains in northwestern part of the basin and the Columbia Plateau to the southeast. The Cascade Mountains consists of continental formations of Eocene-age sandstone, shale and some coal

layers, and pre-Miocene volcanic, intrusive and metamorphic formations. Tertiary and quaternary age andesite and dacitic lavas, tuff and mudflows form a broad north-south arch along the western edge of the Yakima Basin (Tri-County 2000).

The principal rock of the Columbia Plateau is a series of basalt flows of tertiary age that cover older rock and lap onto the western edge of the Cascade Mountains. The majority of these basalt flows, interspersed with sedimentary layers, are known as the Columbia River Basalt Group. This thickness of the Columbia River Basalt Group within the lower and middle Yakima River basin ranges from 9,000 to 12,000 feet, growing thicker in the downstream direction (Tri-County 2000). The basalt plateau of the eastern basin was subsequently folded and faulted into a series of northwest-southeast trending anticlinal ridges and synclinal valleys, known as the Yakima Fold Belt. These valleys extend from the Cascades to the broad plains of the Columbia River. The antecedent Yakima River incised canyons and water gaps through the ridges and deposited gravels, eroded from uplifting mountains and ridges, in the valleys.

Alpine glaciers draining the Cascade crest down the Yakima and Naches valleys delivered large volumes of glacial outwash to the alluvial basins, resulting in partial filling of Cle Elum, Kittitas and upper and lower Yakima valleys with sand, gravel, and silt. Glaciation left many lakes (four of which were expanded to serve as storage reservoirs). Backwaters from the Ice-age Lake Missoula floods left thick silt deposits in the lower valley.

Extensive portions of the eastern and southeastern subbasin are mantled by loess, a wind-deposited silt derived from outwash deposits.

Soils

Seven soil associations exist in the Yakima Subbasin. Four of these associations, (Weirman-Zillah, Renslow-Ritzville, Naches-Woldale and Warden-Shano), comprising about 18 percent of the subbasin area, are located in gently sloping areas and are subject to intensive irrigated agriculture. These soil types are fine textured and easily eroded.

The soils are part of the Rough Mountainous Land Association and were formed in glacial till or outwash. They are of variable depth, stony, broken by outcrops of underlying rock, and are valuable for timber production, summer grazing, wildlife habitat, recreation, and provide key watershed functions. Maintaining these watershed functions warrants protection from fires, erosion, and uncontrolled development. The Rough Mountainous Land Association makes up 48 percent of the subbasin. Soils on the ridge tops generally consist of the Rock Creek-Starbuck Association, and are shallow, well drained and stony, and are formed in loess and loess mixed with weathered basalt. Topography is gently sloping to very steep along the drainages and hillsides. This association is valuable chiefly as range or wildlife habitat although carrying capacity is low. Much of the area has been overgrazed. The Rock Creek-Starbuck Association makes up 33 percent of the subbasin.

Intensive, irrigated agriculture occurs only on the remaining 19 percent of the soils of the subbasin, which lie in valley bottoms and along the shoulders of the ridges. Most of the soils in this area are very fine, wind-deposited silts and sands with large erosion potential on slopes >2 percent (Boucher 1984).

Vegetation

Vegetation in the subbasin is a complex blend of forest, range and cropland (Figure 3). Over one-third of the land in the Yakima Subbasin is forested. Rangeland lies between cultivated areas, located in the fertile lower valleys, and the higher-elevation forests.

Forests predominate at higher elevations. Moisture and topography dictate the character of the forests in the subbasin. Along the eastern fringe of the timber zone, timber stands are scattered and occur mainly as narrow bands of trees in canyon bottoms. These meandering strips of timber merge into sparse ponderosa pine and Oregon white-oak forests, which in turn give way to denser stands of mixed species in the higher moisture and elevation zones. As a result, a large portion of the timber volume is in a 30-mile-wide band following the crest of the Cascades. Forests in the subbasin are heterogeneous in species composition, age and size class, in part, because of the different management objectives of the various landowners and, in part, because of the sharp gradient in moisture transition zones. In past years, large acreages have been clearcut in the Snoqualmie Pass area and in the upper Little Naches drainage. The cumulative effect on the ecological integrity of the streams that drain the upper Yakima and Naches rivers is a matter of great concern.

Between the forests and the valley floor lie the rangelands. Almost all shrub-steppe habitats in the subbasin are supported by highly fragile soils that are easily eroded. The four major plant associations in the Yakima Subbasin are the big sagebrush-bluebunch wheatgrass association (40 percent of existing rangeland), the three-tip sagebrush-Idaho fescue association (5 percent existing rangeland), the bitterbrush-bluebunch-wheatgrass association (35 percent existing rangeland) and the Sandberg bluegrass-stiff sagebrush association (20 percent existing rangeland). Except for the small three-tip sagebrush-Idaho fescue association, over 50 percent of all shrub-steppe associations are in fair to poor condition today. The increased runoff and erosion from these areas may have a significant impact on water quality.

Riparian conditions are extremely varied, ranging from severely degraded to nearly pristine. Good riparian habitat generally is found along forested, headwater reaches, whereas degraded riparian habitat is concentrated in the valleys, frequently associated with agricultural activity (especially streamside grazing, tillage, or mowing). Recreational development is having an increasing impact, especially along the Yakima River in the critical reach from the city of Cle Elum to Easton Dam.

Land Ownership and Uses

The economic base of the Yakima basin is irrigated agriculture. The Yakima basin is among the leading agricultural areas in the United States. In fact, Yakima County ranks fifth in the United States in total agricultural production. In 1995, agriculture in Benton, Kittitas and Yakima counties produced an estimated crop value of $1.3 billion (Tri-County Water Agency et al. 2000). According to the United States Department of Agriculture (USDA), in 1997 farmers in Benton, Kittitas, and Yakima counties, harvested cropland totaling 624, 000 acres (these totals include Benton County lands outside of the Yakima subbasin).

Major crops include apples, cherries, peaches, pears, prunes, grapes, mint, grain, corn, hops, timothy hay and alfalfa. Crops produced in Kittitas County are primarily timothy and alfalfa hay, much of which is exported outside the basin. Fruit production, including tree fruits and grapes, is located primarily in Yakima County, although Benton County also has significant apple and grape production (Tri-County Water Resource Agency et al, 2000). Livestock production and forestry are also important contributors to the economic base. The major industries in the basin are related primarily to the processing of agricultural and forest products.

Patterns of land ownership within the Yakima basin are complex (Table 3, Figure 4, Figure 5). Within the boundaries of the drainage, about 69 percent of all land is publicly owned and at least 31 percent is private (Table 3, Figure 5).

Table 3: Land ownership in the Yakima Subbasin in hectares and acres (from YSS 2001 DRAFT)

OWNER	HECTARES	ACRES
Private	504,560.0	1,246,818.0
Unknown	67,803.0	167,548.0
US Forest Service	361,179.0	892,509.0
National Park Service	197.0	487.0
US Fish & Wildlife Service	835.0	2,063.0
Bureau of Land Management	19,786.0	48,893.0
Department of Energy	64,788.0	160,098.0
Department of Defense	80,571.0	199,099.0
Bureau of Reclamation	60.0	148.0
Washington Dept. of Fish & Wildlife	63,418.0	156,712.0
Washington State Parks	417.0	1,030.0
Washington Dept. of Natural Resources	82,184.0	203,085.0
University	233.0	576.0
County	253.0	625.0
City	222.0	549.0
Yakama Nation	360,077.0	889,786.0
Other	60.0	148.0
Total Hectares by class	1,606,645.0	3,970,180.0

Figure 4: Current land ownership in the Yakima subbasin (from YSS 2001 DRAFT)

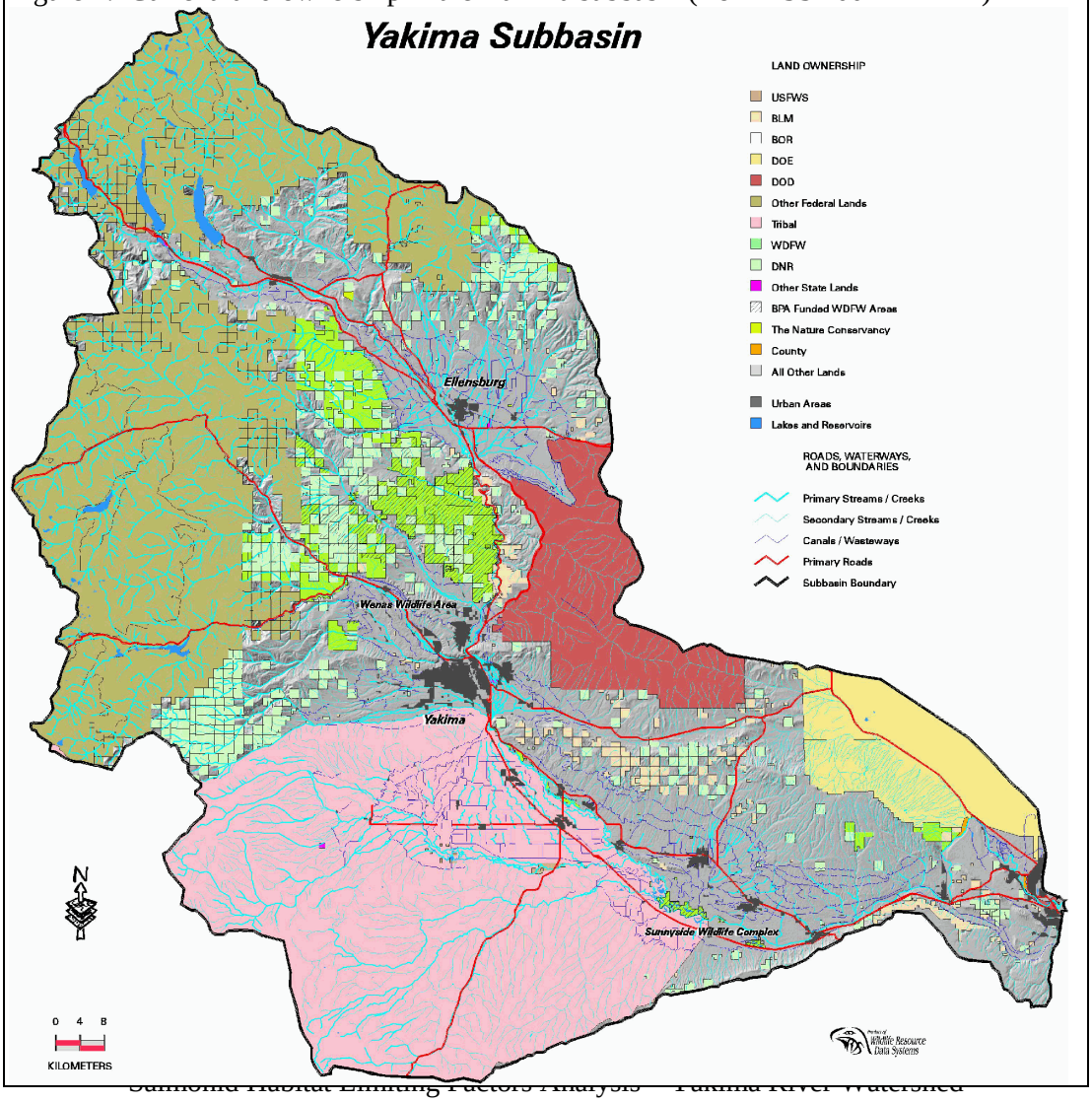
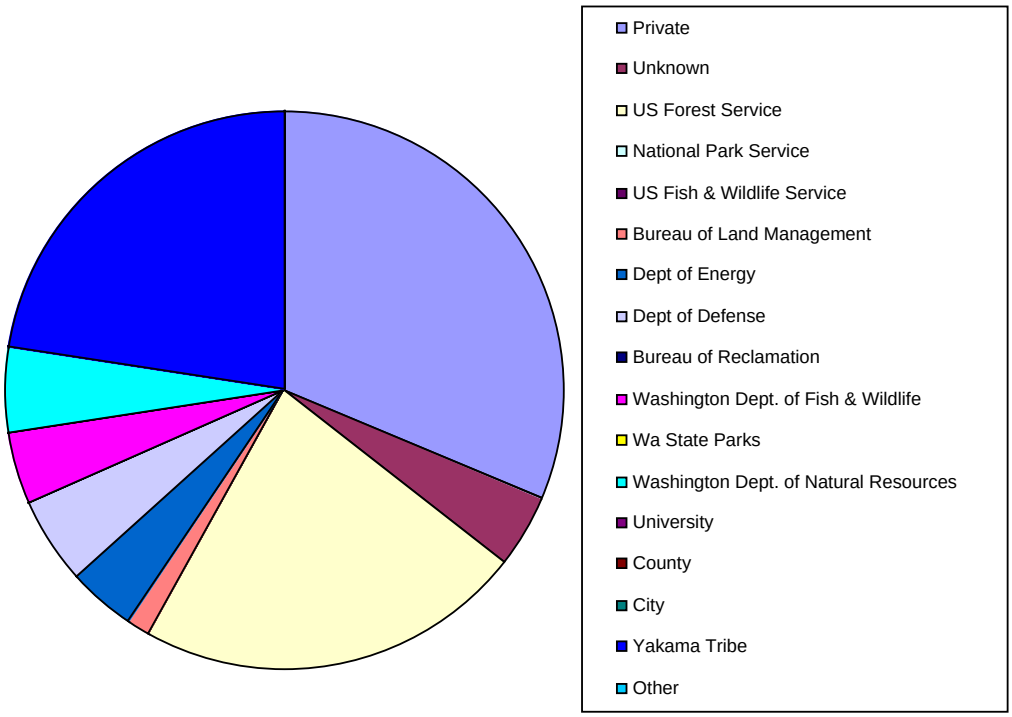


Figure 5: Land ownership in the Yakima Subbasin (from YSS 2001 DRAFT)



The Yakama Nation Reservation in southern Yakima County comprises 25% of the bi-county area. Most of this land is tribally owned, with only a small portion within the reservation being "deeded land." City and county ownerships are on valley floors near population centers. Privately owned lands are primarily used for agriculture, housing, commerce and industry, and are generally situated in valleys and on foothill slopes, where irrigation and transportation are accessible.

The predominant types of land use in the Yakima Subbasin include irrigated agriculture (1,000 square miles), urbanization (50 square miles), timber harvesting (2,200 square miles) and grazing (2,900 square miles). Cropland accounts for about 16 % of the total subbasin area of which 77 % is irrigated. Although the area affected by timber harvesting and grazing is roughly five times the area affected by agriculture and urbanization, the intensity of activity makes agriculture and urbanization of primary importance to water quality.

A change from row crops to hay in the Kittitas Valley has gradually occurred, and there has been a shift from row crops to permanent crops (such as grapes, apples and pears) in the lower valley. These changes affect the amount of water needed for irrigation, the methods of applying irrigation water, and the quality of water draining from fields and returning to the Yakima River.

Mining, wilderness designation, and hydroelectric projects are minor land uses in the Yakima Subbasin. Floodplain gravel mining remains an intensive use. About two-thirds of the floodplain mining in Washington State has occurred along the Yakima River or the lower reaches of two of its tributaries, the Cle Elum and Naches Rivers. The Selah Pit and surrounding pits comprise the largest pit complex in the state, at more than 230 acres in 1986 (Collins. 1997). Other forms of mining are absent in the subbasin, although claims have been filed on Swauk Creek and the Cooper River, and there are large, inactive coal mining sites near Rosalyn.

Hydrology

Five distinct channel provinces are very apparent along the altitudinal gradient from source to mouth; 1) high gradient, largely constrained headwaters, 2) expansive anastomosed or braided alluvial flood plains, 3) constrained canyons, 4) meandering with expansive flood plains containing oxbows, and 5) deltaic flood plain at the confluence with the Columbia River.

The Columbia River basalts, located within the Columbia Plateau, represent a locally important aquifer system including interbeds and overlying sediments. The overlying alluvial aquifers are highly permeable and are heterogeneous and anisotropic, due to their deposition within the fluvial environment where the processes of cut and fill alluviation by the Yakima River and tributaries occurred. The rocks of the Cascade Mountain province store and transmit little water via aquifer systems, and the majority of runoff occurs as overland flow.

In both the Cascade and Columbia Plateau regions, recent glacial activity and the network of tributary and main channel flow deposited large amounts of lacustrine and fluvial material in the valleys. This geologic template produced a series of groundwater basins separated by natural knick points (e.g., Selah and Union Gaps) and longer canyons (e.g., Yakima Canyon) (Kinnison and Sceva 1963). The Yakima River cuts through four large subbasins (Rosyln, Kittitas, Upper Yakima and Lower Yakima). This geological setting influences the hydrologic cycle.

Historically, the hydrologic cycle in each basin was characterized by extensive exchange between the surface, hyporheic and groundwater zones (Kinnison and Sceva 1963; Ring and Watson 1999). This exchange would have occurred mainly in the vast alluvial valleys and flood plains, which would have functioned as hydrologic buffers, distributing the energy of peak flows and moving cool, spring melt water out onto the flood plains. This inundation would annually recharge the shallow, surficial aquifers; a process that would occur potentially well into summer due to extensive and long-lasting snow pack in the Cascades (Ring and Watson, 1999).

Groundwater recharge of this nature would have provided a source of groundwater that would have maintained base flow and cooler thermal refugia as summer progressed and air temperatures increased, as well as maintaining warmer winter temperatures that would prevent or reduce the risk of anchor ice (Ring and Watson, 1999). Bansak (1998) quantified this process in a similar alluvial valley of the unregulated Middle Fork Flathead River, Montana.

Reaches associated with alluvial flood plains have been shown to be centers of biological productivity and ecological diversity in gravel-bed rivers (Stanford and Ward 1988; Independent Scientific Group 1996). In the Yakima basin, bedrock constrictions between alluvial subbasins control the exchange of water between streams and the aquifer system. Under pre-development conditions, vast alluvial flood plains were connected to complex webs of braids and distributary channels. These large hydrological buffers spread and diminished peak flows, promoting infiltration of cold water into the underlying gravels. Side channels and sloughs provided a large area of edge habitat and a variety of thermal and velocity regimes. For salmon and steelhead, these side channel complexes increased productivity, carrying capacity and life history diversity by providing suitable habitat for all freshwater life stages in close physical proximity.

At a large spatial scale, each of the Yakima subbasins is conceptualized as being downwelling, or losing surface water to the hyporheic and groundwater systems at the upstream end and upwelling, or gaining surface water from the groundwater and hyporheic systems at the downstream end as described for other rivers (for example, by Stanford and Ward 1988 and Tockner and Schiemer 1997). The hyporheic zone

(zone of shallow groundwater made up of downwelling surface water) extended the functional width of the alluvial flood plain and hosted a microbe- and invertebrate-based food web that augmented the food base of the ecosystem. As snowmelt-generated runoff receded through the summer, cool groundwater discharge made up an increasing proportion of streamflow. Much of this groundwater upwelled from the gravel into complex channel networks upstream of bedrock constrictions.

This upwelling is driven by the decreasing size of the sedimentary aquifers causing groundwater to move back into the river, tributaries and irrigation drains. Annual inundation and recharge also maintained the connectivity and flow of backwater, or spring brook habitats. These habitats are critical for successful completion of the life-history cycles of numerous fish species and other biota (e.g., Morgan and Hinojosa 1996; Tockner and Schiemer 1997). Historic maps and photographs indicate that these types of habitats were much more abundant prior to anthropogenic alteration of the flood plain (archive, USBR Yakima Office, Morris Uebelacker, CWU, pers. Comm.).

DISTRIBUTION AND CONDITION OF SALMONID STOCKS

(modified from YSS 2001 DRAFT)

The Yakima Subbasin currently supports natural production of spring and fall chinook, coho, and summer steelhead, and resident natural production of bull trout. In March 1995 (64 FR 14517) the National Marine Fisheries Service listed summer steelhead in the mid-Columbia ESU ("Environmentally Significant Unit"), which includes the Yakima Subbasin, as threatened under the Endangered Species Act. In June 1998, the U.S. Fish and Wildlife Service listed bull trout as threatened under the Endangered Species Act. Endemic coho stocks were extirpated about 1980, although naturalized production resulting from releases of hatchery smolts have been documented since 1989. Endemic summer chinook were last observed in the early 1970s and are now considered extirpated. Sockeye were historically abundant, but were extirpated following the completion of impassible storage dams below all natural rearing lakes in the late teens and early 1920's. Pacific lamprey have also become very rare in the Yakima Basin; Pacific lamprey are a U.S. Fish and Wildlife Service category 2 candidate species.

Spring Chinook

Stocks and Distribution

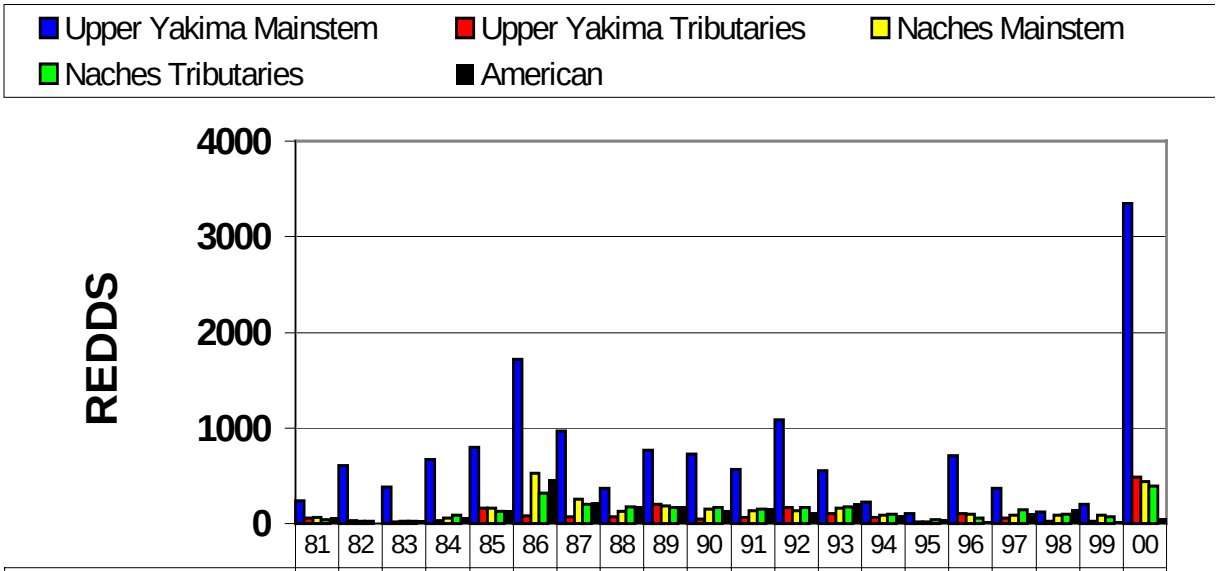
Spring chinook distribution in the Yakima River watershed is shown in Map 1 (in the separate Maps file included with this report) and in the fish distribution reference data table in Appendix A. Historically spring chinook spawned in the upper reaches of the mainstem Yakima and Naches Rivers, most of their larger tributaries and in the three largest lower river tributaries, Satus, Toppenish and Ahtanum creeks. In terms of major drainage areas, spring chinook spawned in the mainstem Yakima from roughly the Wilson Creek confluence to Lake Keechelus, and probably in the lower reaches of most of the larger tributaries between these points. Among the more important of these upper Yakima tributaries were the Cle Elum River (from mouth to Hyas Lake at RM 34), as well as portions of the Cooper and Waptus rivers; all of the mainstem Teanaway River and portions of all three of its forks; Taneum and Manastash creeks below their forks; and a substantial portion of Wenas Creek below its forks. In the Naches drainage, spawning occurred in all of the mainstem Naches above the Tieton River confluence, in portions of the lower Tieton River and especially NF Tieton River, in all of the Bumping River below Bumping Lake, in the American River, and in the lower portions of such smaller tributaries as Cowiche Creek and Rattlesnake Creek. Spring chinook distribution (known, presumed, historic/potential) in the Yakima River watershed (WRIAs 37-39) is shown on the spring chinook species map (see Map 1 in the separate Maps file included with this report) and in the supporting fish distribution reference data table in Appendix A.

Except for streams rendered inaccessible or unusable by unladdered dams (the upper Cle Elum River and the North Fork Tieton River) or by irrigation diversions or releases (Taneum, Manastash and Wenas creeks; the lower Tieton River), the current distribution of spring chinook spawning areas is the same as it was historically. The major difference is simply that many fewer fish utilize the remaining areas.

The situation is rather different for the three lower tributaries, Ahtanum Creek, Toppenish Creek, and Satus Creek. None of these streams support spring chinook runs today. Bryant and Parkhurst (1950) documented the presence of spring chinook in Ahtanum Creek and the lower portions of its forks, as well as lower Satus Creek and its Logy Creek tributary, in the early years of the 20th century. In the absence of any documentation, it is assumed that spring chinook spawned in upper Toppenish Creek in historical times because the habitat there is suitable today, and because similar near-by tributaries (Satus and Ahtanum creeks) were known to have been used.

The genetic composition of the historic spring chinook population is unknown. Currently, three genetically distinct stocks of spring chinook have been identified in the Yakima Basin, the upper Yakima, the Naches, and the American River stocks (SASSI(WDF and WDW 1993)). The upper Yakima stock is the most abundant spawning in the Yakima mainstem from Roza Dam (RM 128) to Keechelus Dam (RM 215), as well as the lower Cle Elum River and the North Fork of the Teanaway River. The Naches stock spawns in the Bumping River, the Little Naches River, Rattlesnake Creek and in the mainstem Naches above the Tieton confluence. The third and least numerous stock spawns exclusively in the American River. Figure 6 summarizes the spawning distribution of these three stocks since 1981.

Figure 6: Yakima spring chinook redd distribution, 1981 through 2000 (from YSS 2001 DRAFT)



	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00
Upper Yakima Mainstem	237	610	387	674	795	171	968	369	766	727	568	108	550	226	105	711	364	123	199	334
Upper Yakima Tributaries	57	30	15	34	156	77	75	74	202	46	62	164	106	64	12	103	56	25	25	487
Naches Mainstem	64	23	23	57	157	526	252	124	187	152	139	134	163	86	19	99	86	86	91	441
Naches Tributaries	36	20	24	91	129	323	203	179	167	169	151	171	177	97	39	57	142	95	68	393
American	72	11	36	72	141	464	222	187	187	143	170	120	214	89	46	28	111	149	27	53

The degree of hybridization between indigenous Yakima spring chinook and exogenous ("genetically foreign") hatchery stocks cannot be determined. Hatchery-reared juveniles (primarily smolts) have been released into the Yakima Subbasin since at least 1959. The releases made prior to 1999 consisted largely of Carson Hatchery (Wind River) stock and occurred primarily in the upper Yakima. It is thus reasonable to expect that some introgression between indigenous upper Yakima and Carson fish would have occurred. It should, however, be noted that the hatchery smolts released between 1982 through 1987 were all marked, and that all marked adults that ascended the ladder at Roza Dam into the upper Yakima were captured and sacrificed to retrieve coded wire tags and to prevent hybridization. Nevertheless, existing genetic data is not inconsistent with some commingling of upper Yakima and Carson fish. Busack et al. (1991) conducted an electrophoretic genetic stock analysis of Yakima spring chinook. Regarding Carson-upper Yakima introgression, they state: "Hatchery influence is to be expected in the upper Yakima, and the observed electrophoretic clustering of the Carson and upper Yakima stocks may reflect this, although it is unknown how similar the stocks were before the hatchery operations began."

The first smolt release of the Yakima/Klickitat Fisheries Project (YKFP) occurred in 1999, resulting in the return of (marked) hatchery-origin jacks in 2000. All broodstock for the YKFP program, however, consists exclusively of upper Yakima fish. Therefore risks associated with the introduction of non-native genetic material are not now a concern.

Life History and Demographics

The three stocks of Yakima spring chinook differ in terms of ocean age, mean fecundity, the spawning timing and perhaps sex ratio. They are similar in terms of the timing of spawning runs, smolt outmigration and emergence, as well as in pre-smolt migration patterns and smolt age.

Although all stocks of Yakima spring chinook smolt as yearlings, adult ages do differ among stocks. As shown in Table 4, the upper Yakima stock is overwhelmingly age-4 (71.9 and 90.4% for males and females, respectively) and includes a relatively high proportion of jacks (17% on average). By contrast, the Naches stock is slightly biased in favor of five-year-olds (50.2% males and 59.9% females), and the American stock decidedly so (61.9% males and 74%, females). Both the Naches Basin stocks include about 11% jacks in their spawning runs. Table 5 indicates a clear difference in sex ratio, with the upper Yakima stock being evenly split between sexes and the two Naches stocks showing a female bias approaching 60/40. The sex ratio figures in Table 4 should be considered provisional because they are based on scale-aged carcasses recovered during spawner surveys. Larger and older fish, and females in general, are disproportionately recovered in spawner surveys and therefore bias the sex-specific age distributions they generate.

Table 4: Sex-specific age distribution of Yakima spring chinook spawners by stock (from YSS 2001 DRAFT)

Stock and Age		FRACTION OF MALES THAT ARE AGE x	FRACTION OF FEMALES THAT ARE AGE x	FRACTION OF ALL FISH THAT ARE AGE x MALES	FRACTION OF ALL FISH THAT ARE AGE x FEMALES
UPPER YAKIMA	Age III =	17.1%	0.0%	9.1%	0.0%
	Age IV =	71.9%	90.4%	35.4%	45.0%
	Age V =	11.0%	9.6%	5.9%	4.6%
	Age VI =	0.0%	0.0%	0.0%	0.0%
	Sum	**100.0%**	**100.0%**	**50.4%**	**49.6%**
NACHES	Age III =	10.9%	0.0%	7.2%	0.0%
	Age IV =	38.5%	40.0%	24.1%	14.9%
	Age V =	50.2%	59.9%	31.3%	22.3%
	Age VI =	0.4%	0.1%	0.2%	0.1%
	Sum	**100.0%**	**100.0%**	**62.8%**	**37.2%**
AMERICAN RIVER	Age III =	10.9%	0.0%	7.6%	0.0%
	Age IV =	27.0%	24.3%	15.8%	9.1%
	Age V =	61.9%	74.0%	42.6%	23.8%
	Age VI =	0.3%	1.7%	0.2%	0.8%
	Sum	**100.0%**	**100.0%**	**66.2%**	**33.8%**

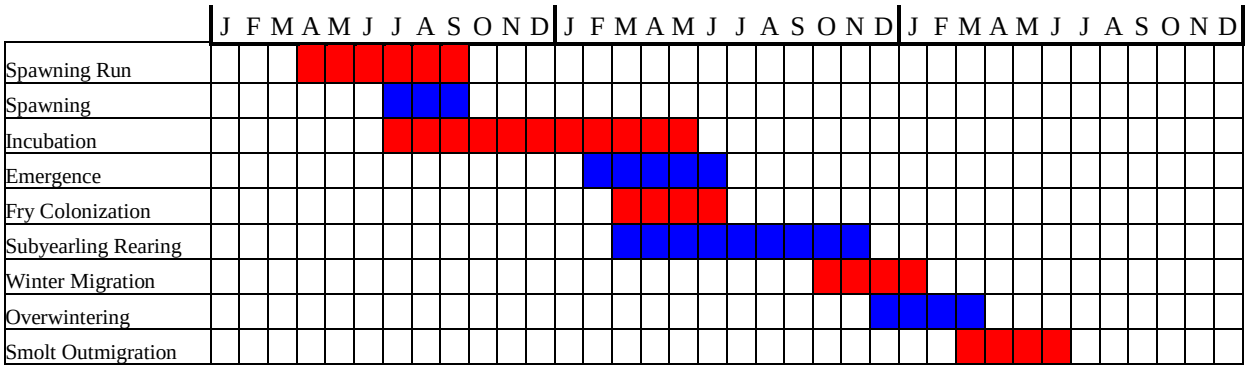
Table 5: Age-specific mean lengths (mid-eye hypural in cm) for females, Upper Yakima, Naches and American River stocks of spring chinook. Mean lengths (cm) estimated from spawning grounds carcasses collected for 1981-2000 broods.

Age	UPPER YAKIMA	NACHES	AMERICAN
Mean Length Age 4	59.7	68.4	64.2
Mean Length Age 5	71.1	68.7	74.7
Mean Length Age 6	--	68.6	78.7
Weighted Mean Length	60.8	68.6	72.2

Table 5 illustrates that Naches and American River females are not only older than upper Yakima females, but considerably larger. Because size and fecundity are positively related, Naches and American River females are also more fecund. On the basis of observed lengths of carcasses and a length-fecundity relationship based on 825 females spawned at the Cle Elum hatchery, it is estimated that the mean fecundity of upper Yakima females over brood years 1981 – 2000 was 4,013 eggs. By the same method, the mean fecundity of Naches females was estimated at 5,067 eggs, and the mean fecundity of American River females at 5,446 eggs.

The duration of the successive freshwater life stages of all three stocks of Yakima spring chinook is summarized in Figure 7.

Figure 7: Mean timing of successive freshwater life stages of Yakima Basin spring chinook

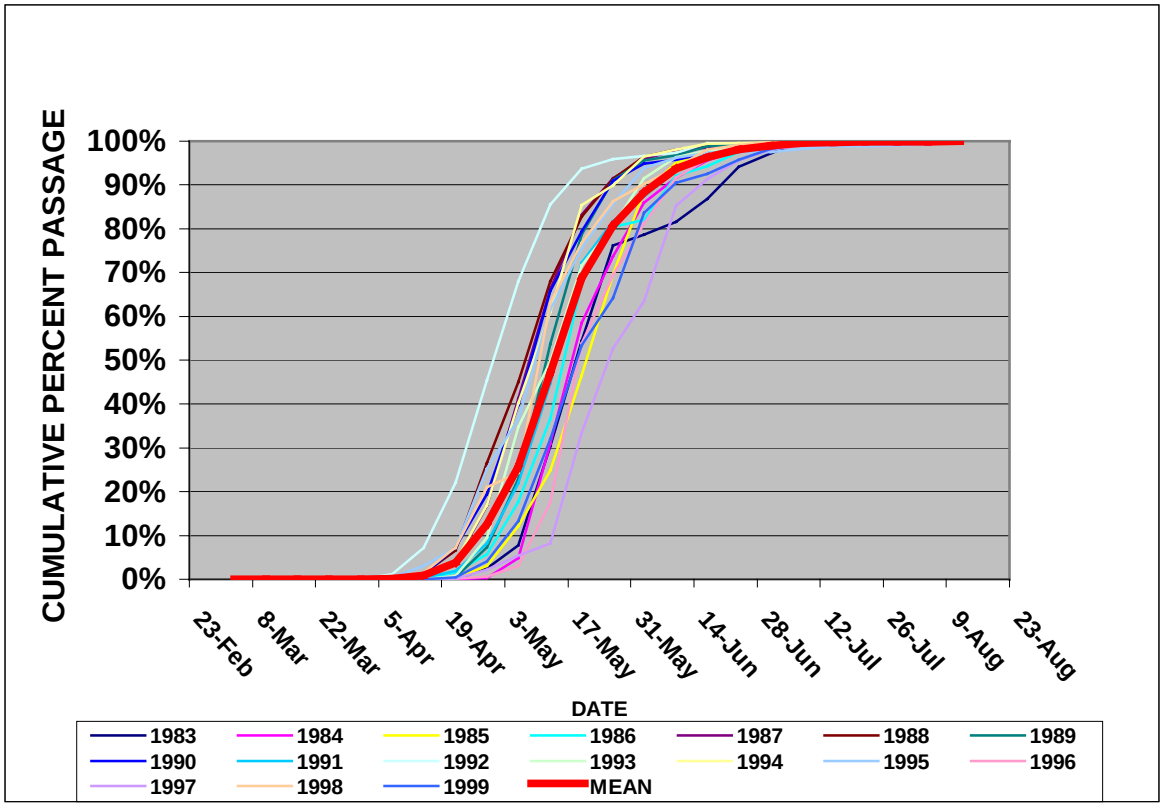


Adult Run Timing

Radio tagged spring chinook adults were released below Prosser Dam in 1991-92 and monitored through spawning in an effort to determine inter-stock differences in run-timing and delays associated with various dams and fish ladders (Hockersmith et al. 1994). Perhaps the most significant finding of this study was that there was no inter-stock difference in the temporal distribution of fish as they arrived at Prosser Dam. This is true even though there are clear inter-stock differences in the onset and duration of spawning.

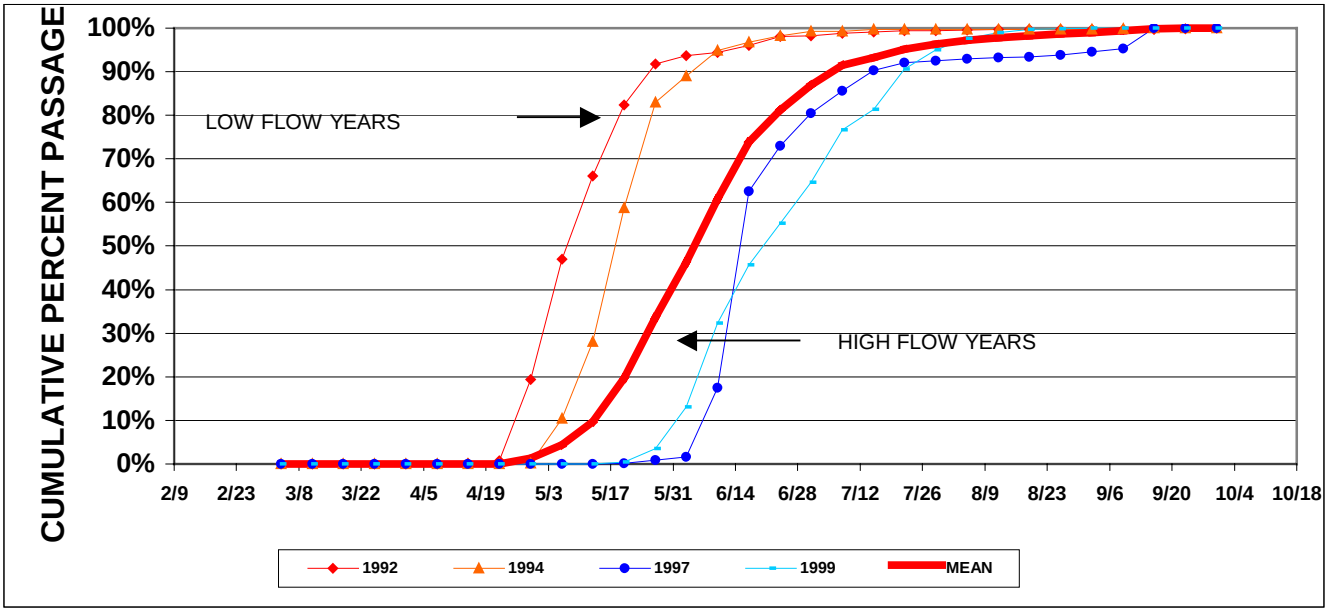
Figure 8 shows the cumulative adult spring chinook passage at Prosser Dam for the years 1983 through 2000. On average, the dates of 10, 50 and 90% cumulative passage are April 10, May 13 and June 3. There is, however, considerable variability from year to year, as the run has been 90% complete as early as May 20 and as late as June 24, a range of 35 days. Although not shown graphically, there is more variability in the timing of the run at Roza Dam, 81 miles upstream. The mean dates of 10, 50 and 90% passage at Roza are May 13, June 3 and July 8, respectively. The run may, however, be 90% complete as early as May 27 and as late as July 22, a range of 56 days.

Figure 8: Cumulative passage of Yakima spring chinook spawning run at Prosser Dam, 1983-1999 (from YSS 2001 DRAFT)



The main reason for the inter-annual variability in run timing is the impact of high and low flows on the migration speed of spring chinook spawners (Figure 9). In an average year, the run is half complete 21 days later at Roza than at Prosser. Therefore, given the 81-mile distance between dams, the average fish

Figure 9: Impact of high and low flows on run-timing of spring chinook spawners at Roza Dam



is traveling at a rate of about 3.8 miles per day. In 1992, a year of unusually low flows, the median fish passed Roza only seven days after it passed Prosser, indicating a migration rate of more than 11 miles per day. Conversely, in years of high flow, like 1997, fish move on average considerably more slowly. This is a pattern observed for the spawning runs of all salmon and steelhead monitored in the Yakima Basin: run-timing is delayed during years of high flow and accelerated in years of low flow.

The onset of spawning activity always is earliest for the American River stock, intermediate for the Naches stock and latest for the upper Yakima stock. Although elevated water temperatures can delay the onset of spawning, American River fish usually begin spawning in late July, Naches fish in late August, and upper Yakima fish in early September. Depending on water temperature, the peak of spawning activity for American River fish ranges from August 8 to August 15, while spawning peaks for Naches and upper Yakima fish range from September 8 to September 18, and from September 15 to October 1, respectively (Fast et al 1991).

Emergence appears to be quite closely synchronized across stocks despite five to seven week differences in spawning timing. Fry traps were installed below most redds in the American River and in the upper Yakima River in the late winter of 1984 to estimate emergence timing. In the American River, fry were captured between March 20 and June 4, with a median capture date of April 17. In the upper Yakima, fry were captured between March 8 and June 13, with a median capture date of April 16. This range of emergence timing—from early March through mid June with a peak in mid April—was also seen in the capture dates of fry collected in mesh traps ("redd caps") that were fitted over spring chinook redds in the upper Yakima in 1984, 1985 and 1986. The mean egg-to-fry survival for the redds capped in these years was 60%, a figure assumed representative for upper Yakima spring chinook (Fast et al 1991).

Juveniles from all stocks redistribute themselves downstream the spring and summer after emergence, with highest densities in summer being found well below the major spawning areas, but above Sunnyside Dam. The lack of fish in the lower Yakima mainstem (the mainstem below Sunnyside Dam) is attributed to excessive summertime water temperatures (Fast et al 1991). There is a rather steep thermal gradient that increases from Sunnyside Dam to the Columbia confluence. During the period from mid-July to mid-August, maximum daily water temperatures below Sunnyside (RM 103.8) and Prosser Dams (RM 47.1) have averaged 68° and 78°F, respectively (BOR Hydromet database) over the period of record. Although water temperature has only recently begun to be monitored continuously in the extreme lower Yakima, Yakama Nation data indicate summertime maxima may be about 5°F higher at West Richland (~RM 8) than at Prosser Dam. Water temperatures of 70°F or more are actively avoided by juvenile salmonids, and temperatures in excess of 77°F are lethal.

Another characteristic common to all stocks of spring chinook is an extensive downstream migration of pre-smolts in the late fall and early winter. Various observations over recent years have led to the conclusion that most spring chinook pre-smolts migrate to the lower Yakima mainstem when water temperatures fall sharply in the late fall. This thermal trigger occurs earlier in the upper reaches of the basin. Subyearling migrants begin appearing at the Wapatox Dam smolt trap on the lower Naches (RM 17.1) and at Roza Dam trap on the mid Yakima (RM 127.9) in October and November, and usually during December at the Chandler smolt trap at Prosser Dam on the lower Yakima (Fast et al 1991). Although 10-35% of the juveniles from a given brood year migrate below Prosser Dam during the winter, most fish overwinter in the deep, slackwater portion of the mainstem Yakima between Marion Drain (RM 82.6) and Prosser Dam (Fast et al 1991), and begin their smolt outmigration from the lower river the following spring. Therefore the dominant life history pattern for all wild Yakima spring chinook is this "winter migrant" pattern, which is contrasted with an "upriver smolt" type, which begins outmigration much nearer natal areas in the Naches and upper Yakima drainage.

Figure 10: Outmigration timing of spring chinook smolts at Chandler trap, 1983-2000

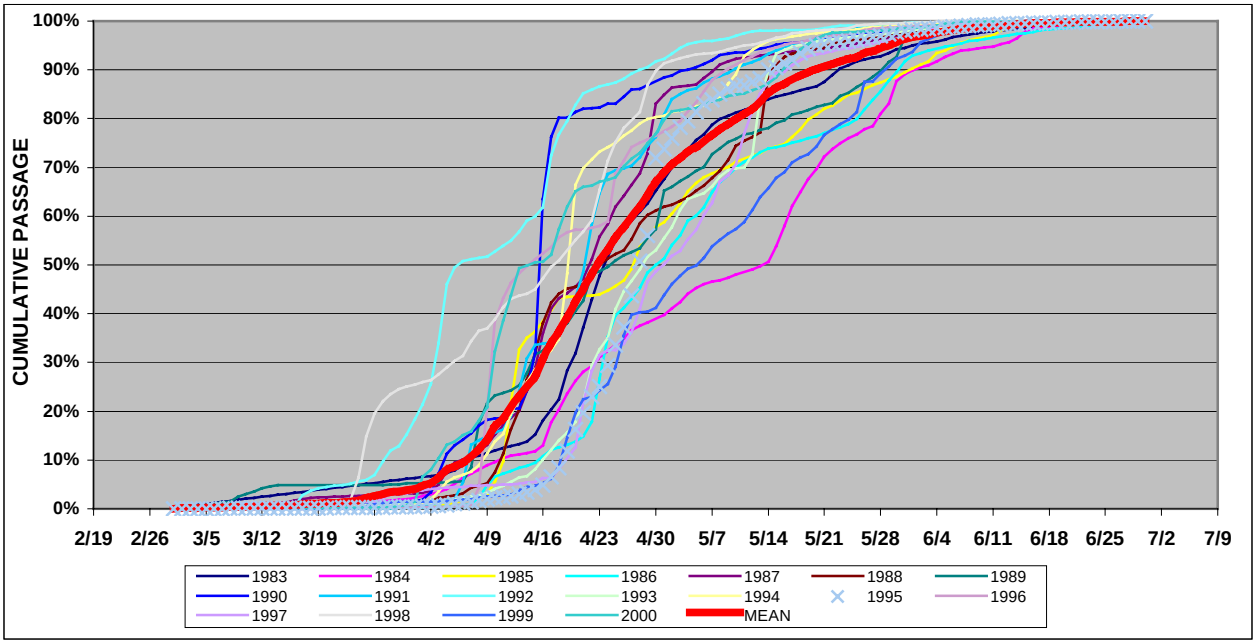


Figure 11: Mean passage date of Yakima Basin spring chinook smolts at Chandler trap

[Figures are a function of cumulative thermal units occurring December through March in the Yakima River at Cle Elum the winter preceding. Numbers indicate outmigration year. Similar relationships hold for outmigration timing and winter water temperatures in the Yakima River at Sunnyside and Prosser dams. Spring chinook outmigration dwindles to a few individuals per day by late June, and by convention has been declared finished by the first of July.]

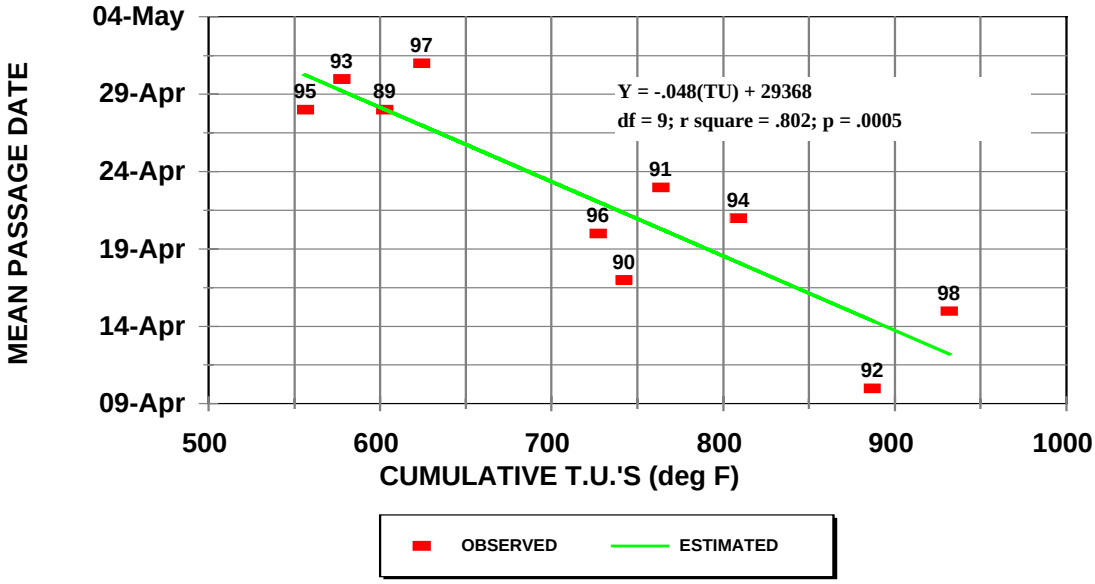


Figure 10 shows that the outmigration timing of Yakima spring chinook smolts is also quite variable. Although the average dates of 10, 50 and 90% cumulative passage at Chandler are April 6, April 23 and

May 20, respectively, the outmigration can be 90% complete as early as April 28 or as late as June 1. The overall timing of the outmigration does not appear to be shifted earlier or later by flow, although the migration rate of actively migrating smolts is positively correlated with flow. The gross timing of the outmigration seems instead to be a function of water temperature the winter preceding smoltification. Specifically, there is an inverse relationship between the mean outmigration date and the thermal units accumulated over the months of December through March: the more degree-days in the Yakima through the coldest part of winter, the earlier the outmigration, and vice versa (Figure 11).

Productivity and Trends in Abundance

The abundance and productivity of Yakima Basin spring chinook is a small fraction of historical values. Estimates of the size of historical Yakima spring chinook returns range from ~50,000 (Kreeger and McNeil, 1993) to 200,000 (Anon. 1990). More recently, Yakima Basin spring chinook have been subjected to an Ecosystem Diagnosis and Treatment (EDT) analysis. An integral element of EDT analysis is the estimation of historical equilibrium abundance and productivity.

Table 6 summarizes the results of this analysis, the salient points of which are as follows. First, all potential production areas contributed meaningfully to equilibrium abundance, and basin-wide life history diversity was 92% (*viz.*, 92% of the biologically possible life histories had adult recruitment rates of 1.0 or more and thus were at least marginally viable). Second, basin-wide equilibrium abundance was nearly 284,000 fish and basin-wide productivity was extraordinarily high, with an adult recruitment rate of 35.5 and a smolt productivity rate of 347 smolts per spawner.

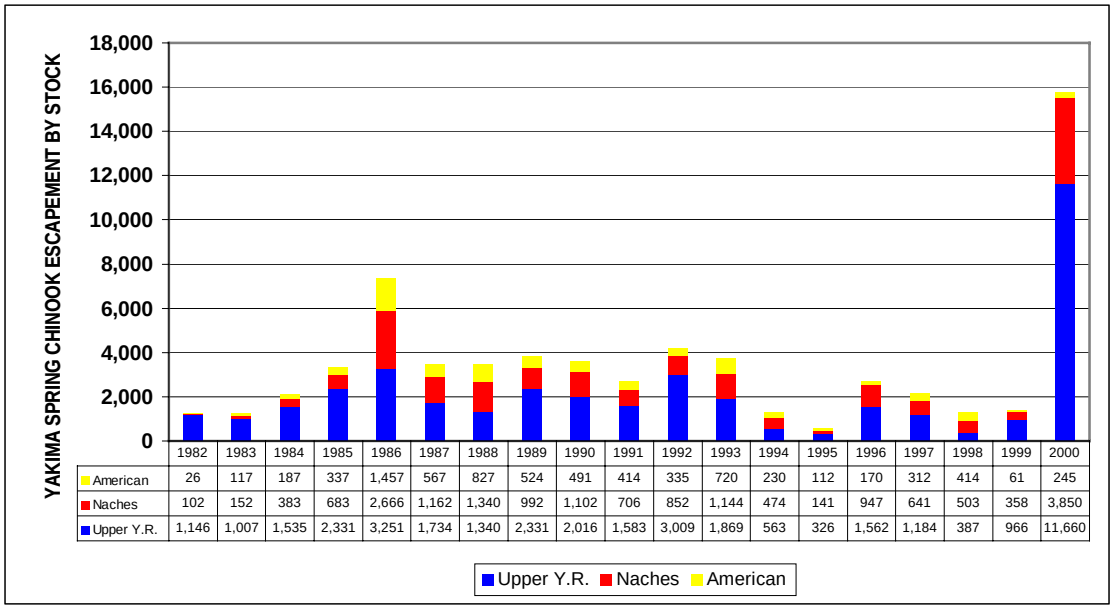
Table 6: Demographic and performance parameters for current Yakima basin spring chinook populations by geographic stock (estimated by EDT model, November 2000)

Population	Smolt Productivity (smolts/spawner)	Adult Productivity (returns/spawner)	Smolt Carrying Capacity	Adult Carrying Capacity	Smolt Equilibrium Abundance	Adult Equilibrium Abundance	Life History Diversity (% viable)
American R.	497.6	42.9	80,050	6,636	77,957	6,469	100%
Ahtanum Cr.	57.8	6.0	72,918	7,337	56,667	5,732	100%
Naches R.	440.9	40.8	785,378	68,757	761,030	66,736	100%
Satus Cr.	247.5	31.7	90,324	8,909	84,998	8,499	63%
Teanaway R.	307.2	33.4	232,903	24,534	222,545	23,474	100%
Toppenish Cr.	304.2	31.1	144,499	14,539	127,408	12,842	60%
Upper Yakima	331.6	35.0	1,612,829	160,725	1,555,923	155,365	100%
Basin-wide[a]	**347.0**	**35.5**	**3,041,858**	**294,127**	**2,929,015**	**283,788**	**92%**

a. Basin-wide parameters estimated separately; the sum of individual population values does not equal the basin-wide figure because of rounding .

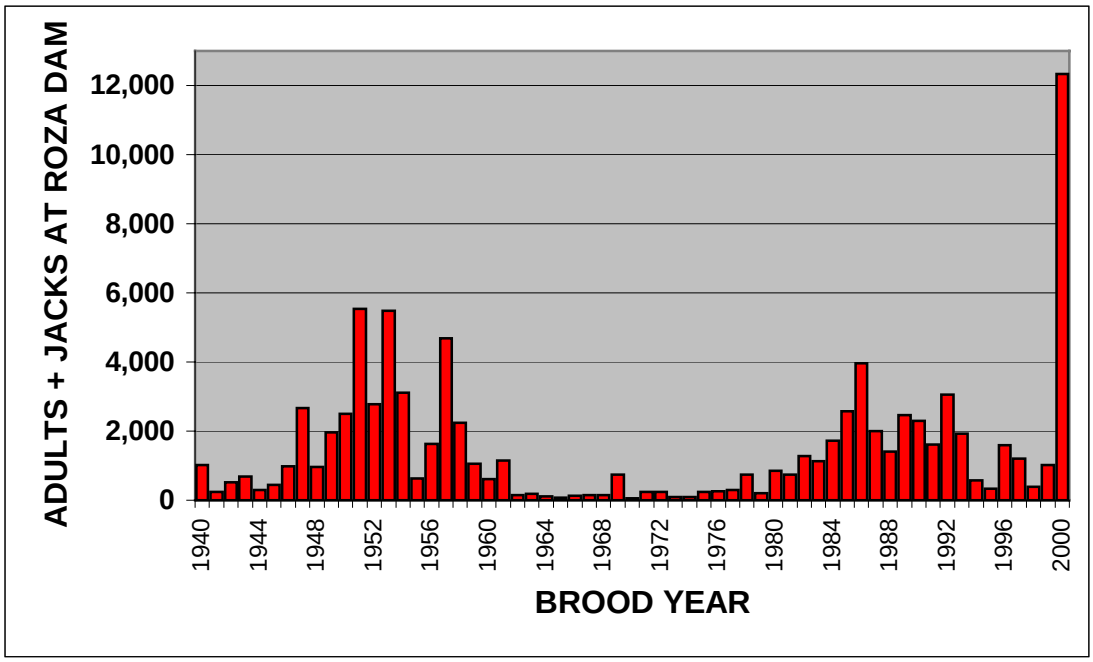
By any measure, current production as summarized in Figure 12 and Figure 13 is a pale reflection of the past. Figure 12 depicts stock-specific escapement for the recent period of record (1982-2000). Over this period basin-wide escapement has averaged 3,591 fish, ranging from 587 in 1995 to 15,959 in 2000. In terms of total returns to the mouth of the Yakima, the mean, maximum and minimum figures are, respectively, 4,285, 19,010 and 666. Thus, assuming historical spring chinook returns ranged from 50,000 to 284,000, current production represents from 1.5 to 8.5% of historical values.

Figure 12: Stock-specific escapement of Yakima spring chinook, 1982-2000



	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
American	26	117	187	337	1,457	567	827	524	491	414	335	720	230	112	170	312	414	61	245
Naches	102	152	383	683	2,666	1,162	1,340	992	1,102	706	852	1,144	474	141	947	641	503	358	3,850
Upper Y.R.	1,146	1,007	1,535	2,331	3,251	1,734	1,340	2,331	2,016	1,583	3,009	1,869	563	326	1,562	1,184	387	966	11,660

Figure 13: Escapement of upper Yakima spring chinook, 1940-2000



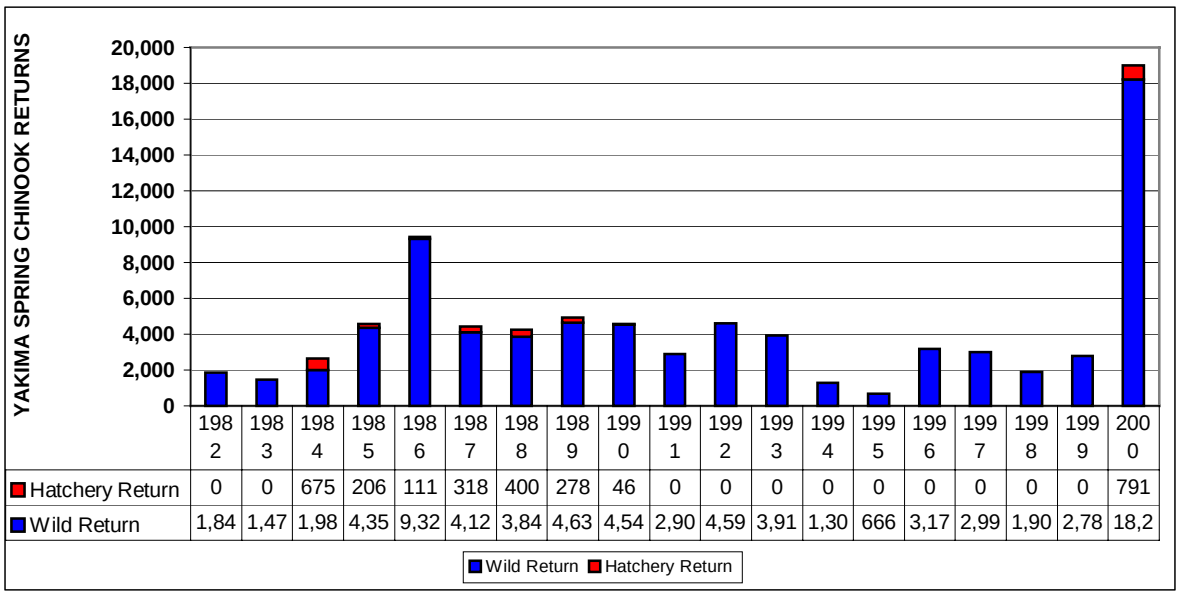
The mean contribution by stock from 1982 – 2000 has been 13% American River fish, 26% Naches stock and 60% upper Yakima stock (YN, unpublished data 2001). These figures, incidentally, compare favorably with those predicted by the EDT model in its simulation of production under current conditions. The EDT model predicts an equilibrium population composed of 8.4 % American River fish, 23.8% Naches fish and 67.7% upper Yakima fish. The EDT estimate of an equilibrium basin-wide escapement of 3,945 fish also matches the mean observation of 3,591 quite well.

Figure 13 shows the escapement of the upper Yakima stock (Roza Dam counts) from 1940 through 2000. A strong cyclical trend in abundance is evident, as is the unprecedented magnitude of the 2000 return. The magnitude of the 2000 return is in fact quite striking in all four of the figures summarizing recent spring chinook production. Over 90% of the fish in the 2000 return are four-year-olds, and therefore represent the 1996 brood year. Clearly it is important to understand the factors that so dramatically increased the productivity of the 1996 brood.

At the present time, the best explanation is that environmental conditions for the '96 brood improved substantially along every point of the life cycle. The '96 brood spawned after the flood of February 1996, an event which scoured and cleaned streambeds. Fry then emerged into a "refurbished" environment, one which had become substantially more complex as a result of the river having carved many new side channels and acquired thousands of new pieces of large woody debris. Instream flows throughout the Yakima Basin were unusually high, and water temperatures unusually cool as parr reared in the summer of 1997. Instream flow was also good in both the Yakima and the Columbia during the outmigration of 1998. Finally, there is both direct and indirect evidence that ocean conditions improved substantially in 1998. Indirect evidence of improved ocean conditions is evident both in the large increase in the Bonneville jack count in 1999 and the Bonneville count of upriver spring chinook adults in 2000. Significantly, a large return of Naches and American River fish is expected for 2001, as the majority of these stocks are five-year-olds (age-5 fish in 2001 are '96 brood). Moreover, the jack count at both Prosser Dam and Bonneville Dam was high in 2000. Indeed, based on regressions of jack counts and returns of age-4 fish and cohort ratios, the YN has predicted a total return of 27,907 Yakima spring chinook in 2001: 20,055 upper Yakima fish (9,564 wild and 10,991 hatchery), and 7,352 Naches and American River fish. Preliminary data indicate the 2001 spring chinook run (23,200) was slightly below the forecast, but is the largest run in recent history (Cummins).

Figure 14 shows that hatchery fish have contributed relatively little to the return since 1982. During the period 1984 – 1990, when experimental fish released during Yakima River Spring Chinook Enhancement Study were returning, hatchery fish contributed only 9.3% to the return, with a range of 1.1 to 34.1%. Returns for 2000 include 791 hatchery-reared jacks, 4% of the total. These fish are the first returns of the YKFP, and were released as smolts in 1999.

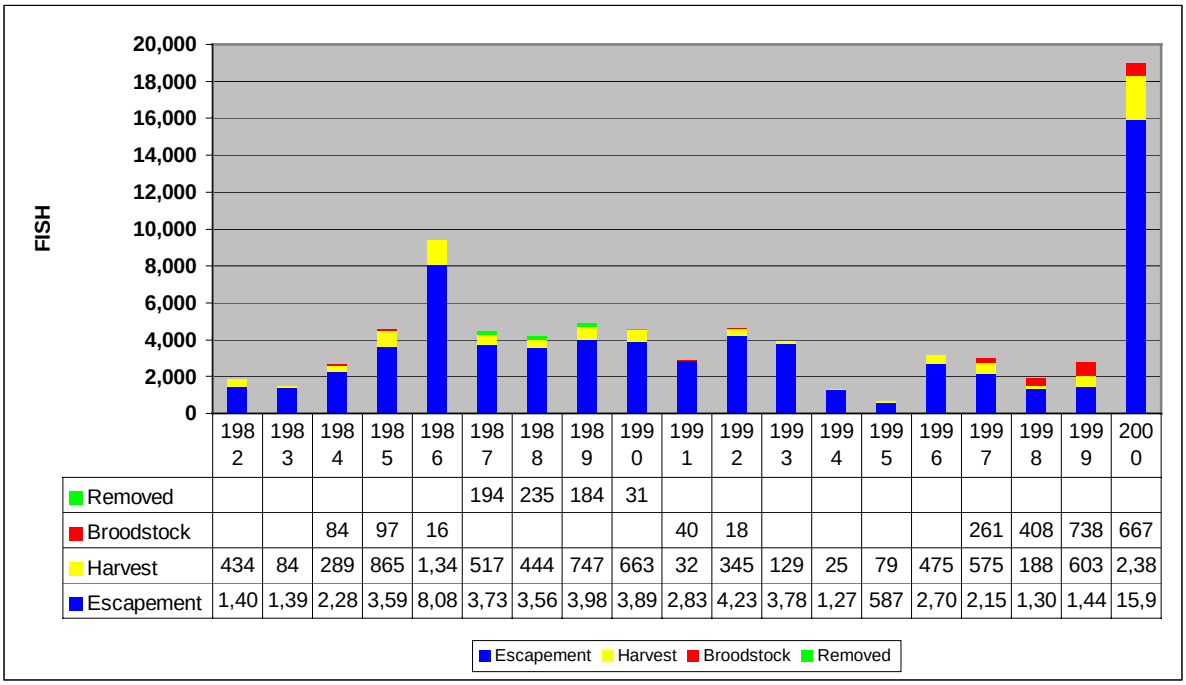
Figure 14: Hatchery and wild returns of Yakima spring chinook, 1982 – 2000



	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Hatchery Return	0	0	675	206	111	318	400	278	46	0	0	0	0	0	0	0	0	0	791
Wild Return	1,84	1,47	1,98	4,35	9,32	4,12	3,84	4,63	4,54	2,90	4,59	3,91	1,30	666	3,17	2,99	1,90	2,78	18,2

Figure 15 shows how basin-wide returns were utilized – *viz.*, the relative magnitude of the numbers of fish that were harvested, utilized for broodstock or other scientific endeavors, or allowed to escape to spawn. From 1982 though 2000, the harvest rate ranged from 1.1 to 23.6% and averaged 12.1%. Except for 100 fish taken in a sport fishery in 2000 (the first sport fishery in 40 years), all harvest occurred in the tribal ceremonial and subsistence fishery, which is managed for an exploitation rate of 20% or less. Collection of adults for broodstock or other scientific purposes has also been quite low, except for 1998, when 48.7% of the upper Yakima return (51.3% of the count of fish at Roza Dam) were taken for broodstock by the YKFP. Note that YKFP policy is to take no more than 50% of the upper Yakima escapement for broodstock. Considering all sources of utilization, natural escapement has ranged from 98.1 to 51.8% of the total return, with a mean of 83.7% of the total return.

Figure 15: Annual escapement, harvest, broodstock collection and other removals of returning Yakima spring chinook, 1982 – 2000



	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Removed						194	235	184	31										
Broodstock			84	97	16					40	18					261	408	738	667
Harvest	434	84	289	865	1,34	517	444	747	663	32	345	129	25	79	475	575	188	603	2,38
Escapement	1,40	1,39	2,28	3,59	8,08	3,73	3,56	3,98	3,89	2,83	4,23	3,78	1,27	587	2,70	2,15	1,30	1,44	15,9

Table 7 summarizes annual smolt production and productivity for Yakima spring chinook. In this table, overall productivity is adult recruitment rate (adult progeny per spawner), which is the product of the in-basin (smolts/spawner) and out-of-basin (smolt-to-adult survival) productivity components. Over the period of record, adult productivity has ranged from 0.2 to 8.7 adult progeny/spawner, with a mean of 2.2, while smolt productivity has ranged from 19 to 256 smolts/spawner with a mean of 87. The Yakima Basin and the region as a whole experienced drought or near-drought conditions over the years 1986 through 1993, and these years of poor conditions are reflected by adult recruitment rates that are less than 1.0 for seven of the eight years.

Table 7: Annual basin-wide smolt and adult productivity of Yakima Basin spring chinook

BROOD YEAR	SMOLT YEAR	SMOLTS[a]	SMOLTS PER SPAWNER	SMOLT TO ADULT SURVIVAL[b]	ADULT RECRUITMENT RATE[b]
1981	1983	245,921	201	2.5%	5.1
1982	1984	365,755	256	2.1%	5.4
1983	1985	140,755	104	3.3%	3.4
1984	1986	218,321	96	1.7%	1.6
1985	1987	252,165	70	1.8%	1.2
1986	1988	260,932	33	1.7%	0.6
1987	1989	72,460	19	3.3%	0.6
1988	1990	134,162	44	4.2%	1.8
1989	1991	104,405	26	2.6%	0.7
1990	1992	123,041	34	1.0%	0.3
1991	1993	87,844	31	0.6%	0.2
1992	1994	162,989	38	2.2%	0.8
1993	1995	168,471	44	2.0%	0.9
1994	1996	207,365	181	0.8%	1.4
1995	1997	49,524	84	3.4%	2.9
1996	1998	278,706	103	8.4%	8.7
1997	1999	291,982	135		
1998	2000	84,821	71		

a. Estimated as the sum of "spring smolts", counted from March 1 through the end of the outmigration, and one half of the "winter migrants" – subyearlings passing Prosser the winter preceding the spring of outmigration.

b. Figures for brood year '96 estimated: the historical proportion of age-5 to age-4 returns was assumed.

Current overall productivity is 6.2% of the historical rate estimated by EDT (35.5 adult progeny/spawner), and current in-basin productivity is about 25% of the estimated historical rate (347 smolts/spawner). These figures imply that current out-of-basin productivity (smolt-to-adult survival) is also 25% of the historical value, because 0.25^2 is about 6.2%.

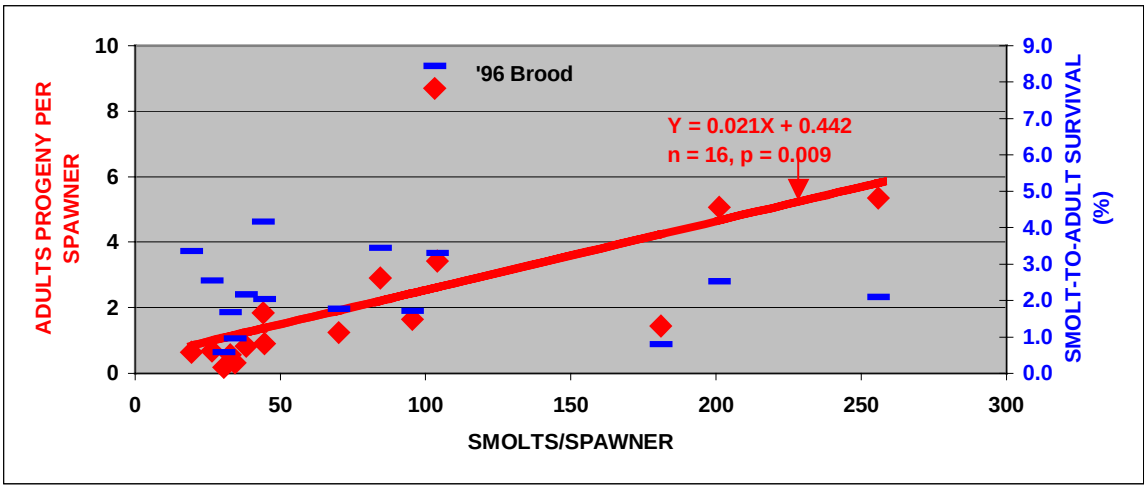
One final point about the figures in Table 7. As is evident in Figure 16, there is a significant positive correlation between in-basin and total productivity, but no relationship between in-basin and out-of-basin productivity. This may mean that the factors which control smolt production inside the basin and smolt survival outside the basin are not correlated, and that differences in adult recruitment between years have usually been attributable to differences in smolt productivity. Whatever the explanation the data points for the 1996 brood are clearly outliers and may reflect a change of state for the production system.

Fall Chinook

Stocks and Distribution

Little is known about the historical distribution of fall chinook although managers generally believe the primary production area was the same as it is today: the lower ~100 miles of the Yakima mainstem, from the current site of Sunnyside Dam to the Columbia confluence. Fall chinook distribution (known, presumed, historic/potential) in the Yakima River watershed (WRIAs 37-39) is shown on the fall chinook species map (see Map 2 in the separate Maps file included with this report) and in the supporting fish distribution reference data table in Appendix A. A *Yakima Herald* article from October of 1944 reported

Figure 16: Adult recruitment rate and smolt-to-adult survival as a function of smolt productivity (smolts/spawner) for Yakima Basin spring chinook, 1981 – 1996 brood years



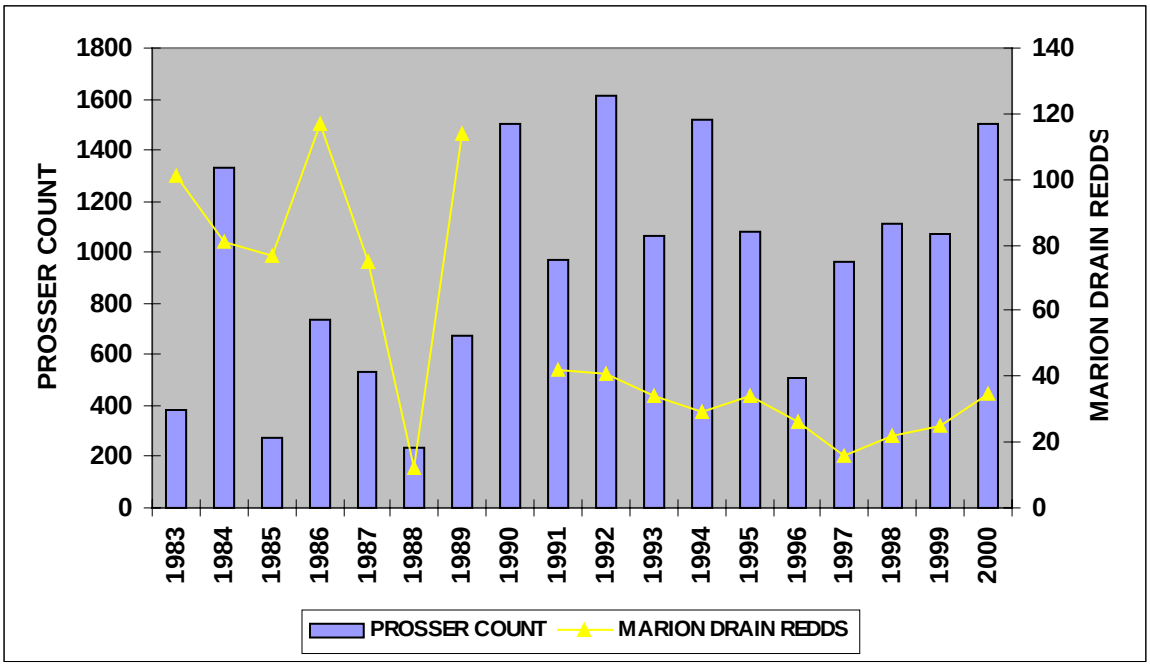
a "volunteer run" of fall chinook over Roza Dam and into the Naches River as far as Wapatox Dam. Similarly, Roza Dam counts from 1941 through the 1950's record a handful of chinook in September and October (WDF Annual Report 1964), some of which were probably fall chinook. Although the historical distribution of fall chinook may have been somewhat broader than now, there is, with one exception, no reason to suspect the general area of production was located differently. There is, however, reason to suspect that the upper portions of their range were utilized relatively more successfully historically. This is because the temperatures in the lower portion of the drainage have increased to the point that fish spawned toward the upstream limit of the range are unlikely to reach smolt status and migrate out of the basin before temperatures become prohibitively high downstream.

The exception is the self-sustaining population of fall chinook that now occurs in Marion Drain. Marion Drain is a 19-mile-long drainage ditch for the Wapato Irrigation Project (WIP) which was dug early in the 20th century to drain wetlands and enlarged over the years to serve as a major delivery canal for WIP. It discharges into the Yakima River at RM 82.6, 2.2 miles upstream of the mouth of Toppenish Creek.

The scant literature on the subject suggests that historical abundance probably ranged from about 38,000 to 100,000. These figures are based on two documents: Kreeger and McNeil, 1993 and the Yakima Subbasin Plan (YIN et. al 1990). Kreeger and McNeil (1993) argue that 3.8% of the historical run of salmon and steelhead in the entire Columbia Basin should have been produced by the Yakima because it represented 3.8% of the historical Columbia Basin watershed. On the basis of a moving average of peak historical Columbia River catch data and assumed exploitation rates, they estimate that the historical run of summer chinook, and of spring and fall chinook combined, was on the order of 2.7 million and 2.0 million fish, respectively. If 3.8% of all spring and fall chinook entered the Yakima, the historical run to the Yakima would have been 76,400. It is often assumed that the historical summer chinook run was twice as large as either the spring or the fall chinook runs, which were approximately equal in size. If this held for the Yakima, the historical run of fall chinook would be about 38,000 fish. The Yakima Subbasin Plan bases its considerably higher estimate on the amount of suitable spawning habitat for chinook historically present in the Yakima Basin, and the area taken up by a typical chinook redd. This approach yields estimates of ~200,000 for spring chinook and ~200,000 for summer and fall chinook combined. If summer and fall chinook, whose spawning distributions overlapped broadly, are assumed equally abundant, the historical abundance of fall chinook would have been on the order of 100,000.

The recent abundance of fall chinook is summarized in Figure 17. As with all other Yakima basin stock, fall chinook production today is only a small fraction of historical estimates. Escapement above Prosser Dam has ranged from 232 in 1988 to 1,612 in 1992. However, because about 70% of the spawning occurs below Prosser Dam[1], the true range and mean might be more on the order of 773 to 5373,with a mean of 3,159, from 3 to 8% of historical estimates. Figure 17 also shows the Marion Drain redd count over the same period of record. Marion drain escapement does not track above-Prosser escapement particularly well. Neither of the above-Prosser population displays a clear trend over these 18 years, except that Marion Drain escapement fell sharply after 1988, and has yet to recover.

Figure 17: Prosser Dam counts of fall chinook (adults + jacks) and Marion Drain



WDFW estimated fall chinook escapement below Prosser Dam in 1998, 1999 and 2000. WDFW estimated that 1998 below Prosser Dam fall Chinook run size ranged from 667 based on carcass tagging and recovery data to 1,203 fish based on expansion of redd counts. The redd count was 188 (Watson and LaRiviere 1999). An insufficient number of recaptured carcasses precluded the use of the carcass tagging and recovery method to estimate the number of fall chinook spawning in the lower Yakima River in 1999. By applying an area under the curve model, using redd counts, WDFW estimated 2069 fall chinook spawned below Prosser Dam in 1999. The redd count was 463 (Watson and Cummins 2000). In 2000 the lower Yakima River escapement estimate from Prosser Dam down stream using the area under the curve method from redd counts was 3,125. The 2000 redd count was 689 (Rick Watson, personal communication, 1/30/2001). The redd count method, at best provides a rough estimate of run size because visibility of redds is dependent on water visibility. Visibility generally ranged from .3 to 1.7 meters during these surveys. Therefore, all redds were not counted.

[1]Because turbidity usually precludes accurate redd counts, the proportion of fall chinook spawning below Prosser has had to be based on two reasonably successful aerial redd counts in which the number of redds and live fish above Prosser Dam was only 30% of the total

There is a history of hatchery fall chinook smolt releases into the Yakima watershed (Table 8). The genetic status of the historical fall chinook population is unknown, but two genetically distinct stocks of fall chinook currently occur in the Yakima River, the lower mainstem (or "mainstem") stock, and the Marion Drain stock (Busack and Marshall 1991, Marshall et al. 1995, Talbot 1999). Although in terms of

Table 8: Summary statistics, hatchery fall chinook smolt releases in the Yakima subbasin 1983–2000

Year	Hatchery Plants Above Prosser		Hatchery Plants Below Prosser		Hat. Smolt Survival To Prosser, Pen Reared Fish Only (%)	Hat. Smolt Survival To Prosser, Direct Releases Only (%)	Catch Rate In Oceanic And Columbia River Fisheries (% Of No. Tagged Fish Released)
	No.	% Clipped	No.	% Clipped			
1983	0	N.A.	323,796	0	N.A.	N.A.	NO DATA
1984	105,097 (Sunnyside Dam)	100 (98.8% tagged)	479,556 (84.6% Horn, 15.4% Prosser)	21.5 (all Horn; 99,522 tagged)	N.A.	27.1	.09%
1985	100,655 (Sunnyside Dam)	100 (100% tagged)	1,763,500 (52.4% Horn, 47.6% Prosser)	6.1 (all Prosser, all tagged)	N.A.	15.7	PROSS = .09% SUNNY = 0.0%
1986	97,460 (Sunnyside Dam)	100 (96.1% tagged)	1,547,700 (53.2% Horn, 46.8% Prosser)	6.5 (all Prosser, all tagged)	N.A.	32.2	PROSS = .03% SUNNY = 0.0%
1987	196,980 (Sunnyside Dam)	100 (100% tagged)	872,609 (all Prosser)	22.6 (all Prosser, all tagged)	N.A.	44.4	PROSS = .15% SUNNY = .09%
1988	444,795 (55.3% Wapato net pens, 44.7% Sunnyside Dam)	100 (100% tagged)	1,375,888 (all Prosser)	14.5 (all Prosser, 95.6% tagged)	22.6	6.7	PENS = .001% PROSS = .005% SUNNY = 0.0%
1989	540,198 (63% Wapato net pens, 37% Sunnyside Dam)	90.6 (85% Wapato fish clipped and tagged; 100% Sunnyside fish clipped and tagged)	1,430,316 (24% Horn, 76% Prosser)	14.0 (18.4% Prosser fish clipped and tagged; 0% Horn fish clipped and tagged)	18.5	8.7	PENS = .001% SUNNY & WAPATO = .0005%
1990	679,714 (70.6% Wapato net pens, 29.4% Sunnyside Dam)	45.6 (39.9% Sunnyside fish clipped and tagged; 50% Wapato fish clipped, 48% Wapato fish clipped and tagged)	880,344 (all Prosser)	9.2 (9.2% Prosser fish clipped and tagged)	38.0	33.9	PENS = .05% PROSS & SUNNY = .05%
1991	478,916 (Wapato net pens); 1,152,829 (Roza WW #3)	100% Wapato fish clipped and tagged; all of the Roza WW #3 fish were ventral clipped, but none were tagged.	0	N/A	35.0	31.4	PENS = .04%
1992	0	N/A	0	N/A	N/A	N/A	No Data
1993	165,428 Frontage Rd.	98.5% tagged, 100% clipped	582,731 Prosser ?	98.5% tagged, 100% clipped	N/A	5.5	.005%
1994	0	N/A	1,703,892 Prosser Hatch.	11.6%	N/A	N/A	.001%
1995	0	N/A	1,694,188 Prosser Hatch.	11.7%	N/A	N/A	NO DATA
1996	0	N/A	1,885,504 Prosser Hatch.	10.6%	N/A	N/A	NO DATA
1997			1,693,000				
1998			1,965,000				
1999			1,700,000				
2000			1,295,037				

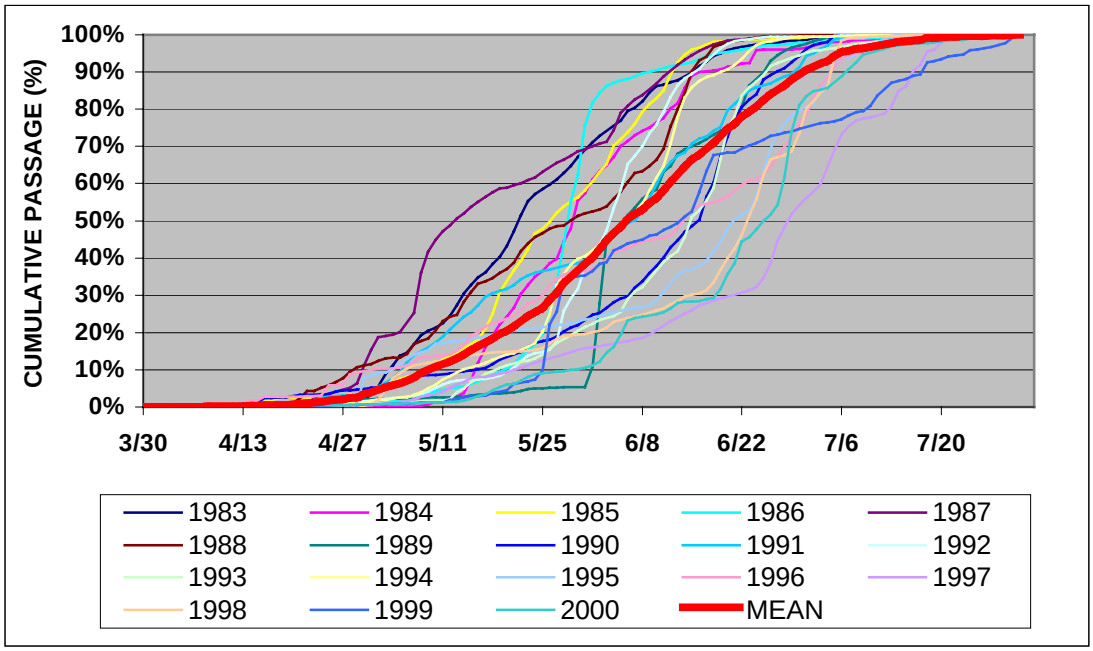
run-timing and spawning timing, both stocks are "Upriver Brights" (URB's), electrophoretic and demographic differences led Marshall et al. 1995 to assign the two populations to different genetic diversity units (GDUs): the Marion Drain population is assigned to the mid-Columbia and Snake fall chinook GDU (GDU 6), whereas the mainstem population is assigned to the upper Columbia fall chinook GDU (GDU 5). The mainstem stock spawns in the lower Yakima River primarily below Wapato Dam (RM 106.7), and most intensively between the Benton City Bridge (RM 29.8) and Horn Rapids Dam (RM 18). The Marion Drain stock spawns primarily in Marion Drain, although some fish probably spawn in the mainstem near the mouth of the drain.

Based on existing electrophoretic and life history data, the genetic variability within the Marion Drain population represents a substantial portion of the genetic variability found in mid-Columbia summer and fall chinook. What this variability means to the future productivity of chinook stocks in the area is unclear. Possibly it means nothing, and the variability is nothing more than a curiosity. But it may be quite valuable, and the Marion Drain population may prove to be an important part of the effort to rebuild fall chinook in the Yakima Basin.

Demographics and Life History

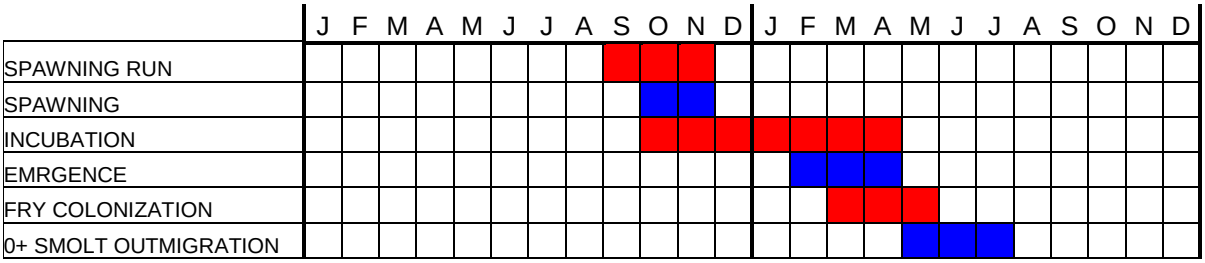
Little is known of the demographic characteristics or life history strategies of historical fall chinook populations. Given the very large loss of habitat diversity, it is reasonable to assume that historical life history diversity was greater than it is today. One important life history difference between present-day and historical fall chinook populations is known: smolt outmigration timing. In intact habitats, many populations of ocean-type[2] chinook begin their smolt outmigration in May, reach a peak in June or July, and continue migrating through September (Groot and Margolis, 1991). Just such an outmigration of

Figure 18: Passage timing of wild Yakima River fall chinook smolts at Chandler trap, 1983 – 2000



[2] "Ocean type" chinook migrate to the ocean in their first year of life as "subyearlings."

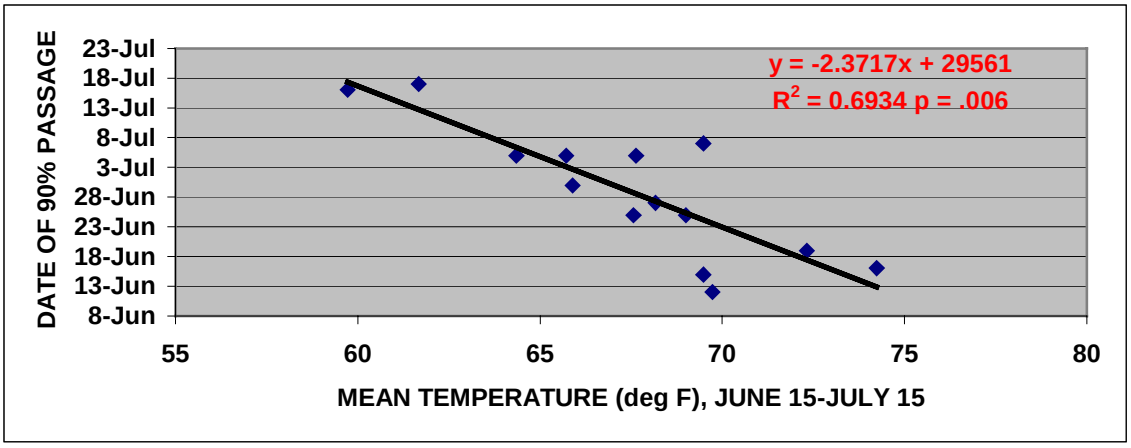
Figure 19: Mean timing of successive freshwater life stages of Yakima Basin fall chinook



subyearling chinook was observed in the Yakima in 1928, 1929 and 1930 (Lichatowich, 1992). This timing contrasts sharply with the current outmigration, which typically ends in early July (Figure 18 and Figure 19).

Figure 18 summarizes the outmigration timing for wild, subyearling, fall chinook smolts at Chandler since 1983[3]. The average dates of 10%, 50% and 90% passage are May 9, June 6 and July 1, but there is a very large amount of interannual variability. It is possible that much of this variability is due to temperature – to a temporary "stalling" of the outmigration by a short period of high temperatures, or to a premature truncation of the entire run by a prolonged period of high temperatures which directly or indirectly kills the later portion of the outmigration. This hypothesis is supported by two observations. One is the strong inverse relationship between the date of 90% passage and mean Chandler water temperature from June 15 – July 15 (Figure 20). This data shows that the outmigration ends considerably earlier during hot years, and that an increase of 10°F in late spring water temperatures usually means the outmigration will end nearly a month earlier.

Figure 20: Inverse relationship between date of 90% passage of Yakima fall chinook smolts at Chandler and mean water temperature at Chandler over the period June 15–July 15, outmigrations of 1988-2000



[3] All fall chinook smolts in the Yakima are subyearlings, but not all subyearling smolts are fall chinook. About 40% of a sample of small chinook smolts collected at Chandler in July were subsequently found by electrophoretic techniques to be spring chinook (Busack et al 1991). A subyearling-smolt life history may once have contributed significantly to the productivity of Yakima spring chinook, but they definitely do not now. Of the thousands of adult spring chinook scales aged over the past 20 years, perhaps one or two indicated ocean entry as a subyearling.

WDFW collected fall chinook carcasses (Richland to Prosser Dam) to determine age composition and sex ratios in 1998, 1999, and 2000 (Table 9, Table 10, Table 11). Lower Yakima fall chinook age data from wild and supplementation fish for 1998, based on 172 carcasses with readable scale samples, were 3.5% age 2, 52.9% age 3, 28.5% age 4, and 15.1% age 5 (Table 9). Wild fall chinook age distribution was 6.5% age 2, 27.4% age 3, 37.0% age 4, and 29.1% age 5. The hatchery supplementation age distribution was 2.2% age 2, 62.7% age 3, 26.9% age 4, and 8.2% age 5. Percent hatchery/wild contribution was 73/27 and male/female ratio was 61/39 (Watson and LaRiviere 1999). Age and sex analysis for lower Yakima fall chinook in 1999 is summarized in Table 10. Based on scale analysis of 277 wild and supplementation fish, the lower Yakima River age composition was 0% age 2, 22.5% age 3, 66.2% age 4, 11.3% age 5 in 1999. Wild fall chinook age distribution was 0% age 2, 24.1% age 3, 68.5% age 4, and 7.4% age 5. The hatchery supplementation age distribution was 0% age 2, 22.2% age 3, 65.6% age 4, and 12.2% age 5. Percent hatchery/wild contribution was 81/19 and male female ratio was 46/54 (Watson and Cummins 2000). Age and sex analysis for lower Yakima fall chinook in 2000 is summarized in Table 11. Based on scale analysis of 564 wild and supplementation fish, the lower Yakima River age composition was 6.2% age 2, 10.5% age 3, 43.1% age 4, 40.2% age 5 in 2000. Wild fall chinook age distribution was 15.6% age 2, 18.8% age 3, 31.2% age 4, and 34.4% age 5. The hatchery supplementation age distribution was 1.6% age 2, 6.3% age 3, 48.9% age 4, and 43.1% age 5. Percent hatchery/wild contribution was 67/33 and male female ratio was 48/52 (Watson, Hoffarth, and Cummins, 2001).

Table 9: 1998 Lower Yakima river fall chinook carcass recoveries by age and sex [Note - One chinook age 2 was classified as an adult by field staff, that used criteria of > 56 cm.]

Actual Age	2	3	4	5	Unreadable	**Totals**
Male	6*	66	20	12	9	**113**
Female	-	25	29	14	3	**71**
Totals	6	91	49	26	12	**184**

Table 10: 1999 Lower Yakima River fall chinook carcass recoveries by age and sex

Actual Age	**2**	**3**	**4**	**5**	**6**	**Totals**
Male	0	38	81	12	0	**131**
Female	0	26	107	20	0	**153**
Totals	**0**	**64**	**188**	**32**	**0**	**284**

Table 11: 2000 Lower Yakima River fall chinook carcass recoveries by age and sex

Actual Age	**2**	**3**	**4**	**5**	**6**	**Totals**
Male	35	52	89	96	0	**272**
Female	0	7	154	131	0	**292**
Totals	**35**	**59**	**243**	**227**	**0**	**564**

The spawning run at Prosser begins in early September, peaks in late September, and is almost always totally finished by the second week of November (Figure 21). The variability in run-timing is related to flow, but not water temperature, and the flow/passage relationship is the opposite of that seen for spring chinook; higher flows accelerate passage (Figure 22).

The other piece of evidence is the disparity between simultaneous passage estimates at Chandler and in a screw trap fished near Richland in the lower Yakima (RM 8) in the spring of 1992. Figure 23 shows the estimated passage of fall chinook smolts at Chandler and at the Richland screw trap, lagged three days to

Figure 21: Timing of fall chinook adult and jack returns at Prosser Dam, 1983-1999

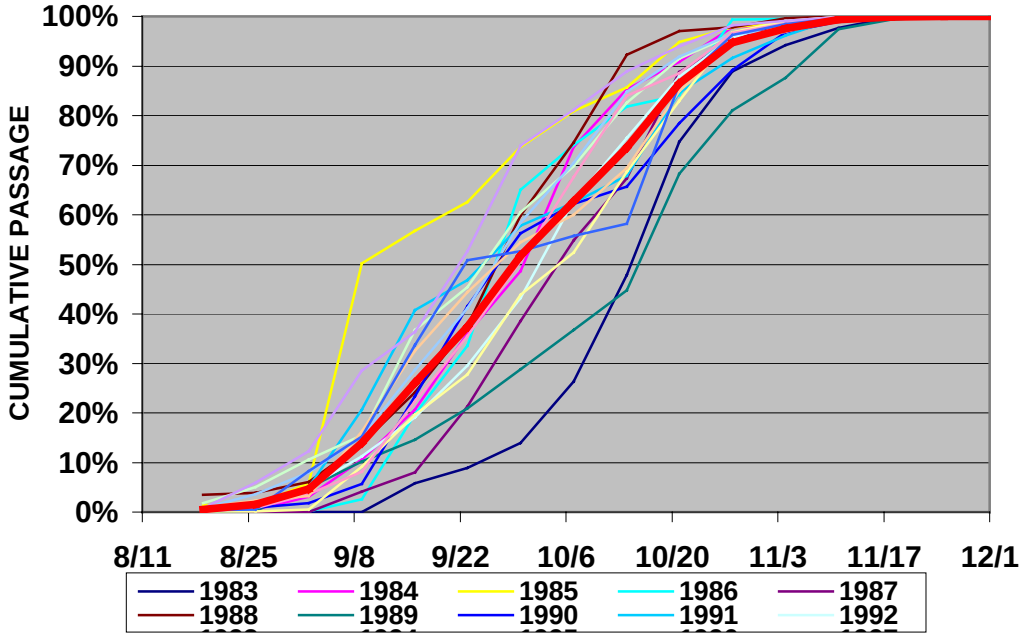
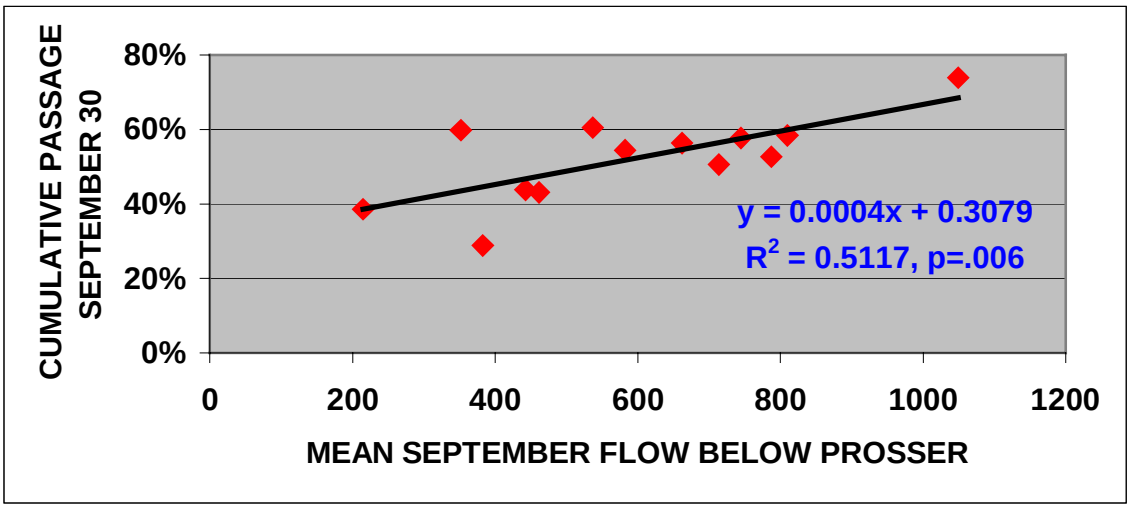


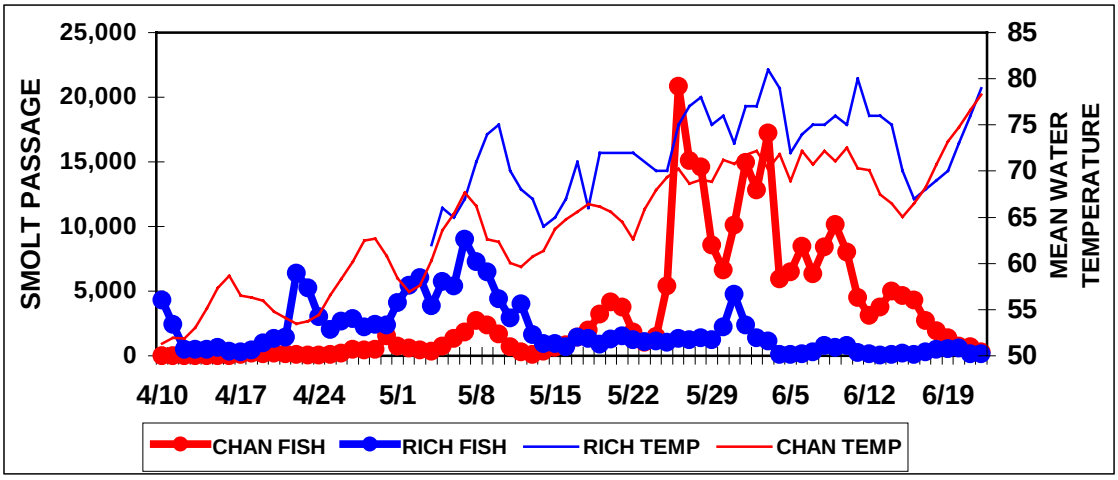
Figure 22: Relationship between mean September flow below Prosser Dam and cumulative passage of fall chinook adults on September 30, 1983 – 1999



adjust for travel time. Between May 26 and June 10, passage at Chandler averaged 10,538 fish per day, and totaled 174,624 fish. Comparable figures for the trap at Richland, 40 miles downstream, were 1,246 and 19,929[4], respectively. This loss of fish is all the more remarkable in light of the fact about 70% of Yakima fall chinook spawn below Chandler. During this period, mean daily water temperatures at Richland averaged 76°F, and ranged from 72 to 81° F. Temperatures at Chandler averaged 71°F, ranging from 69 to 73°F. Evidently the smolts were able to cope with the temperatures at Chandler, but not those further downstream.

[4] Note that the figures for the Richland screw trap are estimates of *passage*, not raw catch. Were generated by dividing daily catches by 0.045, the mean entrainment rate estimated from the recapture of marked fish.

Figure 23: Estimated daily passage of fall chinook smolts at Chandler and near Richland (RM 8.0), and mean daily temperatures in degree F, April–June, 1992



Spawning is relatively concentrated above Prosser Dam, and appears to be synchronous in Marion Drain and the mainstem (Hubble, YN, pers comm 1999). It begins about the middle of October, peaks the first week of November, and is complete by the third week of November. Spawning in the lower mainstem, however, apparently includes some fish that spawn much later than the norm. WDFW biologists operated a screw trap in the lower river in 1990 and captured 35 mm newly-emergent fry in May, when most fall chinook were 80-100 mm smolts (Busack et al., 1991). A spawning timing of late December or early January would be consistent with a May emergence.

There are striking differences in age distributions and sex ratios between the two fall chinook stocks. Curt Knudsen (WDFW, personal communication, 1992) estimated that the mean proportion of fish that were ocean age 1 through 4 in the mainstem stock was, respectively, 12%, 12%, 66% and 11%. By contrast, the age distribution for Marion Drain fish for the same ages was 48%, 46%, 6% and 0%. These figures represent the mean values observed in spawner/GSI surveys in 1989-1991, and incorporate corrections for sex- and size-related biases known to skew spawner survey data. Note that nearly half of the Marion Drain population consists of jacks (ocean age 1). Not surprisingly, sex ratios between stocks are equally divergent. The mean sex ratio in Marion Drain is 73% males and 27% females. By contrast, the sex ratio for the mainstem stock is 46% males and 54% females. These figures are based on spawner/GSI surveys in 1989 and 1990, and fish counts through the Horn Dam ladders and a picket weir in Marion Drain in 1992 (Busack et al., 1991; Seiler, 1992).

The highly skewed sex ratio in Marion Drain implies a correspondingly high spawners/redd ratio. The mean ratio observed in 1991 and 1992 was 9.3 spawners/redd. More importantly, the Marion Drain sex ratio implies a low reproductive potential and therefore low productivity, absent unusually high egg-to-adult survival rates or fecundity. Although the fecundity of Marion Drain fish has been estimated only for a handful of fish to date, it can be estimated from mean size-at-age and sex-specific age data for females (Busack et al. 1991), and the length fecundity relationship for spring chinook (Fast et al. 1991). The result of this calculation is 4,728 eggs/female. By contrast, the mean fecundity for mainstem females estimated at 6,106.

Typical emergence timing in the Yakima occurs from mid February to late April. A commonly accepted value for the cumulative thermal units for emergence of fall chinook is 1,600 TU's (Piper 1987). Hubble

(1997) used this value and historical temperature data from Marion Drain, Sunnyside Dam, Prosser Dam, and a regression for temperatures at Richland, to estimate emergence timing for fish spawned in Marion Drain and at various points along the mainstem. Marion Drain is totally fed by groundwater through the winter, and is often 10°F warmer than the mainstem. Accordingly, emergence occurs earliest for Marion Drain fish, ranging from mid-February for eggs deposited by early spawners (mid October) to late March for late spawners (mid November). In the mainstem, emergence does not occur before late March and extends into the third week of April.

Productivity and Trends in Abundance

Table 12 summarizes the productivity parameters for a combined mainstem/Marion Drain fall chinook population spawning and rearing above Prosser Dam. The figures in the table entailed a number of assumptions relating to the proportion of Marion Drain and mainstem fish in the spawning escapement, spawning escapement in Marion Drain, etc, and so should be interpreted as rough approximations. The mean in-basin productivity is 120 smolts per spawner which, adjusting for the differing contributions of Marion Drain and mainstem fish over years, translates to a mean egg-to-smolt survival rate of 9.0% (range 0.2 to 27.9%). For such a population to be self-sustaining, the mean smolt-to-adult survival rate must be at least 1/120 or 0.83%. In this analysis, the mean out-of-basin productivity (smolt-to-adult survival rate) is 1.7% (range 0.5 to 5.0%). If these rates were estimated exactly, their product (2.07) would be the adult recruitment rate. Adult recruitment, estimated on the basis of adult counts, is 1.66, indicating perhaps the smolt-to-adult survival rate has been overestimated by an undetermined number of unmarked hatchery adults included in the wild spawning escapement. An adult recruitment rate of 1.66 is

Table 12: Estimated natural production productivity parameters for the combined mainstem and Marion Drain Yakima fall chinook population spawning above Prosser Dam, 1983 – 2000

YEAR	WILD SMOLTS	ALL WILD SPAWNERS	SMOLT-TO-ADULT SURVIVAL	SMOLTS PER SPAWNER	ADULT RECRUITMENT RATE	MEAN TEMP (°F)[a]
1983	103,521	380	0.58%		1.34	
1984	43,586	1331	1.17%	115	0.49	
1985	68,181	273	0.96%	**51**	1.39	
1986	33,380	731	1.14%	122	0.97	
1987	154,307	486	0.46%	210	2.23	69.7
1988	76,205	220	1.42%	142	6.35	69.5
1989	27,841	576	5.01%	120	1.74	67.6
1990	110,792	1161	0.91%	165	0.96	68.2
1991	55,083	823	2.03%	**37**	1.41	65.9
1992	253,455	1442	0.46%	261	0.83	74.2
1993	148,709	855	0.81%	92	1.34	69.0
1994	195,613	976	0.59%	184	1.20	72.3
1995	33,386	1241	3.51%	**22**	1.33	65.7
1996	6,512	1190		**5**		64.3
1997	35,578	992	5.02%	**26**		59.7
1998	406,814	1081		363		67.6
1999	45,702	1880		**40**		61.7
2000	175,912	1980		93		69.5
MEAN	**109,699**	**979**	**1.72%**	**120**	**1.66**	**67.5**

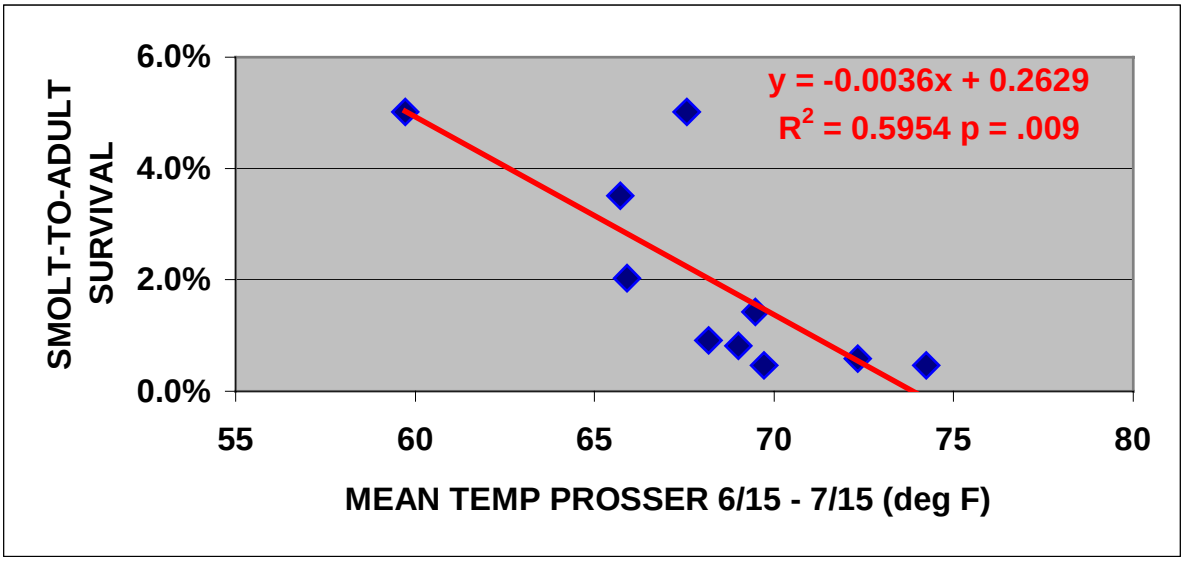
[Mean water temperature at Prosser Dam over the period June 15 – July 15. A continuous thermal record of Prosser water temperature does not exist prior to 1987]

large enough to provide a measure of security for perpetuation of the population, but not large enough to sustain a significant fishery.

The seven brood years with the lowest smolt production rates (Table 12) encountered very high water and presumably a measure of redd scouring during incubation. From earliest to most recent: brood year 1984 -- 15,936 cfs on January 27, 1984; brood year 1990 -- 22, 432 cfs on November 22, 1990; brood year 1994 -- 17,406 CFS on February 23, 1995; brood year 1995 - 46,400 cfs on February 10, 1996; brood year 1996 -- 18,642 cfs on March 22, 1997; and brood year 1998 – 14,174 cfs on December 10, 1998. One might speculate that flows of this magnitude would not have had such an impact historically, when the river was free to expand laterally and spread its power over a much wider area.

One other relationship is apparent in Table 12; the adverse impact of late-spring water temperatures in the lower river on smolt-to-adult survival rates. Figure 24 plots smolt-to-adult survival against the mean water temperature at Prosser Dam over the period June 15 – July 15. The implication of this relationship is that, above 60°F, every increase in water temperature of about 10°F in the late spring will lower smolt-to-adult survival by about half.

Figure 24: Relationship between smolt-to-adult survival for wild Yakima fall chinook and mean water temperature at Prosser Dam over the period June 15 - July 15



Summer Chinook

The Yakima River continued to support endemic summer chinook until the early 1970s. A total of three summer chinook redds were counted in the Yakima River between the confluence of the Naches River and Ahtanum Cr. in 1970 (YIN et al. 1990), the last year summer chinook redd surveys were conducted. Prior to the 1970s summer chinook spawned in the Yakima mainstem from approximately Marion Drain to Roza Dam, and in the lower Naches from its mouth to the Tieton confluence (RM 17.5). Kreeger and McNeil (1993) and Yakama Subbasin Plan (1990) estimate historical abundance at 86,000 and 100,000, respectively.

Summer Steelhead

Stocks and Distribution

Summer steelhead distribution (known, presumed, historic/potential) in the Yakima River watershed (WRIAs 37-39) is shown on the summer steelhead species map (see Map 3 in the separate Maps file included with this report) and in the supporting fish distribution reference data table in Appendix A. Historically, steelhead were probably found wherever spring chinook were found, and in many other tributaries and reaches as well. Yakima steelhead spawn in intermittent streams (Hubble 1990), side channels of larger rivers (Pearsons et al.), and in smaller streams and streams with steeper gradients than are suitable for spring chinook or coho. Except possibly for streams at the highest elevations (USBOR 2000; Mullan), any reach in the basin with at least pocket of gravel at suitable depths and velocities can and probably will be used by steelhead spawners. Therefore it is probable that the historical spawning distribution of summer steelhead included virtually all accessible portions of Yakima Basin, with highest spawning densities occurring in complex, multi-channel reaches of the mainstem Yakima and Naches, and in third and fourth order tributaries with moderate (1-4%) gradients. Estimates of the size of the historical steelhead run range from 20,800[5] (Kreeger and McNeil 1993) to 100,000 (Smoker 1956).

Table 13 summarizes the life history diversity, productivity and equilibrium abundance of a number of stocks of Yakima Basin steelhead under current and historical conditions as estimated by an initial EDT simulation made in the spring of 2000. The EDT simulation predicted a historical population of about 43,000 adults, a figure midway between the Kreeger and McNeil and Smoker estimates. It is noteworthy that the EDT-based estimates for *current* mean adult return and smolt production of about 1000 and 61,000, respectively, agree rather well with recent observations.

The current distribution of Yakima Basin steelhead is much more restricted and spatially variable than it was historically. Well over half of the spawning occurs in Satus and Toppenish Creeks, with a smaller proportion in the Naches drainage and a much smaller proportion in the upper Yakima (the Yakima mainstem and tributaries upstream of the Naches confluence) (Hockersmith et al. 1995). Summer steelhead spawner distribution in recent years is shown in Current steelhead abundance is only about 1.3 to 6% of historical estimates, averaging 1,256 fish (range = 505 in 1996 to 2,840 in 1988) over brood years 1985[6] - 2000.

In 1989, Yakima steelhead returns declined sharply from the 2000- to 3000-fish runs seen in the late 1980's. Except for 1992, abundance has fluctuated around 1000 fish since 1989.

Table 13 indicates that all areas were much more productive historically than currently, and that a much larger proportion of life histories were viable. Also notable is the fact that the upper Yakima is identified as the area supporting the largest steelhead population in historical times, whereas now it supports the smallest.

There are a number of reasons to believe that the historical upper Yakima was in fact the largest steelhead-producing area, and a number of factors can be cited as contributing to its decline. The upper Yakima clearly should have been a major steelhead producer because its total area is greater than any other, and it provided habitat types including complex, alluvial mainstem reaches and third- and fourth-order tributaries (e.g., Wilson, Manastash and Taneum Creeks) that still provide good steelhead habitat

[5] Mean of range estimated – 18,200 to 23,400.

[6] Prior to the run of 1984-85, it was impossible to use the ladders at Prosser Dam to count adult steelhead, and estimates of runsizes before the 1985 brood are based on estimated catch and an assumed exploitation rate.

Table 13: Estimated steelhead performance parameters in the Yakima subbasin as estimated by an initial EDT simulation made in April 2000

Area	Sub Area	Life History Diversity	Productivity	Adult Equilibrium Abundance	Smolt Equilibrium Abundance
Historical Production					
Lower Yakima	Satus	52.0%	20.3	4,802	59,519
	Toppenish	68.0%	18.7	6,205	76,000
	Ahtanum	100.0%	7.6	1,745	20,580
	Lower Mainstem Yakima	52.0%	26.6	4,310	55,090
Naches	American	100.0%	18.1	1,419	15,513
	Naches excluding American	92.0%	16.7	11,016	124,339
Upper Yakima	Upper Yakima	91.0%	19.0	13,434	151,319
	Total			**42,931**	**502,359**
Current Production					
Lower Yakima	Satus	22.1%	2.0	288	18,028
	Toppenish	19.2%	1.5	173	11,891
	Ahtanum	8.7%	1.2	11	781
	Lower Mainstem Yakima	0.0%	0.0	0	0
Naches	American	58.8%	1.4	46	2,743
	Naches excluding American	11.3%	1.9	335	20,240
Upper Yakima	Upper Yakima	13.6%	1.2	125	7,242
	Total			**979**	**60,925**

where they are not affected by irrigation withdrawals and agricultural development (Johnston, 1989). Just as clearly, several factors played a large role in the decline of steelhead production in the upper Yakima. The most severe of these factors were the structural simplification of most of the anastomosing reaches of the mainstem, the partial or total blockage of spawning tributaries by irrigation diversion dams, and the wholesale entrainment of smolts in tributary and mainstem irrigation diversions. Another irrigation-related impact was the release of large volumes of water from storage reservoirs in the summer, when steelhead fry are just emerging and are incapable of holding position against high flows. In a river like the Yakima, swept clean of large woody debris by 30 years of log drives, significant downstream displacement of fry to less suitable lower river areas is probable. Stranding of fry and parr in shallow side channels during frequent, artificial flow fluctuations is another probable irrigation-related impact.

The completion of Roza Dam in 1941 is an impact that negatively distinguishes the upper Yakima from all other steelhead production areas. Between 1941 and 1959, the ladder at Roza Dam was dewatered whenever the pool was lowered at the end of the irrigation season. During this period, the pool was down, on average, from October 19 through March 17 (USBOR HYDROMET data). This dewatering made the upper Yakima inaccessible to most fall-run steelhead, and provided only a narrow window of opportunity for spring-run fish needing to reach spawning areas miles upstream by April or May. A new ladder was installed in 1989 that allows full access to the upper Yakima so long as the pool is either completely up or completely down.

There are other factors that probably affect steelhead production in the upper Yakima at the present time. Some are the genetic or behavioral legacy of the long period of reduced access, and some are the outcome of intra-specific competition in the existing, non-normative system.

In light of the fact that steelhead spawners were almost totally excluded from the Yakima Basin above Roza Dam for 18 years, it is rather surprising that the area produces any steelhead at all. Are steelhead in the process of recolonizing the upper Yakima, now that full adult access has been restored? Are upper Yakima steelhead the subdominant anadromous ecotype of an *O. mykiss* population selected for residency by many years of restricted adult access and low smolt-to-adult survival? And what role does relative rainbow/steelhead productivity play in the issue? Given the high growth rates and favorable survival rates (after the fry stage) that characterize upper Yakima *O. mykiss* populations (Pearsons et al 1994), the productivity (adult progeny/spawner) of resident fish must be considerably greater than for anadromous fish, which must survive two to three more years, including a round-trip through the lower Yakima River, before reaching reproductive maturity. Indeed, in an initial allopatric EDT simulation of rainbow and steelhead production in the upper Yakima, the productivity of the rainbow population was over three times larger than the productivity of steelhead. In this light, it seems inevitable that the composite rainbow/steelhead population in the upper Yakima should be weighted toward the resident ecotype at this time.

These questions have not yet been answered. This uncertainty is difficult because different answers entail different kinds of enhancement programs. One need only consider two logical alternatives and their implications to get a sense of the importance surrounding these issues. First, suppose anadromy is strongly heritable and the existing upper Yakima "steelhead" population has been selected for residency. In that case, a local-stock supplementation program would be futile: almost all "smolts" would "residualize". Even restoration of normative habitat conditions would fail to increase steelhead abundance until enough time had elapsed for the newly-favored anadromous genotype to become dominant. In this case, a better approach would be to introduce "real steelhead" from a nearby population (e.g., Naches stock) in concert with habitat projects geared toward improving egg-to-smolt survival. If, on the other hand, anadromy is determined largely by environmental conditions, the appropriate response is to restore conditions that favor smolt production over sexual maturation, and that increase smolt-to-adult survival.

At the core of these post-passage restoration issues lies the fundamental question of the mechanism that determines residency and anadromy in *O. mykiss* populations. Surprisingly little research has been done in this area. It is known that some areas support sympatric populations of steelhead and rainbow that are reproductively isolated while others are not: steelhead breed with rainbow and vice versa (Zimmermann 2000). In addition many rainbow trout populations have been observed to produce occasional smolts, just as many steelhead populations occasionally produce individuals that live out their lives entirely in fresh water. What is not known is the relative importance of heredity and the environment: specifically whether or under what circumstances environmental conditions can tip a genetically equipotential population from a stable equilibrium dominated by one ecotype to a stable equilibrium dominated by the other.

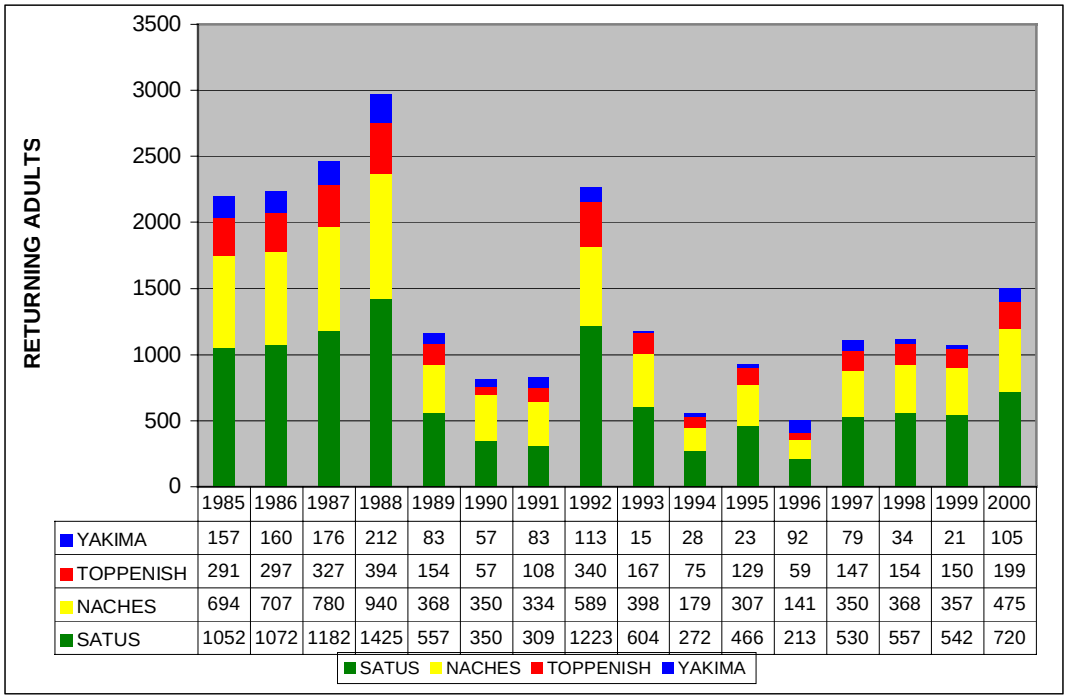
While this issue and its implications are most serious in the upper Yakima, they are important wherever resident and anadromous *O. mykiss* coexist. Resident and anadromous ecotypes are both present in the Naches drainage (Pearsons 1996) and probably in the middle Yakima (the Yakima mainstem from Roza Dam to Sunnyside Dam), but only the steelhead ecotype seems to be present in Satus and Toppenish Creeks. The latter assertion is based on the fact that very few three-year-olds and no four-year-olds were found among large numbers of juveniles sampled in the 1980s and 1990s, and the fact that the few three-year-olds observed were very smolt-like in appearance.

The genetic composition of historical steelhead populations in the Yakima Basin is unknown, but a considerable amount is known about the genetic structure of the existing populations of rainbow and steelhead in the basin. Busack and Phelps (1996) performed a number of electrophoretic analyses on rainbow trout and steelhead of both wild and hatchery origin collected at 14 sites over six years. On the basis of a large number of paired comparisons of allozyme frequencies, Busack and Phelps determined there are four genetically distinct population of wild steelhead in the basin: an upper Yakima stock, a Naches stock, a Satus Creek stock and a Toppenish Creek stock. They also determined from admixture analyses that wild rainbow and steelhead from a number of locations in the upper Yakima interbreed. Although a comparable analysis of wild Naches trout and steelhead was not performed, it was determined that hatchery trout and Naches steelhead have interbred, as have hatchery trout and wild steelhead in the upper Yakima. Wild Satus and Toppenish Creek steelhead, on the other hand, showed no evidence of interbreeding with hatchery trout or steelhead.

These findings are consistent with the fact over three million hatchery trout (primarily South Tacoma and Goldendale stock) have been planted in the upper Yakima and Naches since 1950, and that 1.6 million hatchery steelhead (primarily Skamania stock) have been planted in the upper Yakima and Naches since 1961. Hatchery rainbow trout have never been released in either Satus or Toppenish Creek and, except for one release of 25,000 hatchery-reared Yakima-stock smolts made in Toppenish Creek in 1989, the same is true for hatchery steelhead.

In summary, Yakima steelhead populations comprise four genetic stocks, two of which, the upper Yakima and Naches stocks, are sympatric with wild resident trout. Both of these stocks interbreed with both hatchery and wild rainbow trout. Finally, both wild Naches and upper Yakima steelhead have interbred with Skamania stock hatchery steelhead, although no wild sample indicated more than a 20% infusion of Skamania genes (Busack and Phelps 1996).

Figure 25: Estimated returns by stock of Yakima Basin summer steelhead, 1985 – 2000



	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
YAKIMA	157	160	176	212	83	57	83	113	15	28	23	92	79	34	21	105
TOPPENISH	291	297	327	394	154	57	108	340	167	75	129	59	147	154	150	199
NACHES	694	707	780	940	368	350	334	589	398	179	307	141	350	368	357	475
SATUS	1052	1072	1182	1425	557	350	309	1223	604	272	466	213	530	557	542	720

Hockersmith et al (1995) successfully monitored 105 radiotagged steelhead to spawning over brood years 1990 – 1992. Because high and turbid water in the Naches and Yakima mainstem during steelhead spawning precludes redd counts, this radio-tagging data is the only means of estimating the stock composition of the run. The mean percent over all three brood years of radiotagged fish that spawned in Satus Creek, Toppenish Creek, the Naches Subbasin and the upper Yakima mainstem was 48.0%, 31.6%, 13.3% and 7.1%, respectively. These percentages, in combination with adult steelhead counts at Prosser Dam (brood years 1985–2000) and Roza Dam (brood years 1993–1996 and 1998–2000), were used to estimate the stock-specific total returns for steelhead depicted in Figure 25.

Yakima Basin summer steelhead have been included in the Middle Columbia River (MCR) Evolutionarily Significant Unit (ESU; Busby et al. 1986), which was listed under the Endangered Species Act (ESA) as "threatened" on March 25, 1999 (64 FR 14517). The MCR USU includes all wild populations of summer steelhead in the Columbia River and its tributaries from the Wind River to the Yakima River – specifically, the Wind, Deschutes, Yakima, John Day and Umatilla Rivers. The inclusion of Yakima Basin steelhead in the MCR ESU was based on similarities of life history and habitat as well as electrophoretic similarities (Phelps et al. 1994).

Life History and Demographics

Table 14 and Table 15 summarize sex-specific age data for Yakima Basin summer steelhead collected at Prosser Dam for brood years 1990–1992. As Prosser Dam lies below almost all spawning areas, the data collected there represents a composite across all four stocks. Age was determined by scale analysis. This is the most comprehensive age data yet collected for Yakima steelhead, although adults collected as broodstock in 1986 and 1987 were also aged, as were a small number of adults sampled in the 1983 sport fishery. Over all collections and both sexes, the mean proportion of 1-, 2- and 3-salt fish are 52.4%, 44.2% and 3.3%. Total age, also averaged over all collections and both sexes, for total ages three through seven, is 8.0%, 49.1%, 38.2%, 4.3% and 0.4%, respectively. The mean sex ratio over the 1990-1992 brood years (the only dataset in which both sexes were accounted for) was 68.5% female and 31.5% male.

Table 16 summarizes what is known about stock-specific smolt ages. Except for the Satus stock, the age composition of Yakima juveniles identified as smolts is fairly typical of what is seen in Washington and Oregon, with 10-14% age-1 fish, 71-85% age-2 fish and 5-18% age-3 fish. Also typical is the change in smolt ages as reflected in adults, which in this case show mean freshwater ages ranging from 0-17%, 83-100% for ages 1 and 2, respectively, and no age-3 smolts. The downward shift in the smolt age distribution as reflected by adults relative to juveniles is usually attributed to a combination of three factors: the likelihood that some of both the age-3 and age-1 fish were not steelhead, but trout; the likelihood that some of the age-1 fish were actually steelhead parr migrating into larger waters for their final year of rearing; and the likelihood that some of the true age-1 steelhead smolts suffered higher mortality rates because of the size-related vulnerability to a wider range of predators. The Satus stock is, however, unusual both in having such a large percentage of age-1 smolts and in their surviving to returning adult. Presumably this is due to the warm temperatures of Satus Creek, in which steelhead fry emerge in May, and in being so productive that 40-50% of steelhead juveniles reach smolt status as yearlings.

Table 14: Sex-specific ocean and total ages, Yakima Basin summer steelhead collected at Prosser Dam, brood years 1990 – 1992 (all stocks)

BROOD YEAR AND AGES		FRACTION OF MALES THAT ARE AGE x	FRACTION OF FEMALES THAT ARE AGE x	FRACTION OF ALL FISH THAT ARE AGE x MALES	FRACTION OF ALL FISH THAT ARE AGE x FEMALES	FRACTION OF ALL FISH THAT ARE AGE x
1990	1 SALT	66.7%	62.5%	18.2%	45.5%	63.6%
	2 SALT	16.7%	37.5%	4.5%	27.3%	31.8%
	3 SALT	16.7%	0.0%	4.5%	0.0%	4.5%
	Total	**100.0%**	**100.0%**	**27.3%**	**72.7%**	**100.0%**
	Total age 3	0.0%	6.3%	0.0%	4.5%	4.5%
	Total age 4	66.7%	56.3%	18.2%	40.9%	59.1%
	Total age 5	16.7%	37.5%	4.5%	27.3%	31.8%
	Total age 6	16.7%	0.0%	4.5%	0.0%	4.5%
	Total age 7	0.0%	0.0%	0.0%	0.0%	0.0%
	Total	**100.0%**	**100.0%**	**27.3%**	**72.7%**	**100.0%**
1991	1 SALT	50.0%	30.0%	10.5%	23.7%	34.2%
	2 SALT	50.0%	63.3%	10.5%	50.0%	60.5%
	3 SALT	0.0%	6.7%	0.0%	5.3%	5.3%
	Total	**100.0%**	**100.0%**	**21.1%**	**78.9%**	**100.0%**
	Total age 3	25.0%	13.3%	5.3%	10.5%	15.8%
	Total age 4	25.0%	23.3%	5.3%	18.4%	23.7%
	Total age 5	50.0%	56.7%	10.5%	44.7%	55.3%
	Total age 6	0.0%	3.3%	0.0%	2.6%	2.6%
	Total age 7	0.0%	3.3%	0.0%	2.6%	2.6%
	Total	**100.0%**	**100.0%**	**21.1%**	**78.9%**	**100.0%**
1992	1 SALT	74.4%	56.5%	26.9%	36.1%	63.0%
	2 SALT	23.1%	40.6%	8.3%	25.9%	34.3%
	3 SALT	2.6%	2.9%	0.9%	1.9%	2.8%
	Total	**100.0%**	**100.0%**	**36.1%**	**63.9%**	**100.0%**
	Total age 3	15.4%	7.2%	5.6%	4.6%	10.2%
	Total age 4	66.7%	63.8%	24.1%	40.7%	64.8%
	Total age 5	15.4%	26.1%	5.6%	16.7%	22.2%
	Total age 6	2.6%	2.9%	0.9%	1.9%	2.8%
	Total age 7	0.0%	0.0%	0.0%	0.0%	0.0%
	Total	**100.0%**	**100.0%**	**36.1%**	**63.9%**	**100.0%**

Table 15: Percent of radiotagged steelhead observed spawning in various tributaries and reaches, brood years 1990-1992 (Hockersmith et al. 1995)[Toppenish stock includes fish spawning in Marion Drain]

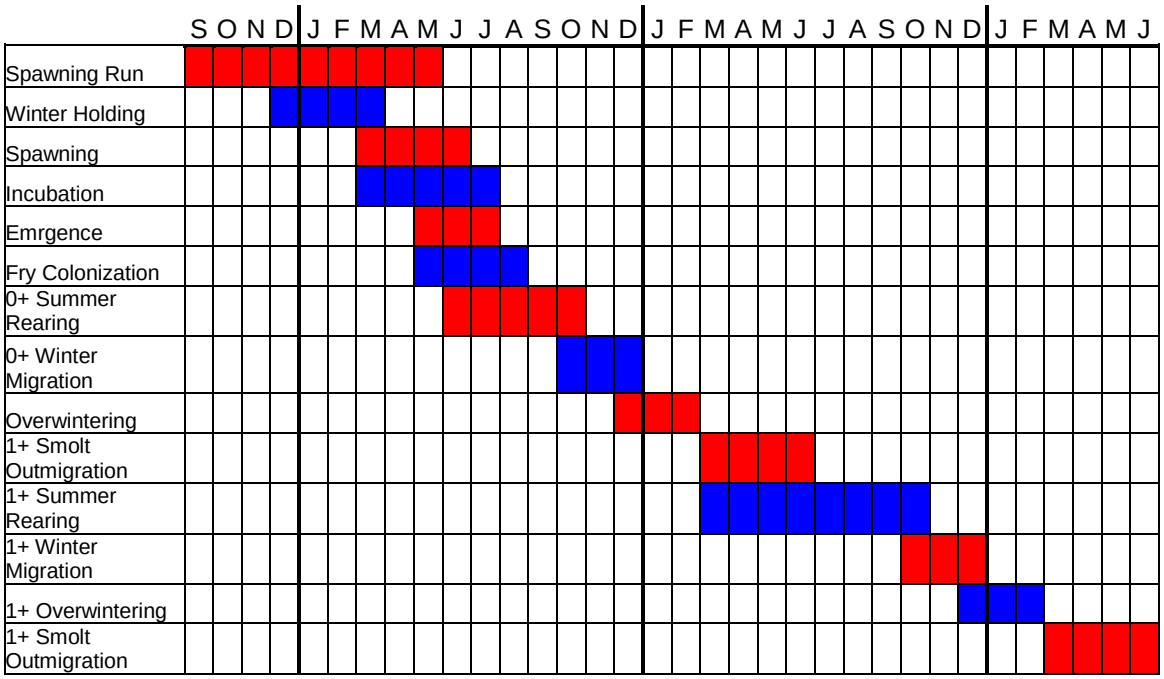
STOCK	BROOD YEAR			
	1990	1991	1992	MEAN ALL YEARS
SATUS	43%	37%	54%	48.0%
NACHES	43%	40%	26%	31.6%
TOPPENISH	7%	13%	15%	13.3%
YAKIMA	7%	10%	5%	7.1%

Table 16: Estimates of ages of Yakima steelhead smolts by stock as determined from scales sampled from smolts and scales sampled from adults (Busack et al 1991; YN, unpublished data, 2001)

STOCK	Smolt age determined from smolts			Smolt age determined from adults		
	1	2	3	1	2	3
Satus	42%	57%	1%	37%	63%	0%
Naches	14%	75%	12%	10%	90%	0%
Toppenish	10%	85%	5%	0%	100%	0%
U. Yakima	11%	71%	18%	17%	83%	0%
Basin-wide	41%	56%	4%	23%	77%	0%

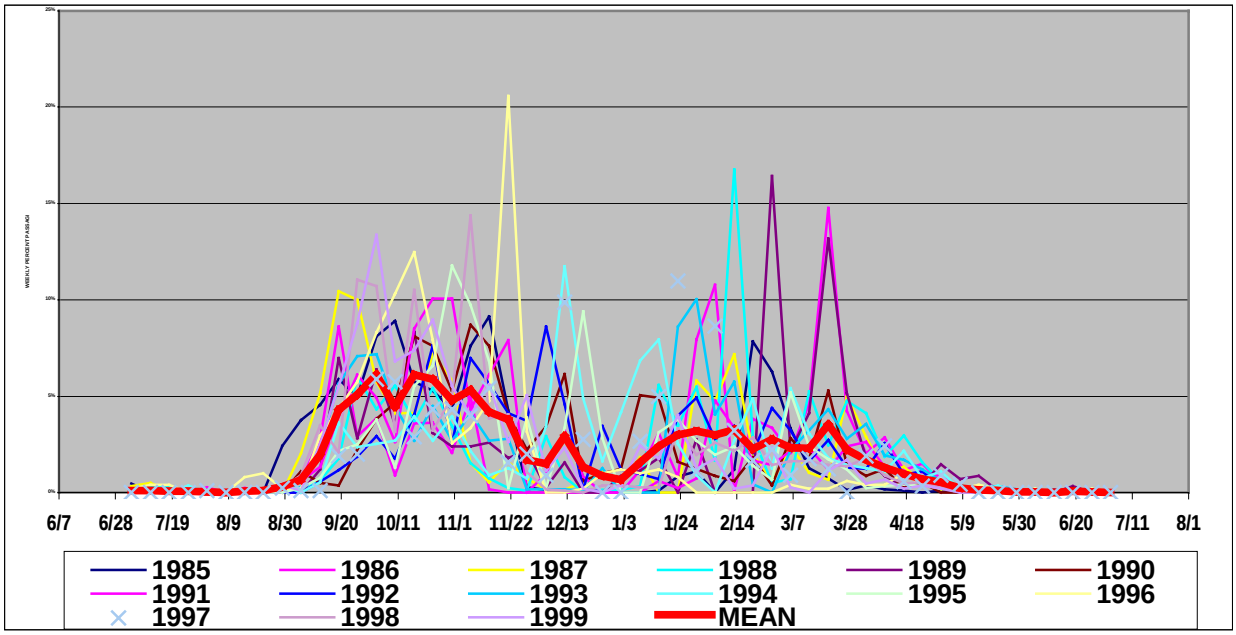
Yakima steelhead are relatively small, as might be expected for fish that are 52% 1-salts. The mean fork length of the fish sampled in the 1990 – 1992 broods was 66.5 cm (about 26 inches), and the mean weight was about 3.0 kg (about 6.7 lbs). In spite of their size, Yakima steelhead are quite fecund. Mean fecundity for fish collected as broodstock in brood years 1986, 1987, 1989, and 1990-1993 was 5,100 eggs. The duration of the successive freshwater life stages of all four stocks of Yakima summer steelhead is summarized in Figure 26 (Note: the duration of life stages for age-3 smolts is identical to that for age-2 smolts).

Figure 26: General duration of successive life stages in for Yakima Basin summer steelhead (all stocks)



Steelhead adults begin passing Prosser Dam in September, cease movement during the colder parts of December and January, and resume migration from February through June (Figure 27). The run has two peaks, one in late October, and one in late February or early March. The relative numbers of wild fish returning during the fall and winter-spring migration periods varies from year to year, perhaps depending on the duration of a "thermal window" in the fall.

Figure 27: Weekly percent passage of wild adult summer steelhead at Prosser Dam, 1985-1999



Studies of steelhead radiotagged and released at Prosser Dam over the years 1990 - 1993 (Hockersmith et al. 1995) indicate that most "fall-run" steelhead spawners overwinter in the mainstem Yakima, in reaches with deep holes and low velocity. About 25% hold below Prosser Dam, 60% between Prosser Dam and Sunnyside Dam (many in the vicinity of the Satus Creek confluence) and 6% between Sunnyside Dam and Roza Dam. Only about ten percent of the fish held in Satus Creek, Toppenish Creek, Marion Drain the lower Naches River, or the upper Yakima combined.

The final migration to the spawning grounds begins between January and May, generally with fish that will eventually spawn in lower elevation tributaries beginning to move earlier. There is some evidence that the cue triggering this final run is thermal, as very few fish ascended Satus Creek during mid-winter floods, and virtually none of the eventual Naches spawners began moving until water temperatures reached 3°C (Hockersmith et al. 1995).

Most Yakima steelhead are tributary spawners. Over 90% of the steelhead tagged in the Hockersmith study spawned in the Naches River and tributaries, Satus Creek or Toppenish Creek.

In Satus Creek, 70% of the spawning occurs in three areas: Satus Creek between Logy and Bull Creek (RM 23.6 – 36.0), in Dry Creek (confluence at Satus RM 18.7) and in Logy Creek (confluence at Satus RM 23.6). The remainder occurs in smaller tributaries and various Satus Creek reaches above Dry Creek (confluence at Satus RM 8.0), including 15% that spawn in tributaries that regularly go dry by mid to late May.

Spawning timing is the earliest in the basin, and is relatively protracted. Hockersmith et al. believed spawning began in February and YN biologists have observed spawning in mid March. The peak is in early April and with the last activity occurring in early May.

In the Naches, 69% of spawning occurs in only two reaches, the Naches between Cowiche Cr. (RM 2.7) and the Tieton River (RM 17.5), and the Naches between Rattlesnake Creek (RM 27.8) and the Little

Naches River (RM 44.6). The Bumping River (confluence at Naches RM 44.6) and the Naches between the Tieton River and Rattlesnake Creek each support 11.5%, and Rattlesnake Creek and the Naches from the mouth to Cowiche Creek each support 3.8%. Importantly, about 43% of all spawning occurs below the Tieton River confluence, and progeny are therefore subject to the most severe impacts of flip-flop. No spawning has been observed in the Tieton River or the American River. The lack of spawning in the Tieton is to be expected, in light of the fact it has been swept virtually clean of spawning gravel, but the absence of steelhead from the American River, one of the most pristine streams in the basin, is puzzling. In the Naches as elsewhere in the basin, spawning begins earliest at the lowest elevations. From radiotagging data and records of the first observations of steelhead fry, steelhead spawn in the lower Naches (below Tieton) and its tributaries from early March through mid May. In the upper Naches, the spawning period is from late March through late May. In the higher elevation tributaries of the upper Naches (the Little Naches River, Bumping River, Rattlesnake Creek), spawning occurs from late April through late May, with peak in early May.

Toppenish Creek drains a large watershed (~650 mi^2), but only the upper half of the drainage is used for spawning. Over 57% of the steelhead spawning in Toppenish Creek occurs from Willy Dick Creek (RM 48.5) to Panther Creek (RM 69.2); the remainder occurs in the major tributary to Toppenish Creek, Simcoe Creek, which is also located relatively high in the drainage (confluence at Toppenish RM 32.7). In upper Toppenish Creek, about 60% of the spawning occurs in Toppenish Creek itself, with the remainder in two small tributaries. All but 9.7% of the spawning in the Simcoe drainage occurs in a number of small tributaries. Several of the upper Toppenish and Simcoe Creek tributaries are intermittent. Marion Drain is an irrigation return which parallels Toppenish Creek and into which Toppenish Creek water is diverted. It is probable that all of the steelhead that spawn in Marion Drain are or were ancestrally Toppenish Creek fish, lured into a cul de sac by Toppenish Creek water. The Toppenish Creek stock would be about 15% larger if the Marion Drain fish are included. Steelhead spawn in Toppenish Creek from early March to early May with a peak in early April.

Over 70% of the handful of radiotagged fish that have been called “upper Yakima spawners” actually spawned in the Yakima mainstem below Roza Dam – between Roza Dam and Ahtanum Creek (RM 106.9). Of the remaining 30%, 14% spawned in the Teanaway River and its forks and the remainder in various upper Yakima tributaries and mainstem reaches. As nearly as can be determined spawning occurs in the middle Yakima (the Yakima between Roza Dam and Sunnyside Dam), the upper Yakima mainstem and higher elevation upper Yakima tributaries according to the following approximate schedule:

- Middle Yakima: late February through early April, peak in late March
- Upper Yakima mainstem: in Yakima Canyon (including Umtanum and Wilson/Naneum Creeks), late March to mid May with a peak in late April, and above the Yakima Canyon from mid April to late May with a peak in early May
- Upper Yakima tributaries (Big Cr., Teanaway River, Swauk Cr., Taneum Cr., Manastash Cr.): late April through early June, with a peak in late May.

Using an estimate of 1,300 TU’s for 50% emergence, known or assumed spawning dates, existing water temperature data (when available), and field observations of newly emerged fry (fry 25-30 mm long), fry emergence probably occurs at the following times in the following places:

- Satus Creek: early May to early June
- Toppenish Creek: late May through early July
- Lower Naches and Cowiche: early June through mid July
- Upper Naches: mid June through mid July
- Upper Naches tributaries: late June through late July
- Middle Yakima and tributaries: early June through early July
- Upper Yakima mainstem in Yakima Canyon (including Umtanum Cr and Wilson/Naneum): early June through early July

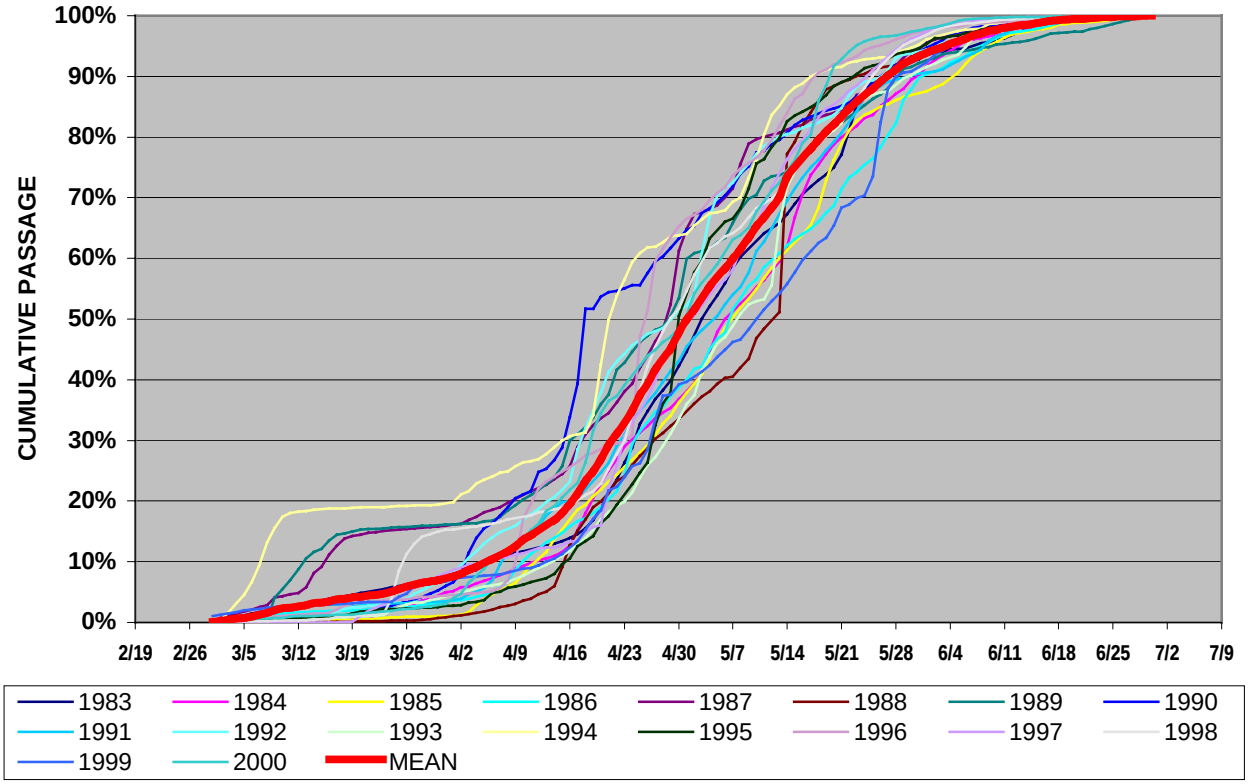
- Upper Yakima mainstem above the Yakima Canyon: mid June through late July
- Upper Yakima tributaries: late June through early August.

Pre-smolt rearing migrations are less well understood for steelhead than they are for spring chinook. The presence of steelhead juveniles in small tributaries throughout the summer, sometimes in high densities, indicates that the fish are less inclined to migrate downstream for early rearing than spring chinook. However, *O. mykiss* juveniles are found in substantial numbers in the Yakima Canyon far from spawning areas, so a gradual downstream dispersal of fry and parr obviously occurs.

As observed at the Chander smolt trap, a lower proportion of steelhead juveniles migrate to the lower river in the winter than do spring chinook. Substantial winter migrations do occur however, albeit perhaps not over so great a distance. In the winter of 1990-91 and the following spring, the YN operated a smolt trap on Satus Creek just below the Logy Creek confluence. A third more steelhead juveniles moved past the Satus Creek trap that winter than the following spring. A distinct pulse of steelhead juveniles were also seen in the late fall at a smolt trap operated at Wapatox Dam from 1984 – 1990, although icing always forced closing of the trap by early December at the latest, precluding estimates of the relative magnitude of spring and winter movements. At Chandler virtually all winter movement occurs in February, more than a month after the typical peak of spring chinook movement.

At Chandler, the steelhead smolt outmigration begins in late February and ends in mid June (Figure 28). Statistically, the mean date of passage for the 10th, 50th and 90th percentiles of the outmigration are April 6, May 1 and May 19. These are almost exactly the same dates as for spring chinook, which are, respectively, April 6, April 23 and May 20. Comparison of Figure 10 and Figure 28 suggest that the outmigration timing of spring chinook is more variable inter-annually than steelhead, even though their

Figure 28: Cumulative passage of steelhead smolts at Chandler smolt trap, 1983-2000



means are similar. In addition the timing of the steelhead outmigration is not accelerated by higher cumulative thermal units the preceding winter, as is the case with spring chinook.

The midpoint of outmigration at Wapatox is also generally around the first week in May. Given the distances involved and smolt migration rates observed, the midpoint of the outmigration of Naches steelhead would not occur at Prosser for at least another week. Thus, as many as half the smolts leaving the Naches River must negotiate the perilous lower river in late-May and early-June.

Productivity and Trends in Abundance

Table 17 summarizes the productivity parameters of the composite Yakima steelhead population: smolts per spawner, smolts-to-adult survival and adult recruitment rate. Both the smolts and the adults in Table 17 were counted at Prosser Dam. Over the period of record, smolt-to-adult survival ranges from 0.8 to 7.4%, with a mean of 3%, and smolt productivity ranges from 8.0 to 222.8, with a mean of 62.4. In six of the 11 years for which adult recruitment rate can be estimated, recruitment was less than 1.0. The adult recruitment rate ranged from 0.31 to 1.79, with a mean of 0.97, a value that justifies the listing of the species under the Endangered Species Act.

Table 17: Steelhead smolt production, adult return and spawning escapement, smolts/returnees and returnees/smolt estimates

Year	Total Smolts	Adult Return			Wild Adults from Smolts Yr X	Brood Year Escapement (Wild + Hatch)	Smolts from Brood Year Escapement	Smolt to Adult Survival	Smolts per Spawner	Adult Recruitment Rate
		Hatchery	Wild	Total						
1983	81,640	N.D.	N.D.	N.D.	1,818			2.23%		
1984	97,920	N.D.	N.D.	N.D.	2,987			3.05%		
1985	65,735	0	2,194	2194	2,249	689	107,329	3.42%	155.78	1.44
1986	120,591	0	2,235	2235	1,858	1408	101,232	1.54%	71.90	0.67
1987	109,934	0	2,465	2465	879	1822	39,168	0.80%	21.50	0.42
1988	70,961	239	2,601	2840	925	2496	31,330	1.30%	12.55	0.75
1989	26,620	96	1,066	1162	1,040	864	22,654	3.91%	26.22	1.06
1990	23,075	87	727	814	1,697	539	31,169	7.36%	57.83	1.28
1991	22,983	104	730	834	845	782	20,054	3.68%	25.64	0.84
1992	36,225	251	2,014	2265	661	2095	16,824	1.82%	8.03	0.31
1993	17,339	80	1,104	1184	657	1089	20,017	3.79%	18.38	0.78
1994	18,738	14	540	554	630	551	30,115	3.36%	54.66	1.79
1995	17,715	98	820	918	881	918	63,729	4.98%	69.42	1.29
1996	45,814	54	451	505	996	485	108,036	2.17%	222.76	
1997	69,450	145	816	961	1,215	961	91,962	1.75%	95.69	
1998	117,765	165	948	1113		1,113	36,697		32.97	
1999	70,293	52	1,018	1070		1,070				
2000	41,361	52	1,448	1500		1,500				
MEAN	**58,564**	**86**	**1357**	**1444**	**1,289**	**1,149**	**51,451**	**3.01%**	**62**	**0.97**
MAX	**120,591**	**251**	**2601**	**2840**						
MIN	**17,339**	**0**	**451**	**505**						

Existing data suggests density-dependence is a significant depressing factor on steelhead productivity as observed at Prosser Dam. Figure 29 and Figure 30 show significant, curvilinear, inverse relationships between adult recruitment rate and smolt productivity as a function of the number of brood year spawners. It is likely that these relationships reflects the fact that the majority of production under current conditions is restricted to Satus and Toppenish Creeks, which obviously have limited carrying capacities.

Figure 29: Yakima smolt productivity (smolts per spawner) as a function of brood year spawners

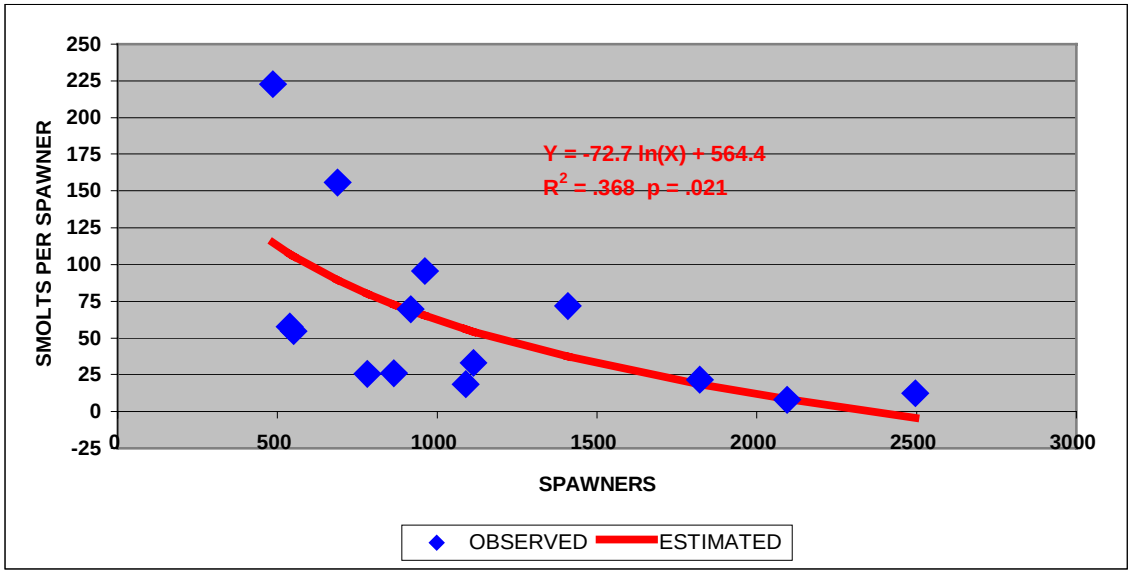
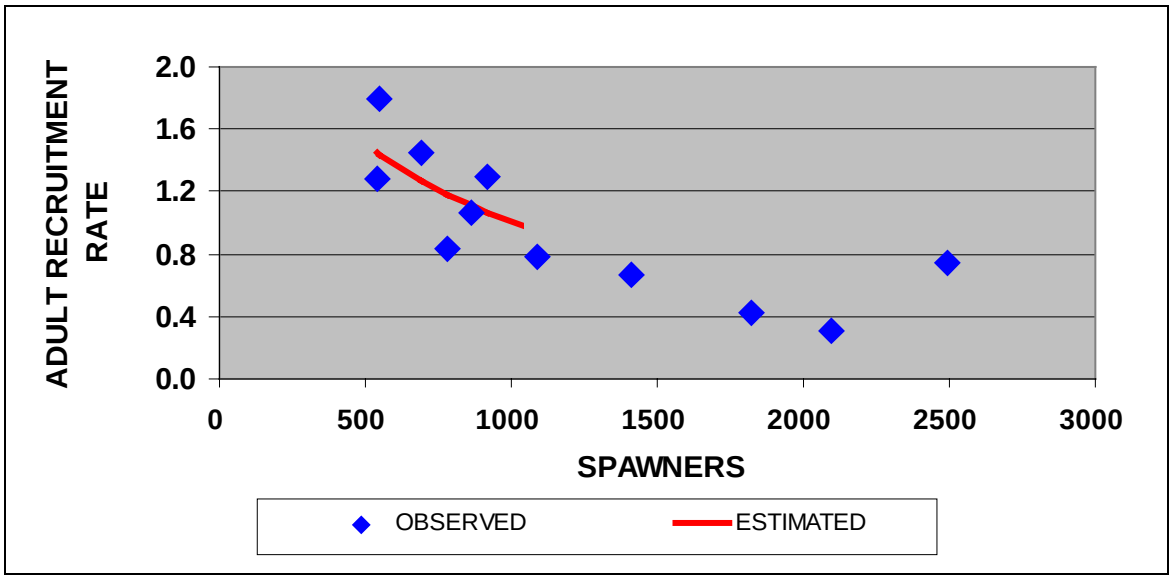


Figure 30: Yakima steelhead adult recruitment rate as a function of brood year spawning escapement



Coho

Stocks and Distribution

Coho distribution (known, presumed, historic/potential) in the Yakima River watershed (WRIAs 37-39) is shown on the coho species map (see Map 4 in the separate Maps file included with this report) and in the supporting fish distribution reference data table in Appendix A. Although endemic coho were extirpated in the early 1980s, natural reproduction of hatchery-reared coho, out planted as smolts, is now occurring in both the Yakima and Naches Rivers. Natural reproduction is evident from the increasing occurrence of zero-aged coho parr in samples taken at numerous points in the basin (YN, unpublished data, 2000). Adult passage data at Roza Dam from 1941-1968 indicate that the endemic stock was early-run. The vast majority of the hatchery coho smolts out planted since 1985 have also been early run. Based on fragmentary WDFW records of spawner surveys, the endemic stock spawned in the upper Yakima above the Cle Elum confluence and in the Naches, primarily in the lower alluvial reaches, below the Tieton confluence. Bryant and Parkhurst (1950) report that coho also spawned in smaller tributaries of the upper Yakima, such as Taneum and Umtanum Creeks, in the early years of the 20th century, and affidavits from early settlers of the Wenatchee basin state that "silvers" were found in virtually every perennial creek and river in the basin before extensive development. It is now assumed that coho utilized virtually every low-gradient, perennial stream in the basin prior to extensive habitat alteration in the late 19th century (CBSP 1990).

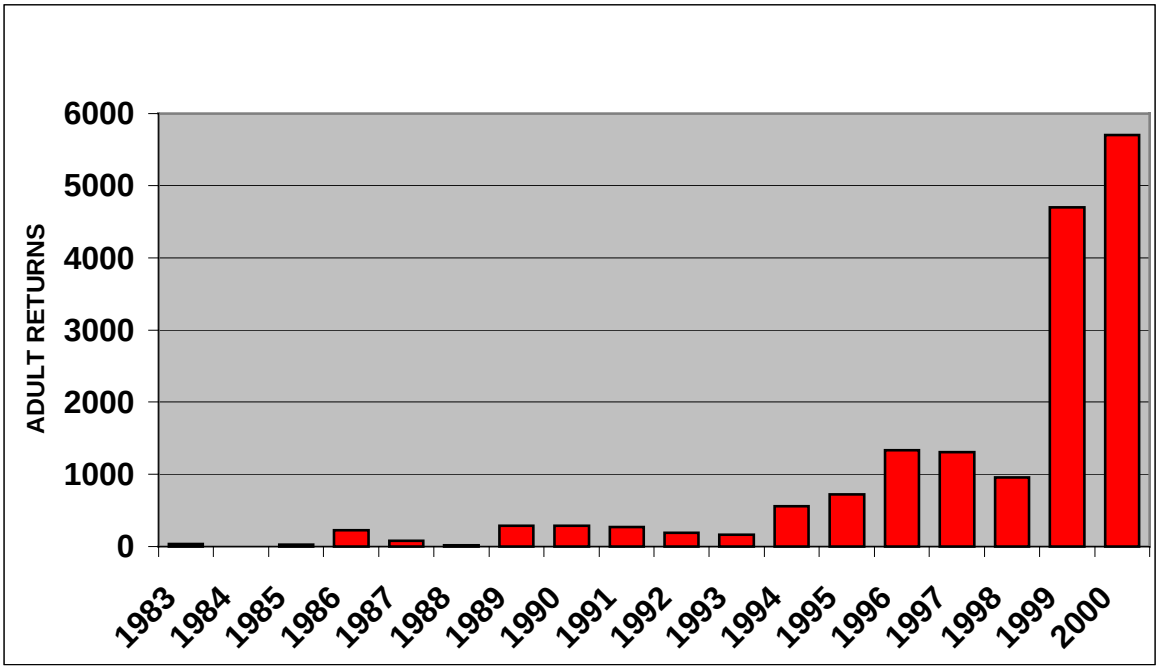
Efforts to restore coho within the Yakima basin rely largely upon releases of hatchery coho. The Yakama Nation has released between 85,000 and 1.4 million coho smolts in the Yakima Basin annually since 1985. However, before 1995, the primary purpose of these releases was harvest augmentation; after 1995, the primary purpose became a test of the feasibility of re-establishing natural production.

The current, naturalized run spawns in reaches downstream of the historical areas because, until 1999, the vast majority of hatchery smolts were acclimated and/or released well downstream of historical spawning areas. Most coho now spawn in proximity to their acclimation and release points, primarily in the middle Yakima below Sunnyside Dam (from RM 95 - RM 104), as was evident from the monitoring of radio tagged adult coho in the fall of 1999 (Dunnigan, 2000). In recent years, coho spawning has been documented in side channels of the mainstem Yakima between Roza Dam and the town of Wapato (~RM 100) and in the Yakima Canyon (RM 129 – RM 146); in Naches River below the Tieton confluence; and in numerous smaller tributaries including Corral Cr., Spring/Snipes Cr., Toppenish Cr., Marion Drain, Wanity Slough, Ahtanum Cr., Wide Hollow Cr., Cowiche Cr., and Buckskin Slough.

Kreeger and McNeil (1993) and (Yakama Subbasin Plan, 1990) estimate the historical coho run at 44,000 and 150,000, respectively. Coho returns to Prosser Dam, since regular outplanting began in 1985, have increased steadily, climbing from 0 in 1984 to a peak of 5,700 in 2000 (Figure 31). Few of the outplanted coho were marked until the current brood year. Therefore the proportion of natural origin recruits in recent returns is unknown.

The spawning distribution and spawning success of coho returning to the Yakima is just beginning to be determined. Earlier attempts to determine the spatial distribution of spawning coho in the Yakima were compromised by difficulty in finding redds. A measure of the problem is the fact the ratio of adults passing Prosser Dam to redds counted later in the season during the period 1989 – 1996 was approximately 25:1. Thus, assuming a 50% sex ratio, only about 8% of the potential redds were discovered (YN 1997).

Figure 31: Returns of coho salmon adults and jacks at Prosser Dam, 1983-2000



A preliminary reproductive success experiment conducted in Wenas Creek in 1998 showed that most female hatchery coho construct redds (Dunnigan 1999). This study also intended to determine egg-to-fry survival for these first generation hatchery fish by capping the redds and collecting and counting the fry as they emerged. High water, unfortunately, prematurely terminated the study.

A three-year radio telemetry study was initiated in 1999 to determine the spawning distribution of coho in the Yakima basin. The first year of this study produced the following findings. Most coho homed back to the general vicinity of the three lowest acclimation sites from which coho smolts were released in the spring of 1998.

Sockeye

Before unladdered dams were built at the outlets of all four natural sockeye rearing lakes, the sockeye run was probably larger than any other in the Yakima Basin in terms of numerical abundance (CBSP 1990). The contemporary dams were constructed by BOR from 1910-1933, smaller log crib dams were built by the Cascade Irrigation District at Kachess in 1904, and by the Union Gap Irrigation District at Cle Elum in 1905. Indications are that even the log crib dam at Cle Elum was a barrier to returning adult anadromous salmonids (see Cle Elum River discussion in the Habitat Limiting Factors by Subbasin chapter of this report). Historically, juvenile sockeye reared in all of the headwaters lakes—Keechelus, Kachess, Cle Elum and Bumping—and adults probably spawned both in the lakes and in feeder tributaries.

Except for a handful of fish returning from experimental releases of hatchery-reared, Wenatchee stock sockeye smolts in the years 1992-1995, and a number of experimental releases of sockeye smolts in the 1940's, sockeye have not returned to the Yakima basin since the1920's (CBSP 1990).

Bull Trout

In the past, wild bull trout *(Salvelinus confluentus)* occurred throughout the Yakima River subbasin. Today, however, they are now fractured into isolated stocks. Although bull trout were probably never as abundant as other salmonids in the Yakima basin, they were certainly more abundant and more widely distributed than they are today (WDFW 1998). In June 1998, the U.S. Fish and Wildlife Service listed bull trout in the Columbia River basin as threatened under the Endangered Species Act. Historical and present distribution in the Yakima River watershed (WRIAs 37-39) is shown on the bull trout species map (see Map 5 in the separate Maps file included with this report) and in the supporting bull trout distribution data in Table 18 and Table 19.

Until recently, nine bull trout stocks were identified in the basin. Distinct stocks are present in the Yakima River, Ahtanum Creek, Naches River, Rimrock Lake, Bumping Lake, North Fork Teanaway River, Cle Elum/Waptus Lakes, Kachess Lake, and Keechelus Lake (WDFW 1998). Recently, due to additional data collection, and review by the Mid-Columbia (Bull Trout) Recovery Unit Team, a total of 13 populations have been identified, Ahtanum Creek (including NF, SF, and MF), Rattlesnake Creek, American River, Crow Creek, SF Tieton River, Indian Creek, NF Teanaway River, Deep Creek, Box Canyon Creek, Upper Kachess River, Gold Creek, Upper Cle Elum River, and Upper Yakima Mainstem (Keechelus to Easton)(USFWS 2001 DRAFT). All thirteen bull trout populations in the Yakima basin are native fish sustained by wild production, as there are no hatchery bull trout stocks in Washington state. According to WDFW, there is no information to indicate that these are genetically distinct stocks; they are treated separately because of the geographical, physical and thermal isolation of the spawning populations. See Table 18 for summary of annual redd counts of these bull trout stocks. The complete bull trout survey database for the Yakima River watershed is included in Appendix B of this report.

Three bull trout life history forms are present in the Yakima basin: adfluvial, fluvial and resident. Adfluvial stocks occur in Rimrock, Bumping, Kachess, Keechelus and Cle Elum/Waptus lakes (WDFW 1998). Adfluvial stocks spawn and, in the early stage, rear in streams, with most growth and maturation occurring in lakes or reservoirs. Adults enter mainstem rivers early in summer, often holding near their natal tributaries for months before migrating upstream. Most mature adults range in size between 20 and 32 inches.

A fluvial stock is present in the mainstem Yakima River; a resident stock occurs in Ahtanum Creek; and fluvial/resident forms are present in the Naches River drainage and in the North Fork Teanaway drainage (WDFW 1998). Fluvial bull trout spawn and, in the early stage, rear in smaller tributaries with major growth and maturation occurring in mainstem rivers. They may move randomly throughout river systems, generally congregating near spawning tributaries in the summer. Mature adults are usually smaller than anadromous or adfluvial char, ranging from 16 to 26 inches long. Resident bull trout spend all life stages (spawning, rearing, growth, maturation) in small headwater streams, often upstream of impassable barriers. Mature adults can vary from 8 to 15 inches, but they are seldom larger than 12 inches in total length. Resident native char have been observed to mix and interbreed with migratory forms unless physically separated by barriers.

It is possible that anadromous forms also occurred in the Yakima basin in the past (WDFW 1998). Run timing of the Keechelus Lake stock and the spawning population in the South Fork Tieton River (part of the Rimrock Lake stock) are distinct. Run timing for other Yakima stocks is not distinct from other Washington state bull trout or is unknown (WDFW 1998).

According to WDFW, of the nine stocks identified in 1998, only Rimrock Lake is healthy; Bumping Lake is depressed; Yakima River, Ahtanum Creek, North Fork Teanaway, Kachess Lake and Keechelus Lake

are critical and Naches and Cle Elum/Waptus Lakes are unknown (WDFW 1998). Additional data are needed to determine the status of the unknown stock. WDFW has not reviewed and reported the status by population since the Mid-Columbia (Bull Trout) Recovery Unit Team identified thirteen populations (USFWS 2001 DRAFT).

There are only a few historical references (mostly old catch records) that indicate the presence of bull trout in Yakima River tributaries. In all streams where bull trout are noted in the historical catch records relatively few fish were recorded compared to other game fish. Whether this is a reflection of historically low population abundance is difficult to tell.

All life history stages of native char are associated with complex forms of cover, including large woody debris, under cut banks, boulders, and pools. Preferred spawning habitat consists of low gradient streams with loose, clean gravel and water temperatures of 5 to 9° C in late summer and early fall. Depending on the life history form, rearing and over wintering habitat vary but still require cool clean water with insects, macro-zooplankton, and small fish for larger adults. Thermal refugia are particularly important for bull trout, especially for suitable spawning habitat. Bull trout can be found in streams/lakes where summer temperatures exceed 18°C, provided appropriate thermal tolerance requirements are met the remainder of the year for bull trout spawning and initial rearing. Cool water temperatures during early life history results in higher egg survival rates, and faster growth rates in fry and possibly juveniles as well (Pratt 1992).

Slow juvenile growth delays maturation until about age five, and reproduction may only occur on alternate years. Native char may live for 12 or more years, reaching sizes over 20 pounds where adequate forage is available. Stock densities of native char are generally much lower than other native game fish such as cutthroat trout *(Oncorhynchus clarki)* and rainbow trout *(O. mykiss)*, or mountain whitefish *(Prosopium williamsoni)*. The migratory forms of native char may travel long distances to reach spawning tributaries. Mature native char normally penetrate farther upstream than any other salmonids present in the watershed.

Table 18: Annual summary of bull trout spawning (number of redds) in the Yakima subbasin, 1984-2000

STREAM INDEX	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
YAKIMA RIVER (F)																	
Keechelus to Easton Reach	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2*
AHTANUM CREEK (R)																	
N.F. Ahtanum Cr. (Shellneck Cr.)	–	–	–	–	–	–	–	–	–	9	14	6	5	7	5	7	11
M.F. Ahtanum Cr.	–	–	–	–	–	–	–	–	–	–	–	–	1*	1*	–	0*	10*
S.F. Ahtanum Cr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5*
NACHES RIVER (F)																	
Rattlesnake Cr. (Little Wildcat Cr.)	–	–	–	–	–	–	2	2*	–	–	4*	26*	38	46	53	44	45
American R. (Union Cr., Kettle Cr.)	–	–	–	–	–	–	–	–	–	–	–	–	25	24	31	30	44
Crow Cr.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	19	26
RIMROCK LAKE (AD)																	
S.F. Tieton R. (Bear Cr.)	–	–	–	–	–	–	32*	–	–	38*	167	95	233	177	142	161	144
Indian Cr.	29*	69*	16*	35*	25	39	69	123	142	140	179	201	193	193	212	205	226
BUMPING LAKE (AD)																	
Deep Cr.	–	–	–	–	–	17*	15*	84	78	45	12	101	46	126	98	107	147
N.F. TEANAWAY R. (F/R)																	
NF Teanaway/DeRoux Cr.	–	–	–	–	–	–	–	–	–	–	–	–	2*	0*	0*	–	0*
KACHESS LAKE (AD)																	
Box Canyon Cr.	5	4	3	0	0	0	5	9	5	4	11	4	8	10	16	17	10
Kachess R (upper)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0*	–	15
KEECHELUS LAKE (AD)																	
Gold Cr.	2	2	21	15	12	3	11	16	14	11	16	13	51	31	36	40	19
CLE ELUM LAKE (AD)																	
Cle Elum R. (upper)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7*

R = Resident, F = Fluvial, F/R = Fluvial/Resident, AD = Adfluvial

(Number of redds in index areas)

Table 19: Historical and present distribution of bull trout in the Yakima subbasin

R=Resident, F=Fluvial, F/R=Fluvial/Resident, AD=Adfluvial (Updated and modified from Goetz 1989)

Lake or Stream	Last Year Present	Last Year Checked
Yakima River (Benton Co) (F)	1997 (1)	2000
Yakima River (Yakima Co)(F)	2000	2000
Satus Cr.	1953	1991
Ahtanum Creek(R)	2000	2000
N.F. Ahtanum Cr.	2000	2000
Shellneck Cr.	2000	2000
M.F. Ahtanum Cr.	2000	2000
S.F. Ahtanum Cr.	2000	2000
Naches River(F)	2000	2000
Cowiche Cr.	1974	1981
Tieton R.	2000	2000
Oak Cr.	1999	1999
Rattlesnake Cr.	2000	2000
N.F. Rattlesnake Cr.	1996	1996
Hindoo Cr.	1995	1996
Dog Cr.	1996	1996
Little Wildcat Cr.	2000	2000
Milk Cr.	1996	1996
Bumping R. (Lower)	1997	1997
American R.	2000	2000
Kettle Cr.	2000	2000
Timber Cr.	1993	1993
Union Cr.	2000	2000
Little Naches R.	1998	1998
Crow Cr.	2000	2000
Quartz Cr.	1998	1998
Pileup Cr.	1998	1998
Rimrock Lake (AD)	2000	2000
S.F. Tieton R.	2000	2000
Short and Dirty Cr.	1994	1994
Spruce Cr.	1996	1996
Grey Cr.	1994	1994
Bear Cr.	2000	2000
Indian Cr.	2000	1997
N.F. Tieton R. (Lower)	1997	1994
Clear Lk.	1993	1996
N.F. Tieton R.(Up.)	1996	1990
Dog Lk.	1950 (2)	
Bumping Lake (AD)	2000	2000
Deep Cr.	2000	2000
Bumping River (Upper)	1994	1994

Lake or Stream	Last Year Present	Last Year Checked
Yakima River (Kittitas Co.)(F)	2000	2000
Coleman Cr.	1970	1984
Swauk Cr.	1993	1999
Easton Lake	2000	2000
N.F. Teanaway R.(F/R)	2000	2000
Jack Cr.	1997	1997
Jungle Cr.	1997	1997
DeRoux Cr.	2000	2000
Cle Elum Lake (AD)	1993	1993
Cle Elum R. (Upper)	2000	2000
Waptus Lake	1997	1998
Kachess Lake (AD)	2000	2000
Box Canyon Cr.	2000	2000
Kachess R. (Upper)	2000	2000
Mineral Cr.	2000	2000
Keechelus Lake (AD)	2000	2000
Rocky Run Cr.	1983	1983
Gold Cr.	2000	2000

(1) A single fish captured near Benton City by WDFW biologists (extreme rare occurrence).
(2) This record possibly species misidentification (brook trout).

HABITAT LIMITING FACTORS BY SUBBASIN

Overview of Yakima River Watershed Key Habitat Limiting Factors

This chapter identifies habitat-related limitations to salmonid production for each species, and within each subwatershed within the Yakima basin. In addition, a list of habitat–related action recommendations is included at the end of each subwatershed discussion. These action recommendations are intended to restore ecosystem function, and are ranked/prioritized on the basis of anticipated benefit to salmonid recovery in the subwatershed. The ranking provides a technical foundation to be used by the Lead Entity and habitat project sponsors in focusing protection/restoration/assessment efforts in ways that are most beneficial to salmonids. However, although efforts should be made to pursue the highest ranked action recommendations, much of habitat protection/restoration is based on landowner willingness and project feasibility, and it may not always be possible to implement the highest ranked actions, particularly in the short-term. It is important to utilize available opportunities and continue to make progress towards restoring functional habitat throughout the watershed.

Anadromous salmonids in the Yakima River, like the rest of the Columbia River Basin, have experienced a significant decline during the last century (Northwest Power Planning Council 1986 and Nehlsen et al. 1991, as cited in Snyder and Stanford 2000 DRAFT). The estimated magnitude of historic runs vary from several hundred thousand (Embrey and Watson 1992, USBR 1999, as cited in Snyder and Stanford 2000 DRAFT) to >800,000 (CBSP 1990). Over the past two decades, the total number of returning adult anadromous salmonids has ranged from a low of 3,300 fish in 1995, to >30,000 fish in 2000. This decline is due to a combination of factors, including harvest, hatcheries, hydro-power, and habitat factors within and outside the Yakima basin. This report focuses on opportunities to improve habitat quality and quantity in the Yakima watershed.

The decline of salmon and steelhead in the Yakima watershed occurred in two major phases. The first phase, from 1850 through 1900, resulted in a decline in salmon abundance of approximately 90% from historic values (Davidson 1953, Tuck 1995, Lichatowich 1996; as cited in YSS 2001 DRAFT). Significant irrigation withdrawals began in the 1870s, dramatically accelerating after the railroad reached Yakima in 1884, with most smaller tributaries completely appropriated (dried up by late spring) by the 1890s. The major causes of decline during this period were associated with water diversions, including fish passage barriers, loss of instream flow, and lack of juvenile fish screening (Tuck 1993). Harvest rates in the Columbia River salmon fisheries at the turn of the century were estimated to be as high as 80-88%, contributing to declines in salmon abundance throughout the Columbia watershed (Chapman 1986). However, analysis of lower Columbia River harvests in comparison to the estimated reductions of adult salmon in the Yakima watershed indicates that fishing in the lower Columbia River had little, if any, impact on salmon and steelhead production in the Yakima River Basin (Tuck 1993). Other than the screening of one small irrigation diversion on the Naches River in 1928, none of the hundreds of diversions in the Yakima watershed were screened until the Works Progress Administration (WPA) program of 1934-1940, under President Franklin Roosevelt's "New Deal" (Tuck 1995, as cited in YSS 2001 DRAFT). The probability that a smolt could survive emigration from the Yakima River or its tributaries was extremely small, and the bulk of the initial decline can be attributed primarily to smolt entrainment in irrigation diversions (Tuck 1993; Earnest Brannon Sr. 1929, as referred by Easterbrooks).

The second phase of major irrigation impacts occurred in the 1900s. Construction of dams on the upper Yakima River (Keechelus Dam), the Kachess River (Kachess Dam), the Cle Elum River (Cle Elum Dam), the Bumping River (Bumping Dam), and the Tieton River (Tieton Dam), to provide water storage for irrigation, precluded anadromous salmonid passage to 112 miles of highly productive areas upstream. None of these dams were constructed with fish passage, and still do not have fish passage. Preclusion of fish passage at these dams (except for Tieton Dam) resulted in the extirpation of sockeye salmon in the Yakima watershed. In addition, upstream adult fish passage was precluded after the end of the irrigation season at Roza Dam, from its completion in 1940 until the installation of the new ladder in 1989, except during periods (particularly in the 1950s-1960s) when the BOR operated the power plant after the end of the irrigation season (Perala). Fish passage problems at Roza Dam had devastating effects for both coho and steelhead migrating to the upper Yakima River. Passage was also precluded by construction of splash dams, used for the ponding and transport of logs through the upper Yakima River and tributaries. Another major problem involved the complete dewatering of extensive river reaches downstream of Cle Elum Dam on the Cle Elum River, Tieton Dam on the Tieton River, Wapatox Dam on the Naches River, Keechelus Dam on the upper Yakima River, and Sunnyside and Prosser Dams on the lower Yakima River. Dewatering of these reaches precluded upstream migration of adult salmonids, eliminated spawning and dewatered redds, and impaired/eliminated juvenile salmonid rearing in these reaches. Although fish passage problems at Roza Dam and instream flow problems downstream of the dams have been significantly reduced or eliminated, they played an important role in determining the status of existing salmonid stock status.

Species Considerations

Chinook

Chinook salmon (*Oncorhynchus tshawytscha*) are capable of taking advantage of a wide variety of habitats due to their flexibility in life history. In the Yakima Basin, two distinct forms of chinook salmon occur: spring chinook, which return to the Yakima River as adults in the spring and spawn in headwaters of the Yakima Basin; and fall chinook, which return in the fall and spawn in the lower elevation portions of the basin. Spring chinook juveniles tend to spend a full summer in their natal stream, overwinter in freshwater, and migrate to the sea in spring as yearling smolts. In contrast, fall chinook juveniles migrate to the sea as subyearling smolts during their first spring and summer. Water temperature, which is correlated with elevation, is the most important habitat factor influencing the distribution of spring and fall chinook salmon in the watershed (Miller and Brannon 1982).

The differences in the life history strategies of spring and fall chinook may also lead to differences in the habitat factors that limit their production. Spring chinook are generally considered limited by amount of available juvenile rearing habitat, because of their longer residence time in freshwater. Decreases in juvenile abundance throughout the summer, and density-dependent growth rates for juveniles, are common observations indicating spring chinook find juvenile rearing habitat limiting (Bjornn 1978). For this reason, projects that are focused on increasing the amount of juvenile rearing habitat have the most promise for enhancing spring chinook returns to the Yakima River. A number of habitat related activities could contribute to maintaining or improving spring chinook juvenile habitat: protecting and maintaining current high-quality rearing habitats, removing barriers to fish passage, screening diversions, improving instream flows in key locations, and reconnecting floodplain/hyporheic zone habitats that have been disconnected from the river are all considered high priority projects.

The major constraints to spring chinook (*Oncorhynchus tshawytscha*) production in the Yakima River watershed are, in order of decreasing importance: 1) non-normative instream flows (too low or too high), 2) upstream and downstream passage at diversions despite recent investments in modern fish passage facilities (upstream and downstream passage concerns have been addressed at most of the large diversions; passage problems remain at many of the smaller tributary diversions), 3) smolt predation in the lower Yakima (often associated with delay or concentration of smolts at diversion passage facilities) on juvenile spring chinook by aquatic and avian species, 4) excessive water temperatures in the lower river, and 5) degraded riparian and instream habitat (modified from CBSP 1990). Use of the System Planning Model (SPM) and Tributary Planning Model (TPM) associated with the 1990 Subbasin Planning effort (CBSP 1990) estimated that improving all qualitative aspects of the environment under the existing pattern of instream flow would result in a fourfold increase in total production. On the other hand, the Water Enhancement Team estimated that optimizing instream flows with existing habitat quality would result in a sevenfold increase in adult production. These results support the widely held opinion that instream flows are the most significant limiting factor for spring chinook in the Yakima River watershed. However, physical habitat descriptions and modeling methods have improved since this work in the late-1980s, and should be referenced for the most up-to-date assessment of salmonid habitat restoration potential. It is generally believed that the existing runs of spring chinook retain most of the genetic characteristics of the native, wild population, and that they are uniquely adapted to the sometimes rigorous conditions in the watershed. A habitat productivity relationship model (Ecosystem Diagnosis and Treatment (EDT)) has been developed and refined for Yakima spring chinook (B. Watson). The model contrasts current habitat conditions with historic or restored habitat characteristics for each for the subwatersheds, and can be used as a guide to spring chinook habitat restoration efforts that will provide the greatest recovery benefits.

It is intrinsically difficult to prioritize a species' limiting factors for an entire basin because two interacting factors that must be considered simultaneously (Watson). First, one must consider the life history of the species. In the case of spring chinook, a life history trait that influenced the EDT analysis, and caused it to differ somewhat from the 1990 Subbasin Plan, is the strong tendency of spring chinook to spawn in the upper portions of mainstem reaches and larger tributaries, and not in the lower reaches of the drainage. For this reason, temperature was not considered to be so strong a limiting factor in the EDT analysis as in the 1990 Subbasin Plan. The other factor to be considered is the "intrinsic production potential" of the reaches in the basin, which in turn is a function of their size and their historical suitability – what is termed in an EDT analysis, the "Restoration Potential" of the reach. One should assign a higher importance or weight to the limiting factors characterizing reaches of higher restoration potential. When this was done in the EDT analysis of Yakima spring chinook, the number one limiting factor was **a** loss of key habitat, specifically a decrease in the area of the drainage consisting of channel types strongly preferred by juvenile life stages, especially primary pools, backwater pools, pool tailouts and glides. This is primarily an index of a loss of capacity. Qualitatively, the EDT analysis prioritized limiting factors for spring chinook. In decreasing order of severity, flow, habitat complexity, mortalities associated with irrigation diversions (assumed to be almost exclusively predation), sedimentation, obstructions (primarily unladdered storage dams), and temperature. Except for the emphasis EDT places on habitat complexity, which really wasn't considered directly in the 1990 Subbasin Plan, the diagnosis produced by the EDT analysis is not really that different from the Subbasin Plan.

Fall chinook spawn in large, low elevation channels in the watershed. In general, limiting habitat factors are less well understood for fall chinook salmon than stream-type salmonids (species that live in freshwater for at least one year prior to migrating to saltwater). CBSP (1990) estimated

approximately 30% of fall chinook spawning to occur upstream of Prosser Dam, primarily in Marion Drain, with the remaining 70% occurring downstream of Prosser Dam, in a relatively constrained reach of the Yakima watershed. More recent work (Watson 2001) suggests the proportion of fall chinook spawning above Prosser Dam may be more on the order of 45% (1896 of 3965 in 1999, and 2290 of 5415 in 2000). Habitat limiting factors in the Yakima River for fall chinook may include amount or quality of spawning habitat, as well as the amount or quality of juvenile rearing habitat. Water quality, particularly warm water temperatures, are a factor of concern under some circumstances. The reduction of the spring freshet may also limit the amount of habitat available for juvenile rearing. Projects such as reconnecting floodplain/hyporheic zone habitats or increasing instream flows in certain reaches may improve fall chinook production in the Yakima by increasing the amount of rearing or spawning habitat.

The major habitat factors limiting fall chinook production in the Yakima watershed are, in order of decreasing importance: 1) smolt and pre-smolt mortalities (primarily due to predation), 2) the heavy deposition of fine sediments in spawning areas downstream of Sunnyside Dam to West Richland [although there are no substrate assessments that confirm high presence of fines in the substrate in the lower watershed, there is general consensus from visual observations that presence of fines is high, and that fines are generally detrimental to salmonid spawning and rearing; however, the level of impact is unknown], and 3) water quality in the lower river from Prosser Dam to the confluence with the Columbia River (modified from CBSP 1990). Spawner/carcass surveys below Prosser have been surprising in recent years in that a high percentage (67-83%, 1998-2000) of the fish are fin clipped hatchery fall chinook, so natural production may be relatively low, even though fish are spawning (Cummins). Evidently natural production, due to a combination of factors is low. In addition, loss of key habitats (similar to those used by spring chinook) are also applicable to fall chinook (Watson).

Studies by WDFW (Pearsons 2000 and 2001) and the YN (Dunnigan 2001) have shown that smallmouth bass are by far the most significant fish predator on fall chinook, with northern pikeminnow probably second. Other work suggests that gull predation may be the third most significant predatory impact (Grassley 2000). Increasing presence of other predatory bird species has also been noted along the lower Yakima River corridor, including ospreys, cormorants, and white pelicans, although the extent of predatory impact on salmonids has not been evaluated. Losses of smolts to predators may limit the production potential of fall chinook more than any other species in the subbasin (CBSP 1990).

Interspecific competition may also be a concern in the middle Yakima that primarily impacts fall chinook. Competitive pressure from redside shiners (and possibly other Cyprinids) are probably much higher than they would otherwise be if water temperatures in the middle Yakima were not unnaturally high (Patten and Thompson 1970, as cited in YSS 2001 Draft),. The very high densities of smallmouth bass in the lower Yakima (primarily below Prosser Dam) represent a major competitive obstacle to juvenile fall chinook rearing in the same area.

Steelhead

Habitat limitations for steelhead trout (*O. mykiss*) generally occur during the freshwater rearing phase (Bjornn 1978; Ward and Slaney 1993), and the Yakima steelhead populations appear to be limited by the current carrying capacity of the watershed (Lister 1997). This reflects the fact that the majority of the steelhead production in the Yakima occurs in two streams: Satus and Toppenish creeks (Hockersmith et al. 1995). Steelhead spawn and rear in streams with specific characteristics: spawning in the Yakima occurs predominantly between 1,000 and 2,500 feet elevation, in streams where most of the watershed area is below 3,000 feet (USBR 2000).

Steelhead tend to favor tributary streams for spawning and early rearing over mainstem river reaches, suggesting that streams with certain quantifiable characteristics will be more productive for steelhead. A number of tributaries that may have potential for steelhead production are currently inaccessible due impassable barriers, unscreened diversions, and low instream flows. Improvements in steelhead production in the Yakima Basin will most likely come from improvements in the freshwater rearing habitat in areas suitable for steelhead production. For the upper Yakima River and tributaries, interaction of juvenile steelhead with resident rainbow trout, and an environment that may favor residency over anadromy are factors that may play an important role in the status of steelhead in that part of the Basin. Projects that could improve steelhead production include fish passage barrier removal and diversion screening, improvements in instream flows in identified critical reaches, and habitat enhancement projects in degraded steelhead habitat.

The major habitat factors limiting steelhead production in the Yakima watershed are, in order of decreasing importance: 1) upstream and downstream passage at water diversions in the Yakima watershed, especially those on spawning tributaries; 2) non-normative instream flows (too low or too high) in the mainstem and tributaries; 3) degraded riparian and instream habitat; and, 4) excessive water temperature in the lower reaches of some tributaries and in the lower mainstem Yakima River (modified from CBSP 1990). Steelhead are much more susceptible to existing passage and entrainment problems in the watershed than spring chinook. This is because steelhead spend more of their juvenile life in tributaries, and problems associated with diversions are relatively more severe on tributaries. Entrainment of newly emerged steelhead fry is a particular problem because steelhead emerge when diversions are at or near maximum, and they emerge at a size that often allows passage directly through the mesh of many fish screens. Steelhead passage in tributaries requires substantial flows during October-early December for spawners and juveniles seeking downstream winter habitat, and during March-late April or early-May for spawners and smolts. Mongillo and Falconer (1980, as cited in CBSP 1990) found a significant difference in trout production between control streams and agriculturally disturbed streams in Benton, Kittitas, and Yakima counties. They found the main ecological factors regulating trout production were bank cover, substrate, flow, turbidity, and nitrate concentration in Benton County; bank cover, substrate and flow in Kittitas County; with bank cover being the main limiting factor in Yakima county. Agricultural practices most implicated in habitat degradation in smaller streams are riparian grazing and mowing. While significant increased natural steelhead production may be impossible without widespread improvements in passage (mainly instream flow and screening), increases following passage improvements will be compromised without equally widespread improvements in habitat.

Coho

The Yakima River watershed historically supported coho salmon (*O. kisutch*); coho are known to have migrated as far upstream as the Spokane River in the Columbia Basin (Mullan 1983). The Yakima River is estimated to have accounted for approximately 42% (Fulton 1970, as cited in Mullan 1983) to 68-95% (U.S. Bureau of Reclamation and U.S. Fish and Wildlife Service 1976, as cited in Mullan 1983) of the calculated historic middle and upper Columbia River coho population. Native coho salmon were gradually extirpated from the Yakima River watershed, with the last spawning coho observed in 1977 (Easterbrooks), and coho counts dropping to zero at Prosser Dam by 1984 (Watson). High harvest rates in the lower Columbia River and ocean fisheries are generally acknowledged to be a key factor responsible for the eventual extirpation of coho from the Yakima and other upper Columbia tributaries (Johnson et al. 1991, as referred by Monk), although habitat alterations appear to have resulted in the majority of the decline (Tuck 1993). The primary habitat factors that impaired coho productivity are very similar to those

identified above for steelhead, as adult spawners have similar return timing, they typically spawn in similar tributary habitats, and the juveniles rear in tributary habitats. Because coho juveniles live in freshwater for a year, similar to spring chinook, rearing habitat is generally thought to limit their production. A coho reintroduction effort is currently underway. Initial adult coho returns from the reintroduction effort were encouraging (Prosser Dam counts in 1998, 1999 and 2000 were 4,679, 3,943 and 5,741, respectively (Watson)), the vast majority of the fish spawned in drains and tributaries in the lower watershed (false attraction to irrigation returns) and in lower mainstem areas in the vicinity of irrigation drains, rather than returning to headwater areas of the upper Yakima and upper Naches rivers where they were acclimated prior to release (Jim Dunnigan). Survival of the lower watershed coho spawning is thought to be minimal, due primarily to high water temperatures in the lower watershed (Watson). The Yakama Nation (YN) and the Yakima Klickitat Fisheries Project (YKFP) are currently attempting to develop a locally adapted broodstock by capturing and spawning adults that return to the Yakima.

Sockeye

The Yakima River watershed historically supported sockeye (*O. nerka*) in Keechelus Lake, Kachess Lake, Cle Elum Lake, and Bumping Lake. Sockeye were extirpated from the Yakima watershed in the early 1900s, as the outlets of these lakes were dammed to increase water storage for irrigation. None of the dams included provisions for adult anadromous fish passage. Studies in the Yakima Basin are ongoing to determine the feasibility of sockeye reintroduction, and fish passage at Cle Elum Dam is being considered by the Bureau of Reclamation. Although it may be possible to reintroduce sockeye spawning and smolt production, the thermal block in the lower Yakima River at the time of adult sockeye return would likely result in high mortality of returning adults (Harvester).

Bull trout

In the past, wild bull trout (*Salvelinus confluentus*) occurred throughout the Yakima River basin, but they are now fractured into isolated stocks (WDFW 1998). Although bull trout were probably never as abundant as other salmonids in the Yakima basin, they were certainly more abundant and more widely distributed than they are today. Until recently, nine bull trout populations were identified in the basin, but due to additional investigation, 13 populations have now been identified (USFWS 2001 DRAFT).

Bull trout production in the Yakima watershed is limited by factors similar to bull trout throughout their range, mainly the availability of suitable water temperatures and clean spawning gravel, dams/barriers that block or impair migration, and lack of cover (particularly LWD)(Cummins). In addition, when irrigation storage reservoirs are drafted to extreme low levels, sometimes combined with low tributary flows, bull trout may not be able to migrate into spawning streams. Yakima Basin bull trout spawning (last week in August through the first week in November) generally coincides with the lowest reservoir and stream flows of the year. WDFW recently found bull trout actively spawning on November 6, 2001 in the upper Kachess River. Evidently, these fish have adapted to environmental conditions; the Kachess River is dry near its confluence with Kachess Reservoir in late summer through mid to late-October, depending on timing of fall precipitation. In 2000 and 2001, bull trout were found spawning in late-October and early-November in the Kachess River after fall rains restored flow. Very likely, these fish have been spawning annually during this period, but the spawning was not detected until 2000. This is the latest spawning population of bull trout found in the Yakima Basin to date. Generally, the lower end of bull trout spawning is upstream of the upper end of spring chinook spawning;

exceptions are known in the Rattlesnake watershed (B. Watson), in the American River (Cummins), and in the Easton-Keechelus reach of the Yakima River (Cummins), where spawning areas overlap.

Bull trout are strongly influenced by temperature and are seldom found in streams exceeding summer temperatures of 18ºC (Cummins). Cool water temperatures during early life history results in higher egg survival rates, and faster growth rates in fry and possibly juveniles as well. Buchanan et al. (1997, as referred by Monk) reported observations from throughout published literature and concluded that juveniles require temperatures in the 4-10°C range, while adults find 12-15°C suitable. The strict temperature requirements for bull trout spawning and early rearing habitat means that their habitat is typically limited in any watershed, yet they are the only salmonid capable of exploiting such habitats, which gives them a unique niche to occupy.

All life history stages of bull trout are associated with complex forms of cover, including large woody debris, under cut banks, boulders, and pools. Preferred spawning habitat consists of low gradient streams with loose, clean gravel and water temperatures of 5-9ºC in late summer and early fall. Depending on the life history form, rearing and over wintering habitat vary but still require cool clean water with insects, macro-zooplankton, and small fish for larger adults.

Habitat alterations such as diking, development, and roads in the riparian areas, or removal of riparian vegetation in bull trout habitats increase water temperature, and reduce instream habitat complexity and pools (WDFW 1998). Logging and recreation impacts have impaired riparian function, resulting in the warming of spawning streams, potentially to the extent that they are no longer suitable for bull trout spawning. Bull trout stocks that are already impaired are further impacted by poaching of spawners, which are highly visible and susceptible on the spawning grounds.

Bull trout exhibit both migrant and resident life history strategies. There are resident, fluvial, and adfluvial bull trout stocks in the various headwater tributaries of the Yakima River watershed (WDFW 1998). It is possible that anadromous forms also occurred in the Yakima basin in the past. After rearing as juveniles for 1-4 years in their natal stream (Meehan and Bjornn 1991, as referred by Monk), migrant bull trout emigrate to larger rivers or lakes. Thus, bull trout populations are often times limited by the amount of cold-water juvenile rearing habitat. Bull trout generally spawn at elevations of 2,300-4,000 feet in the Yakima basin, with most fish spawning below 3,000 feet (Cummins). Bull trout spawning streams in the Yakima Basin have 45 -70% of their catchment (the portion above the lowest spawning limit) above 5,000 ft elevation. The exceptions are Gold and Box Canyon creeks, where less than 25% of the area is above 5,000 ft, however the average number of spawners per year in these streams during 1996-1999 was small (1-40 fish). The largest catchment areas above spawning were in the American River (including Union and Kettle creeks), the South Fork Tieton River, followed by Indian Creek. These analyses indicate that bull trout streams have a high portion of their catchment above 5,000 ft, unless the stream has unique morphology that results in stream temperatures that are below 8°C by early fall. Projects that protect, enhance, and maintain these unique habitats may provide the best opportunities for improving and protecting bull trout populations in the Yakima Basin. WDFW redd count data (see Appendix B of this report) indicate that subsequent to prohibition of angler harvest, adult bull trout populations in Yakima watershed reservoir tributaries are either increasing or have increased and subsequently stabilized at much higher levels than a decade ago (Anderson).

In its final listing rule (63 FR 31647) the U.S. Fish and Wildlife Service considered isolation by dams to be a major threat to 5 of the 8 subpopulations (USFWS 2001 DRAFT). The Service

considered agricultural practices and associated water withdrawal as a threat to each subpopulation. Additional threats facing bull trout subpopulations in the basin included, forestry, grazing, roads, mining, harvest, non-native species, and residential development.

Although harvest probably had some effect on the decline of bull trout in the basin, the effect was probably minor in comparison to that from the dams and diversions (WDFW 1998). The construction of reservoir dams without fish passage on the major tributaries of the upper Yakima and Naches rivers has genetically isolated several populations and eliminated/prevented/impaired access to historic spawning areas. Recent research (Leary et al. 1993; Kanda and Allendorf 2001; as provided by Monk) indicates that headwater bull trout populations, such as those in the upper Yakima basin, are likely to have been genetically distinct even prior to dam construction, and that maintenance of each population is not dependent on genetic interchange among populations. However, there are no genetic data for Yakima Basin populations that confirm that these populations were (or currently are) genetically distinct prior to dam construction (Cummins).

Instream Flows In the Yakima River and Tributaries

A primary factor influencing salmonid habitat quantity and quality is instream flow. The natural flow regime of the Yakima River and several of the tributaries has been altered, primarily related to the storage and delivery of water for irrigation. Instream flows are reduced at many locations by impoundment of water for irrigation and/or diversion of water to out of stream uses; in other situations, instream flows are increased as a result of release of impounded water for downstream irrigation use. A large component of the salmonid restoration work to date has been involved with attempting to manage/restore instream flows in a manner that is more representative of the unregulated natural flow regime in the watershed.

Between 1981 and 1984, the USFWS conducted instream flow studies on the Yakima River and tributaries. The USFWS study was primarily related to legally defining the Yakama Nation's treaty secured water tights for fish and other instream uses under the Yakima Basin General Water Rights Adjudication in Superior Court (Acquavella et al. vs. Wash. Dept. of Ecology). The basis of the studies was the Instream Flow Incremental Methodology (IFIM), a widely accepted means of evaluating alternative flow regimes, and predicting water resource project impacts (TRPA 1995b). Results of the USFWS study were released over time, primarily through court documents and affidavits (TRPA 1995a), with the main affidavit being filed by Del Simmons. Simmons recommendations were intended to maximize the amount of water the Yakama Nation could claim for treaty purposes during the Adjudication (Monk). As part of the petition, a U.S. Memorandum stated: "Admittedly, these recommended flows are based on the assumption that the Tribe's treaty-protected fishing rights in the Basin have remained unaffected by the actions to the federal government and that these proposed instream flows will provide the optimum habitat for anadromous fish spawning and rearing in the Basin." The instream flows recommended in the Simmons affidavit have never been officially endorsed by the USFWS (Monk).

An evaluation of results of the USFWS study and supplemental interpretation were prepared for the USBOR as part of the Yakima River Basin Water Enhancement Project (YRBWEP)(Parametrix 1984a and 1984b, as cited in TRPA 1995a and 1995b), and are generally referred to as the IFTAG (Instream Flow Technical Advisory Group) optimum instream flow recommendations. The ability to fully achieve the identified instream flows in the USBOR study was predicated on development of new water storage in the watershed under the YRBWEP (Easterbrooks). Instream flow recommendations were generated by both of these studies for various Yakima River mainstem and tributary sites throughout the basin. <u>However, these studies</u>

contained numerous data and analysis deficiencies, which could result in erroneous flow recommendations (TRPA 1995b). The instream flow recommendations (Simmons affidavit) resulting from the USFWS studies are presented in Table 20; the IFTAG instream flow recommendations are presented in Table 21 (originally presented in Table 1 of Yakima River Subbasin Salmon and Steelhead Production Plan (CBSP 1990)). These instream flow recommendations are included only for reference, and direct utilization of the recommendations is not supported by the TAG (see below).

Because methods for determining instream flows changed since the original work was done, the Yakima River Basin Defense Coalition conducted a reevaluation of the USFWS results, identified potential flaws in the USFWS studies, and collected new data, where necessary (TRPA 1995a). This study identified numerous data and analysis deficiencies, which could result in erroneous, flow recommendations (TRPA 1995b). The identified concerns included: data entry errors, poor stage-discharge relationships, unrealistic velocity predictions, changes in the stream channel during data collection, inaccurate representation of stream habitat with limited transects, and highly irregular means of calculating salmonid habitat indices. The extent of differences between the species habitat use curves between the USFWS and TRPA studies varied between sites. The study identified concerns with the USFWS methodology, and included recommended modifications, but no new instream flow recommendations were generated as part of the study.

The USFWS (Simmons' affidavit) recommended instream flows are the highest developed by any analysis (Perala). The tributary flow recommendations exceed the average annual flow generated. When the TWSA (total water supply available) for the system is computed, the first adjustments made to the numbers are the volume of water passing Sunnyside Dam for the irrigation season and the volume expected for residual storage at the end of the season. Using the Simmons flows, there is no water available to any post-1905 development. The pre-1905 irrigated areas have a partial supply in most years. In 2001, there would be no water for irrigation, and the fish flow recommendations could not be met. The IFTAG flows are higher than the Title XII (need description??) flows that the USBOR operates by now, but would still leave some water in the system for other uses.

Analyses of the data from the USFWS study identified some problems, which to some extent may limit its utility (Parametrix/Hardin-Davis 1984, Thomas R. Payne and Associates 1995; both as cited in BOR 2000). While the study is now dated, and known to contain some flaws, it is still the only comprehensive instream flow study completed in the basin and the results are still being used, albeit with caution. The data have been used by BOR to coarsely evaluate the effects of the managed flow regime.

Of these three evaluations, the only one that involved collaborative involvement in the development of instream flow recommendations was the IFTAG process through YRBWEP. However, full implementation instream flow recommendations from that process was predicated on development of new water storage in the basin, which has not occurred. Direct utilization of instream flow recommendations from these dated studies is generally not supported by the TAG, which supports continued work through the System Operations Advisory Committee (SOAC) to develop and implement a more normative flow regime that combines “the goal of sustaining ecological integrity of watersheds, while also maximizing uses of water resources by humans” (SOAC 1999). The term “normative flow regime” is used throughout this document in this context.

Table 20: Instream flow recommendations developed by USFWS (from affidavit of Dell Simmons)

Stream	Location	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Yakima R.	Below Keechelus Dam	150	125	125	125	175	175	175	175	150	150	150	100
Yakima R.	Above Kachess R.	260	135	125	150	175	175	425	750	640	150	150	170
Kachess R.	At mouth	115	240	250	150	100	100	420	715	575	100	100	50
Yakima R.	Below Easton Dam	375	375	375	300	275	275	845	1465	1215	250	250	220
Yakima R.	Above Cle Elum R.	375	375	375	300	275	275	845	1465	1215	250	250	220
Cle Elum R.	Below Cle Elum Dam	250	200	200	200	250	250	1235	2570	2375	150	150	150
Cle Elum R.	At mouth	250	200	200	200	250	250	1235	2570	2375	150	150	250
Yakima R.	Below Cle Elum R.	500	500	500	500	500	500	2080	4035	3590	400	400	470
Yakima R.	Above Teanaway R.	550	600	675	700	700	740	2450	4385	3780	450	470	550
Teanaway R.	At mouth	60	150	150	100	150	150	785	1808	485	65	65	30
Yakima R.	Below Teanaway R.	610	750	825	800	850	890	3235	5385	4265	515	535	580
Yakima R.	Above Swauk Cr.	785	950	950	950	950	950	3235	6000	4958	825	825	650
Swauk Cr.	At mouth	5	7	14	10	40	40	195	185	50	5	4	5
Swauk Cr.	Below Williams Cr.	5	7	14	10	40	40	195	185	50	5	4	5
Swauk Cr.	Above Williams Cr.	3	5	9	17	30	30	115	185	28	3	3	3
Yakima R.	Below Swauk Cr.	790	955	965	960	990	990	3430	6185	5000	830	830	655
Yakima R.	Above Taneum Cr.	790	955	965	960	990	990	3430	6185	5000	830	830	655
Taneum Cr.	At mouth	15	25	40	40	40	45	110	165	120	15	15	10
Yakima R.	Below Taneum Cr.	805	980	1000	1000	1000	1000	3540	6350	5120	845	845	665
Yakima R.	Above Town Canal	805	980	1000	1000	1000	1000	3540	6350	5120	845	845	665
Yakima R.	Below Town Canal	805	980	1000	1000	1000	1000	3540	6350	5120	845	845	665
Yakima R.	Above Manastash Cr.	805	980	1080	1000	1000	1000	3540	6350	5120	845	845	665
SF Manastash	At mouth	14	20	20	20	29	30	60	110	98	14	14	12
Manastash	Below South Fork	20	25	35	30	35	43	135	240	215	55	25	20
Manastash	At Mouth	20	25	35	30	35	43	135	240	215	55	25	20
Yakima R.	Below Manastash Cr.	825	950	1000	1000	1000	1000	3675	6590	5170	900	875	685
Yakima R.	Above Wilson Cr.	925	950	1000	1000	1000	1000	3900	6750	5170	1000	875	800
Wilson Cr.	At mouth	30	33	36	31	38	61	215	460	300	67	42	33
Yakima R.	Below Wilson Cr.	950	950	1000	1000	1000	1000	4100	7000	5400	1000	900	825

Table 20: Instream flow recommendations developed by USFWS (from affidavit of Dell Simmons)

Stream	Location	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Yakima R.	Above Roza Dam	950	950	1000	1000	1000	1000	4100	7000	5400	1000	900	825
Yakima R.	Below Roza Dam	900	900	1000	1000	900	900	4100	7000	5400	1000	900	825
Yakima R.	Above Wenas Cr.	900	900	1000	1000	900	900	4100	7000	5400	1000	900	825
Wenas Cr.	At mouth	7	9	12	11	13	16	50	85	75	20	9	8
Yakima R.	Below Wenas Cr.	900	900	1000	1000	900	900	4100	700	5400	1000	900	825
Yakima R.	Above Naches R.	900	900	1000	1000	900	900	4100	7000	5400	1000	865	785
Bumping R.	Below Bumping Dam	115	195	200	150	200	200	300	730	795	100	90	75
Bumping R.	Above American R.	115	195	200	150	200	200	300	730	795	100	90	75
American R.	At mouth	75	100	100	100	100	100	300	660	660	80	75	60
Little Naches	At mouth	65	105	190	170	190	200	500	765	570	70	65	50
Naches R.	Below Little Naches	255	400	400	400	400	400	1100	2155	2025	250	230	185
Naches R.	Above Rattlesnake Cr.	255	400	408	400	400	400	1100	2155	2025	250	260	235
Rattlesnake Cr.	At mouth	27	35	47	40	48	59	125	245	190	72	36	25
Naches R.	Below Rattlesnake Cr.	230	200	200	200	300	300	1285	2495	2330	200	295	260
Naches R.	Above Tieton	230	200	200	200	300	300	1285	2495	2330	200	295	260
Tieton R.	Below Tieton Dam	250	200	200	200	300	300	725	1230	1240	200	225	250
Tieton R.	Above Tieton Canal	250	200	200	200	300	300	725	1230	1240	200	225	250
Tieton R.	Below Tieton Canal	250	200	200	200	150	150	725	1230	1240	200	125	250
Tieton R.	At mouth	250	200	200	200	150	150	725	1230	1240	200	125	250
Naches R.	Below Tieton R.	500	400	400	400	400	400	2010	3725	3570	400	400	500
Naches R.	Above Cowiche Cr.	500	400	400	400	400	400	2010	3725	3570	400	400	500
Cowiche Cr.	At mouth	20	30	30	20	40	40	52	88	89	20	15	15
SF Cowiche Cr.	At mouth	14	19	20	20	23	24	40	68	68	15	15	15
Naches R.	Below Cowiche Cr.	500	400	400	400	400	400	2065	3790	3655	400	400	500
Naches R.	At mouth	500	400	400	400	400	400	2065	3790	3655	400	400	500
Yakima R.	Below Naches R.	1400	1300	1400	1400	1300	1300	6165	10790	9055	1400	1300	1325
Yakima R.	Above Ahtanum Cr.	1400	1300	1400	1400	1300	1300	6165	10790	9055	1400	1300	1325
Ahtanum Cr	At mouth	20	20	20	20	50	50	215	355	300	20	20	20
NF Ahtanum Cr.	At mouth	20	26	38	37	40	40	115	195	165	20	20	20

Table 20: Instream flow recommendations developed by USFWS (from affidavit of Dell Simmons)

Stream	Location	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
SF Ahtanum Cr.	At mouth	7	8	13	10	17	23	33	47	42	8	7	8
Yakima R.	Below Ahtanum Cr.	1455	1420	920	920	820	820	5900	11150	8510	955	955	965
Yakima R.	Above Wapato Dam	1455	1420	920	920	820	820	5900	11150	8510	955	955	965
Yakima R.	Below Wapato Dam	1455	1420	920	920	820	820	5900	11150	8510	955	955	965
Yakima R.	Above Sunnyside Dam	1455	1420	920	920	820	820	5900	11150	8510	955	955	965
Yakima R.	Below Sunnyside Dam	1455	1420	920	920	820	820	5900	11150	8510	955	955	965
Yakima R.	Above Marion Drain	1455	1420	920	920	820	820	5900	11150	8510	955	955	965
Yakima R.	Below Marion Drain	1455	1420	920	920	820	820	5900	11150	8510	955	955	965
Yakima R.	Above Toppenish Cr.	1455	1429	920	920	820	820	5900	11150	8510	955	955	965
Toppenish Cr.	At mouth	45	80	80	80	80	80	465	365	125	45	45	35
Toppenish Cr.	Above RM 44.2	20	20	20	20	70	70	97	97	60	23	23	18
Yakima R.	Below Toppenish	1500	1500	1000	1000	900	900	5900	11510	8635	1000	1000	1000
Yakima R.	Above Satus Cr.	1500	1500	1000	1000	900	900	5900	11510	8635	1000	1000	1000
Satus Cr.	At mouth	25	55	125	125	125	125	275	190	118	26	26	19
Satus Cr.	Below Logy Cr.	25	43	90	70	110	110	165	125	100	26	26	23
Satus Cr.	Logy Cr. at mouth	18	26	40	30	40	40	82	70	64	18	18	17
Satus Cr.	Above Logy Cr.	8	17	50	40	70	70	83	57	36	8	8	6
Yakima R.	Below Satus Cr.	1500	1500	1000	1000	1000	1000	5900	11700	8750	1000	1000	1000
Yakima R.	Above Prosser Dam	1500	1500	1000	1000	1000	1000	5900	11700	8750	1000	1000	1000
Yakima R.	Below Prosser Dam	1500	1500	1000	1000	1000	1000	5800	9800	7900	1000	1000	1000
Yakima R.	Above Kiona Canal	1500	1500	1000	1000	1000	1000	5800	9800	7900	1000	1000	1000
Yakima R.	Below Kiona Canal	1500	1500	1000	1000	1000	1000	5800	9800	7900	1000	1000	1000
Yakima R.	Above Horn Rapids	1500	1500	1000	1000	1000	1000	5800	9800	7900	1000	1000	1000
Yakima R.	Below Horn Rapids	1400	1400	1000	1000	1000	1000	5800	9800	7900	1000	1000	1000
Yakima R.	At mouth	1400	1400	1000	1000	1000	1000	5800	9800	7900	1000	1000	1000

Table 21: Optimal instream flow (cfs) recommendations developed by IFTAG through YRBWEP (edited from Table 1 in CBSP 1990)

Reach	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**
Yakima River												
Keechelus Dam-Easton Dam	125	125	100	100	100	125	125	125	125	100	100	100
Easton Dam-CleElum R.	400	400	350	350	275	275	275	275	275	225	225	225
CleElum R.	200	200	200	200	200	275	275	275	275	300	300	300
CleElum R.-Teanaway R.	650	650	600	600	525	525	500	500	500	600	600	600
Wilson Cr.-Roza Dam	750	1000	1000	750	750	900	900	750	750	750	750	750
Roza Dam-Naches R.	750	800	800	750	750	900	900	750	750	750	750	750
Sunnyside Dam-Marion Drain	800	700	700	700	700	600	700	800	800	800	800	800
Prosser Dam-Chandler Powerplant	800	1000	1000	800	800	800	800	700	700	800	800	800
Horn Rapids Dam-Col. R.	1300	1300	1300	900	900	900	900	800	800	800	800	800
Naches River												
Bumping River	150	150	150	150	150	150	200	200	200	100	100	150
Naches at Cliffdell	500	400	400	300	300	300	300	300	300	300	300	500
Tieton R. at Tieton Canal	150	200	200	200	200	125	125	125	125	200	200	150
Naches R. below Wapatox	500	500	400	400	400	400	400	400	400	400	400	400

Yakima River Mainstem 37.0002

Anadromous salmonid presence in the Yakima River mainstem extends from the confluence with the Columbia River at Kennewick (Columbia RM 335.2), to Keechelus Dam (Yakima RM 214.5) near Snoqualmie Pass. Adult and juvenile anadromous salmonids migrate as far as 550 miles between their natal spawning and rearing areas and the mouth of the Columbia River. The flow and habitat conditions vary as the river climbs from the arid desert conditions of the lower river to the moist snow-fed upper reaches.

The Yakima River supports spring chinook, fall chinook, summer steelhead, coho, and bull trout, and historically also supported sockeye in the large natural lakes of the upper watershed (all of these lakes have been converted to irrigation reservoirs, and no longer have anadromous fish passage). These species are the focus of this report. In addition, the Yakima River supports resident salmonids (resident rainbow, westslope cutthroat), although these species are not specifically addressed in this report.

Snyder and Stanford (2000 DRAFT) recently conducted a synthesis analysis of available information regarding salmonid habitat in the Yakima watershed. As a component of their analysis, they designated mainstem reaches that differ in river channel characteristics, and their routing of surface and groundwaters. These river reach designations and associated channel characteristics include:

- Yakima River Delta – The natural delta of the Yakima River is highly altered because of pooling upstream of McNary Dam. The lower 2.1 miles of the historic Yakima River are inundated, reducing the extent of historic distributaries and off-channel rearing areas.
- Mouth to Prosser Diversion Dam (RM 0.0 to 47.1) – This reach is characterized by a single meandering channel with few braids or mid-channel islands. The channel has downcut over time, isolating the channel from the adjacent floodplain. [From approx. RM 8 to RM 16 there is an area of upwelling in the floodplain of the river (Freudenthal). The source for this upwelling is likely from the Columbia River hyporheic zone to the north.] The reach from the mouth to Kiona (RM 29) was identified as the main fall chinook spawning area (CBSP1990), although the report indicated that it was difficult to assess spawning utilization due to turbidity during spawning. However, WDFW has developed new techniques of estimating fall chinook spawning escapement in the lower Yakima, and has successfully done so since 1998 (Watson 2001). Other anadromous salmonids use this reach only for overwintering and migration because of high summer water temperatures.
- Prosser Diversion Dam to Granger (RM 47.1 to 82.8) – The upper 17 miles of this reach includes side channels, backwater areas, and diverse habitat types; the downstream 18 miles are characterized by a low-gradient single channel with little habitat diversity (BOR 2000). Satus and Toppenish creeks are the two major tributaries in this reach, with additional significant inflow from ground water and irrigation return drains.
- Granger to Union Gap (RM 82.8 to 106) – This reach is considered one of the most structurally complex and diverse sections of the Yakima River (BOR 2000). For most of the reach, the highway constrains the floodplain on the west side of the river, whereas the other side of the floodplain is in a semi-natural state with numerous side-channels, braids, and backwater areas.
- Union Gap to Selah Gap (RM 106 to 116.4) - This reach borders the City of Yakima and is characterized by numerous side-channels, islands, and backwater areas. However, the full extent of the natural floodplain through much of this reach is confined by dikes.

- Selah Gap to Wilson Creek (RM116.4 to 147.0) – The river is confined in a canyon through the upper portion of this reach, with no side–channel complexes, few islands, and only a few backwater areas. As the river leaves the lower end of the canyon, it flows across a deep alluvial floodplain that has been heavily mined for gravel. The river is confined through this portion of the reach by dikes and bank protection, with little in-channel complexity.
- Wilson Creek to Thorp (RM 147.0 to 163.0) – This reach flows through the Ellensburg valley (BOR 2000). The channel is constrained on one side by the highway, and there is some flood control diking at several locations. At the lower end, there are braided channel complexes with some side-channels.
- Thorp to Teanaway River (RM 163.0 to 176.1) – The river is confined in this reach as it flows through the Ellensburg Canyon
- Teanaway River to Cle Elum River (RM 176.1 to 185.6) – This reach is primarily a large main channel, with some side channels (BOR 2000). The channel is mainly confined by the highway and railroad berms.
- Cle Elum River to Easton Dam (RM 185.6 to 202.5) - The reach is considered to be a high quality area for spawning and rearing, characterized by numerous side channels, complex structures in the channel, and good riparian vegetation (BOR 2000). There is some housing development within the floodplain in this reach.
- Easton to Keechelus Dam (RM 202.5 to 214.5) - This reach is characterized by numerous side channels, logjams, and braided channels, and is considered to be high quality spawning and rearing habitat with little influence from development (BOR 2000). The channel has an excellent riparian corridor, with a lot of complex in-channel structure.

Although these designated reaches do not relate directly to salmonid habitat limiting factors, they do represent the most contemporary breakout of mainstem channel reaches based on hydrologic function. It would be desirable to present data and recommendations from other studies using the Snyder and Stanford (2000 DRAFT) reach designations, however, much of the data from other studies use different reach breakouts. Consequently, the entire mainstem will be discussed for each of the habitat elements, using the Snyder and Stanford reaches where practical.

The USGS, as part of the National Water Quality Assessment Program conducted in 1990, identified that fish communities in the headwaters and upper Yakima watershed (Cascades and Eastern Cascades ecoregion) were dominated by cool-water species (Salmonidae and Cottidae), whereas the lower Yakima watershed (Columbia ecoregion) was dominated by suckers (Catostomidae) and non-native species, such as sunfish and bass (Centrarchidae)(Cuffney et al. 1997). Yakima Species Interaction Studies have identified significant populations of smallmouth bass, northern pikeminnow, and channel catfish in the lower Yakima River, which are known predators on fall and spring chinook smolts.

Fish Access

Except for Marion Drain fall chinook, adult access is not generally a problem in the lower Yakima (YSS 2001 DRAFT). Occasionally, high September temperatures in the lowermost reaches probably delay the entry of steelhead spawners, and low flows below Sunnyside Dam in drought years might delay migrating spring chinook, although Hockersmith et al (1995, as cited in YSS 2001 DRAFT) found no significant delay among the radiotagged spring chinook they tracked in 1992 (a very low flow year). Impaired passage may not be directly lethal, but it may delay and exhaust adult salmonids, possibly increasing pre-spawning mortality.

There are four major large irrigation diversion dams in the lower reaches of the Yakima River, including Horn Rapids Diversion Dam, Prosser Diversion Dam, Sunnyside Diversion Dam, and Wapato Diversion Dam. The primary impacts to adult salmonids at the lower Yakima diversion dams include: passage delay due to bedload clogging of ladders and/or LWD snagged against ladder exits; entrainment of fall chinook, coho and steelhead in Chandler Canal when it is dewatered for screen maintenance in the fall; and dewatering of fall chinook redds in the bypass reach when power generation resumes after the fall screen maintenance period (YSS 2001 DRAFT). Adult fish passage and screening to prevent juvenile salmonid entrainment into the diversion canals are provided at each of these diversion dams, and adult and juvenile fish passage are enumerated at the Prosser Diversion dam. However, there remains a strong concern that many smolts may be lost to predators (smallmouth bass, northern pikeminnow, gulls) at or below the bypass outfalls of each of these dams (Watson). Downstream smolt migrant mortality in Chandler Canal and the Chandler Smolt Enumeration Facility has been identified as a concern. In the latter half of May 1992 (at relatively high water temperatures of 16-22°C), smolt mortality in the upper Canal was estimated to be in the order of 40% (Sanford and Ruehle 1996, as cited in BOR 2000). Significant apparent mortality of smolts was also associated with passage through the Smolt Enumeration Facility. Subsequent work has shown that mortalities associated with operating the Chandler smolt counting facility occur mainly at higher water temperatures (Watson). Therefore, it is now the policy of the YN Fisheries Department, which operates the Chandler Smolt Enumeration Facility, to cease normal operations and implement a trap-and-haul operation whenever water temperatures at Prosser Dam exceed 70°F, and maximum daily air temperatures at Hanford exceed 90°F. Past experience has shown that when these conditions occur, water temperatures near the mouth are lethal. By this means, not only are mortalities associated with operation of the Chandler smolt facility minimized, but outmigrant smolts are spared heavy thermal- and predation-related mortalities in the lower river.

Migrating juveniles incur losses as they pass through the bypass systems at all four dams. northern pikeminnow congregate in the bypass outfall areas of Wapato, Sunnyside, and Prosser Dams (Dunnigan 1999) and smallmouth bass congregate below Horn Rapids Dam (McMichaels 1999)(all as cited in YSS 2001 DRAFT). Smallmouth bass (McMichaels, Battelle NW, personal communication, 2001) and northern pikeminnow (Fast et al. 1991) also congregate inside Chandler Canal, between the headworks and the bypass drums, and possibly inside the pre-bypass sections of the canals at the other four dams as well. California gulls also congregate in the vicinity of Prosser Dam and Horn Rapids Dam (Phinney 1999). All of these piscivorous animals consume smolts and parr as they negotiate the pre-bypass canal and as they are discharged back into the river.

At the Chandler bypass outfall, smolt losses to gull predation alone have been estimated at 1–2.5% over the years 1998-2000, but likely would have been considerably higher if flows had not been so high during the outmigration. Phinney (1999) observed that gulls cease feeding and begin leaving the Chandler outfall area when flows exceed ~4,000 cfs, presumably because they cannot see prey in turbid, fast water. Phinney (1999) estimated similar losses to gull predation at Horn Rapids Dam over the same time period, and observed a flow threshold of 3,000 cfs for feeding and congregation.

Phinney (1999), McMichaels (1999)(both as cited in YSS 2001 DRAFT) and others have speculated that most of the predation loss at canal bypasses is due to improperly designed outfalls. Accordingly, the YN and others have proposed that the outfall structures at all major dams on the Yakima be redesigned to “diffuse” smolts back into the river over as large an area as practicable.

Another smolt impact associated with lower Yakima diversion dams is the effect of water diversions at Prosser on smolts downstream (YSS 2001 DRAFT). Prosser Dam diverts up to 1,500 cfs into Chandler canal, over half of which is routed through a power plant 11 miles downstream and then returned to the river; the remainder continues down the KID canal to users in the Tri-Cities. During low-flow periods, flows in this "bypass reach" can become very low, delaying smolt outmigration and increasing the effectiveness of visual predators. Lower flows also expose boulders within the channel, which increase heat transfer to the surrounding water.

Radio-tagging studies during 1989-1993 indicated that while migration delays occurred downstream of some dams, the delays were generally attributable to low water temperatures (during winter months), and were not considered to cause significant adverse impact (Hockersmith et al. 1995, as provided by Monk). There is no evidence of adult passage problems at the mainstem dam structures at current YRBWEP minimum instream flow levels.

Low flows between Sunnyside and Prosser may affect Naches River steelhead more severely than Naches spring chinook, as steelhead smolts tend to leave the Naches later, when flows are lower and temperatures are higher (BOR 2000). Naches steelhead smolts are also affected to a much greater degree than smolts from Satus Creek, as Naches system smolts must negotiate up to 4 dams and all 57 miles of the Sunnyside to Prosser reach. Satus smolts have only one dam and the lower 12.5 miles of the reach, which benefits from discharge from Toppenish and Satus creeks and from several irrigation return drains. This possible difference in predatory vulnerability is one of the factors responsible for the relatively lower production of steelhead in the Naches watershed (Watson).

Although the upper Yakima River is thought to have historically supported approximately a third of the steelhead spawning and rearing in the Yakima watershed, populations of all anadromous salmonids in the upper Yakima River were severely depleted due to impaired access past splash dams at Pomona (Croci). Although populations were severely depleted by the time Roza dam was completed in 1940, construction nearly eliminated access, precluding the majority of upstream adult steelhead and coho migration during the fall and winter, when most of the spawning migration occurs. Prior to 1989, the fish ladder at Roza Dam was only functional at full pool. From 1941 through 1958, the pool upstream of Roza Dam was lowered, on average, from October 19 through March 17 (BOR HYROMET database), precluding upstream migration to ~70% of the coho run, and virtually the entire steelhead run (YSS 2001 DRAFT). A power plant was added to Roza Canal in 1959, providing an economic incentive to keep water flowing through the canal and fish ladder during as much of the year as possible. After installation of the power plant, continuous flow was maintained through the ladder, except during periods of severe icing or when the pool as lowered for maintenance. From 1959 until 1989, access still would have been denied to ~30% of a coho return with an early run timing. Ladder modifications in 1989 included fish passage entrances at full pool and low-pool, restoring full access for both coho and steelhead. Efforts are currently underway to increase steelhead production and reintroduce coho production upstream of Roza Dam.

Lake Easton Dam is operated and maintained by the Kittitas Reclamation District (KRD)(BOR 2000). The lake is essentially for diversion rather than storage. Operation of the fish ladder at Easton Diversion Dam varies from year to year based on the water supply outlook. The fish ladder at Easton is open in all years from October 20th through mid-May. Typically, the Bureau of Reclamation (BOR) in consultation with the Systems Operation Advisory Committee (SOAC), decides in May whether to keep the ladder open for spring chinook passage. The decision is based on predicted total water availability. If water supply forecasts indicate that mini flip-flop (increased water releases from Kachess Reservoir to compensate for reduced releases from

Keechelus Reservoir during flip-flop) can be executed during the coming fall, the ladders at Easton Diversion Dam are kept open. If spring chinook are allowed to pass upstream of Easton, but mini flip-flop is not operationally feasible, then a large proportion of the eggs are lost due to low streamflow conditions during the subsequent incubation period. Prior to 1997, mini flip-flop was possible about 50% of the time. The Kachess Dam outlet structure has since been modified, and now mini flip-flop is estimated to be possible 8-9 years out of 10. The fish ladder at Easton Dam was totally rebuilt in 1987 to improve anadromous access to the reach from Easton Dam to Keechelus Dam, because it did not function properly and was a significant obstacle for fish (BOR 2000). However, passage is still impaired in some years (Perala).

Juvenile fish screening has been installed and updated at all major mainstem diversions. In general, mark-recapture studies at fish bypass facilities at mainstem diversion dams showed minimal de-scaling and relatively rapid passage times for chinook salmon and slightly more de-scaling and longer passage times for steelhead (Abernathy et al. 1989, Neitzel et al. 1990; both as cited in YSS 2001 DRAFT). Most sites showed minimal to no entrainment, except for Town Canal and Westside Ditch, where up to 25% of the age-0 chinook (<36 mm long) were found to pass through the screens.

There is evidence that steelhead smolts produced upstream of Sunnyside Dam, like spring chinook smolts, suffered heavy losses before reaching Prosser Dam prior to completion of Phase I screening in 1989-1990. From 1983-1990, mean survival of hatchery steelhead released at Nelson Springs (Naches River tributary), and in tributaries of the Little Naches, to Prosser was just 25% (CBSP 1990). No comparable survival data is available for wild steelhead (Cummins). While the ultimate cause of poor smolt survival was inadequate instream flow in the mainstem Yakima (CBSP 1990), decreases may also be due to residualization, predation, and other causes.

Recent research conducted for the Species Interaction Study in the upper Yakima River basin, and research conducted elsewhere in Washington State, has provided information on residualism for steelhead. McMichael et al. (1990, as cited in BOR 2000) estimated that 26-39% of hatchery steelhead smolts (the hatchery used natural stocks from the area, there are no data on how representative these steelhead are of the natural population) released in the NF Teanaway River did not migrate more than 11 km downstream of the release point. Elsewhere in Washington, residualism of steelhead smolt releases has ranged between 20% (Tipping 1995, as cited in BOR 2000) and 66% (Tipping and Byrne 1996, as cited in BOR 2000). Residualism may explain a portion of past estimated losses upstream of Prosser. Residualism has also been observed in hatchery and wild origin spring chinook, with high encounter rates of 3 and 6-inch long spring chinook in the rainbow-targetted sport fishery (Pearsons).

Floodplain Modifications

A short discussion of the ecological and biological functions of floodplains follows; this discussion will help set the stage for how floodplain modifications have altered floodplain and hyporheic functions in the mainstem Yakima, as well as in the tributaries. Alluvial floodplains develop in predictable patterns, with predictable biologic results (Snyder and Stanford 2000 DRAFT). The alluvial floodplain is a three-dimensional feature that covers an area equivalent to the extent of the Holocene alluvial deposits in each valley, and includes the water table aquifer (which is in contact with the river) laterally and vertically to the extent utilized by organisms (vertebrates and invertebrates) which are dependent on the riverine environment to complete their life histories (Freudenthal). This concept differs from a hydraulic definition of a floodplain which is usually based on conveyance of a given flow or flow of a given recurrence interval (i.e. 100 years)- the ecologic floodplain can be much larger in some situations, which occurs in the

Yakima Basin. The ecologic floodplain (or floodplain/hyporheic zone) in a given valley usually is distinguished by areas of water loss (losing reaches) in the upstream end of the valley. It is in these locations where the surface of the water table (the piezometric surface) is at an elevation below the river – the river is the high point in the local water table. At some point in the mid-valley, the river enters an area where the river surface elevation is the same as the piezometric surface. This area will vary seasonally as the water table rises and falls, lagging behind the river hydrograph. In the lower valley, where the valley walls narrow, there is an area where the piezometric surface is above the surface of the river, and this area is an area of upwelling within the river, and the water table exposed to the surface within alluvial deposits adjacent to the river. Areas of upwelling often occur at the confluence of streams (Columbia/Yakima, Yakima/Toppenish, Toppenish/Simcoe, Yakima/Ahtanum/Wide Hollow, Naches/Rattlesnake, Yakima/Teanaway), and these areas are typically especially diverse. These lower-valley ecologic floodplain areas are the most biologically productive portions of the of the entire alluvial floodplain due to constant cool, and usually well oxygenated waters which flow from the water table. It is these functional elements (downwelling, fluctuating piezometric surface/water storage, upwelling) that form the biologic/ecologic floodplains that figure prominently in the Yakima basin (Snyder and Stanford 2001 DRAFT).

There is much discussion throughout this document regarding both floodplain disconnection and floodplain loss. If the hydraulic or hydrologic definitions of floodplains were being used, remedy for disconnection or loss would primarily involve the removal of dikes, levees and the widening or removal of bridges, and increasing instream flows to mitigate for the loss of storage (Freudenthal). Pursuing these actions will, in many cases, result in restoration of some degree of floodplain function, but will not result in restoration of the full biological/ecological floodplain. Other sources of disconnection (i.e. the loss of processes such as downwelling or routing of water into floodplain storage, loss of the ability of the water table to rise and fall, and upwelling in the river and floodplain) of the ecological floodplain are (Freudenthal):

- Channel downcutting or aggradation: These processes fundamentally change the relationship between the river surface and the piezometric surface. Generally lowering storage capacity and downwelling to the floodplain in the case of downcutting, eliminating upwelling to the river and floodplain in the case of aggradation.
- Modification of river hydrology: Changing the hydrologic (usually flattening the yearly hydrograph) regime of the river changes the storage and flux of the alluvial floodplain.
- Raising and fixing the elevation of the river surface at one elevation: Actions which fix the river elevation (i.e. diversion dams at certain locations, bridges in some locations) do not allow the water table to fall, converting areas of the floodplain and hyporheic zone from “live” storage to “dead” storage and eliminating upwelling where it previously occurred. These actions prevent the release of stored water in the water table (usually cool and well oxygenated) to the river as river flows drop in the summer.
- Lowering and fixing the elevation of the water table: Actions such as this (installation and maintenance of drainage facilities) short circuit floodplain storage, lowering the water table and reducing the amount of live storage in the water table, and lessening or eliminating discharge to the river from the hyporheic zone during summer and fall.

The suite of restoration actions for the ecological floodplain is much more extensive than that for hydraulic floodplains (Freudenthal). It also has profound implications for riverine processes as well, primarily water temperature in the mainstem, and the direct restoration of physical habitat for both vertebrates (i.e. spawning and rearing salmonids) and invertebrates in the floodplain. Restoration of biological/ecological floodplain function will require consideration of the entire suite of potential restoration activities for re-establishment of the floodplain processes.

Historically, the alluvial portions of the lower Yakima River supported all life stages of summer chinook, fall chinook, steelhead, and coho, as well as the juvenile life stages of spring chinook (YSS 2001 DRAFT). One of the most dramatic alterations to the aquatic ecosystem has been the loss of habitat complexity, including connectivity between off-channel and mainstem habitat, which directly relate to the ability of the ecosystem to support salmonid populations (BOR 2000). Flood control dikes and levees, and railroad and highway construction have disrupted the lateral connectivity between wetted areas that occurred historically. This deprivation of lateral connectivity has resulted in loss of habitat, reduced vertical connectivity, loss of or changes in nutrient flux, and reduction in the tempering effect of groundwater on stream temperature. Development on low-lying floodplains adjacent to the Yakima River is reducing historic floodplain water storage areas, thus accelerating movement of water out of the watershed (USFS 1997). This potentially reduces the availability of water in the early irrigation season and therefore creates greater dependency upon water storage. There is a need for local government, with the assistance of the USFS and others, to establish ordinances to effectively deal with development of impervious surfaces and other impacts to floodplain function.

The Yakima River floodplain is one of the most heavily mined floodplains in Washington State (YSS 2001 DRAFT). Resource managers are currently studying the ecology and morphology of floodplain gravel pits and associated effects on the riverine community. The results of these investigations will be used to develop risk assessment approaches for future gravel mining operations and to develop a decision framework for management and mitigation of existing pits.

Pearsons et al. (1994, as cited in Snyder and Stanford 2000 DRAFT) indicated that bank and off-channel habitats in the upper Yakima watershed were extremely important to age 0+ spring chinook, and that on average, 2.7 times more fish were found in side-channels and backwater sloughs vs. the mainstem. Backwater channels are believed to be important rearing grounds for salmonids because of lower water velocity, greater cover, and more abundant food resources. The cumulative loss of floodplain and off-channel habitats, identified below, likely is a significant limiting factor for salmonid production in the Yakima basin.

Evaluations of loss of floodplain in six alluvial reaches of the Yakima River mainstem during the 20th century indicate that on average 66.6% of the historic floodplain in these reaches has been disconnected (Table 22; Eitemiller and Uebelacker, as cited in Snyder and Stanford 2001). These

Table 22: Extent of historic floodplain compared to current floodplain. Historic floodplain delineated as Holocene sediment deposits. Floodplain encroachment includes road and rail revetments and flood control levees (data from Eitemiller and Uebelacker, as presented in Snyder and Stanford 2001)

	Extent of active floodplain (hectares)				**% loss of active floodplain from pristine**		
Reach	**Pristine**	**1884-1915**	**1916-1965**	**1966-1999**	**1915**	**1965**	**1999**
Easton	2687	1692	1529	1046	37	43	61
Cle Elum	1749	978	928	717	44	47	59
Kittitas	5420	3340	2732	1708	38	50	68
Selah	1182	1024	950	389	13	20	67
Union Gap	2325	1840	1592	921	21	32	60
Wapato	26869	8286	NA	3969	69	NA	85

losses are significant, and affect the river structure and function, which depend on the interaction of the floodplain and the channel.

Johnson (1994, as cited in Snyder and Stanford 2000 DRAFT) evaluated floodplain development in the Yakima floodplain from the Cle Elum River confluence upstream to Lake Easton. Findings included:

- All old growth riparian timber was removed by 1936
- Construction of I-90 constrained 8 km of the 31 km reach
- 5 major subdivisions were constructed from 1961-1970, including a private camp, a golf course, and 230 houses built within the designated floodplain
- In a 2 km section at Elk Meadows, at least 10 springbrooks and backwater channels had been disconnected with no indication of replacement or rejuvenation

Yakima River floodplain function in the reach from Easton to Keechelus is excellent, with meandering and braiding of the channel (WDFW 1998). The USFS (1997) identified a concern that Interstate-90 and the railroad may be affecting adult salmonid numbers in the upper Yakima River. I-90 borders much of the river above Manastash Creek; agricultural development is more intense, and diking, riprapping, and channelization have also been concentrated in this area (YSS 2001 DRAFT). Consequently, about three fourths of the river above Manastash has been narrowed to a single thread, leaving a considerable number of isolated side channels. Bank sloughing is common, the riparian corridor is nonexistent or severely degraded, and LWD has been swept away by diking-induced increases in water velocity.

The Yakima River floodplain, in the reach from Wenas Creek to Wilson Creek, lies mostly in the confined, steep, deep-walled Yakima Canyon (YSS 2001 DRAFT). The river is bordered almost continually on the right bank by a railroad embankment, and on the left by SR 821. Although it is apparent that the road construction significantly altered the left bank and confined the channel in places within the canyon (Figure 32), the structure of the river in the Yakima Canyon may not be radically altered since the area was first developed. Water velocities and prey availability in the canyon are suitable for large parr and adult trout, but are too high for smaller life stages. The river is more confined than it was historically, but it is unlikely that it was historically more complex. The canyon is a transport reach, and the natural confinement limits development of multiple channels, accumulations of LWD, or other channel complexity elements. However, a cloudburst in summer 1998 triggered over 30 landslides upstream of Roza Dam, many of which have narrowed the river by up to half and created large downstream eddies. Channel habitat complexity in the canyon was actually increased as a result of these slides.

Figure 32: SR 821 in Yakima Canyon, apparently shortly after initial road construction (circa 1920s)

Yakima River floodplain function in the reach from the Naches River to Wenas Creek has been severely degraded (YSS 2001 DRAFT). Much of the floodplain has been overgrazed for many years. A very large fruit processing wastewater spray field borders one bank and a large gravel mining operation borders the other. Much of the reach is now confined between poorly constructed levees protecting the gravel mining operation and various developed properties. Aerial photos taken in 1927 show this reach to have an extremely sinuous channel in the lower 3 miles of the valley upstream of Selah Gap (Freudenthal). It is likely that the poorly constructed dikes which now line this straightened reach will continue to fail as they did in the 1996 and previous flood events. Although floodplain gravel mining has resulted in some long-term damage, this reach has potential for significant habitat rehabilitation (YSS 2001 DRAFT). The levees could be selectively opened, set back, or removed. A natural springbrook, modified to serve as an irrigation canal (Taylor Ditch), runs through the floodplain and could provide rearing habitat, with riparian and LWD restoration. An assessment of water quality and habitat function in Taylor Ditch is being conducted, and a suite of restoration actions is being developed and is expected to be available by spring 2001.

The importance of the Wapato alluvial reach (from Union Gap to downstream of the mouth of Satus Creek, including the historic lower portions of Toppenish and Satus creeks) to historical production was probably enormous (YSS 2001). The 1909 Indian Irrigation Service map (see YSS 2001 DRAFT) of the Wapato reach shows it to be about 30 miles long and up to five miles wide, with extraordinary complexity. Except for channels in recently disturbed areas, most would have been bordered by dense growths of willows, with the larger/older channels bordered by cottonwoods. The accumulation of LWD, recruited on-site and from upstream, must have been enormous, and was probably a major reason for the extraordinary channel complexity. The abundant LWD would have likely created and maintained ideal structural conditions (pools and gravel beds) for spawning and pre-spawning adults, and the storage and subsequent discharge of cold spring snowmelt runoff in the Toppenish/Yakima hyporheic aquifer, and in various wetlands along Toppenish and Simcoe creeks, would have kept water temperature cool enough for juvenile rearing in summer. Portions of this "floodplain" lie outside of the areas that would be flooded during low-frequency (100 year or more) events, and were essentially the surficial aquifer at the surface of the alluvial deposits (Freudenthal). This relationship to the river would have resulted in an area of springbrooks with extraordinary channel stability over long periods of time, which in turn would facilitate development of life histories that exploited this near-ideal habitat. A major portion of the basin-wide production of chinook and coho salmon was probably attributable to this reach, and to a much lesser degree the less extensive alluvial reach between RM 8 and RM 16. One significant difference between the Wapato and the lower alluvial reaches is that the latter was not fringed by large cottonwoods (early explorers noted that cottonwoods were not encountered downstream of ~RM 40 (except in the delta), although willows and other brush were dense (U.S. Senate Ex. Doc. 1860, as cited by Harner in App. A of Snyder and Stanford 2000 DRAFT). Although the Wapato reach remains one of the most complex alluvial reaches in the Yakima watershed, it is but a mere shadow of its historic condition. The extent of the historic floodplain has been reduced by flow regulation that has eliminated snowmelt flood flows, road constriction, construction of dikes and levees, draining and filling of historic floodplain wetlands, and consolidation of floodplain channels. In addition, because of flow regulation and other structural habitat modifications in this reach, it is no longer thermally suitable for year-round rearing of salmonids. A 137-acre parcel of prime floodplain habitat (Henne Protection Project) was recently acquired on the Yakima River near Union Gap (YSS 2001 DRAFT). The property contains numerous backwater alcoves and wetlands, and has riparian habitat that is properly functioning at several locations.

Floodplain /hyporheic function is likely impaired through much of the lower Yakima (downstream of Union Gap) by presence of numerous deeply incised agricultural drains that bisect the natural Yakima River floodplain. Some of the "drains" are natural channels that have been altered to increase drainage of groundwater from adjacent agricultural lands, others are created channels where none previously existed. These drains intercept natural hyporheic flow, and interrupt hyporheic flow through the Yakima floodplain downstream of the drains. The interception of hyporheic flow and the transport of operational spills of irrigation water through the drains contribute to the "non-normative" hydrograph in the lower Yakima River, and likely also affect water temperatures in the lower Yakima.

Floodplain reaches that appear to be crucial to the long-term survival and recovery of salmon in the Yakima watershed have been evaluated and ranked based on natural habitat heterogeneity, productivity, current and historic use by anadromous salmonids, and restoration potential (Snyder and Stanford 2000 DRAFT). The mainstem Yakima reaches identified for conservation actions, listed in order of priority are:

1. Upper Yakima-Teanaway – From upstream of the Cle Elum confluence downstream to about halfway between the Teanaway River and Swauk Creek, including the lower ~1 km of the Teanaway. This is a very complex floodplain, with the primary zone of upwelling and braiding around the Teanaway-Yakima confluence. Although much of this reach is significantly altered and disconnected (the river is channelized and constricted between the railroad and I-90, there are several gravel pits within the floodplain, the river is generally a flume in the vicinity of the hatchery, and the floodplain is significantly altered downstream of the crossing below Cle Elum), a substantial portion of this floodplain reach remains connected and has little development (Eric Snyder, pers. comm.). This floodplain reach is also influenced by regulated flows, abstraction via Easton Diversion, and several diversions on the Teanaway. The Teanaway-Yakima confluence area has substantial restoration potential because the land is not heavily developed and because the remnant backwaters and spring brooks are present in spite of the road berms and bridge revetments.
2. Kittitas Valley – From the Taneum Creek confluence downstream to the upper end of the Yakima Canyon. Much of this floodplain reach is disconnected from the river by I-90 and other road berms, and it is influenced by flow regulation from the headwater reservoirs and diversions. Riparian encroachment by new homes is also a big problem; there is increasing development occurring and additional existing plats yet to be developed. The Cascade and Ellensburg Water Company (Town Ditch) diversions are within this reach, although both are smaller than the major irrigation diversions in the lower watershed. The lower 5-8 km of the reach is a very complex upwelling system with substantial intact riparian forest and minimal housing encroachment.
3. Yakima City – From the Naches River confluence downstream to Union Gap. This floodplain reach has extensive floodplain urbanization encroachment and revetment. The lower 5 km has extensive upwelling, with a fair amount of interconnected floodplain habitat.
4. Wapato – From Union Gap downstream ~35 km to near the confluence of Satus Creek. What remains of the floodplain is in good condition, with an extensive cottonwood riparian forest. However, the reach is influenced by Sunnyside Dam and other upstream diversions and irrigation returns via numerous drains. In addition, floodplain function is impaired by an old levee that was built prior to construction of the highway, and riparian vegetation through much of the reach is composed of Russian olive and purple loosestrife (TAG). The floodplain habitats are most complex from the Wapato Bridge downstream to the upper end of the meander zone (near the mouth of Satus Creek), with extensive

riparian wetlands associated with upwelling from the alluvial aquifer system. This reach is of likely major importance as rearing habitat for juvenile salmon and steelhead.

5. Selah – From the downstream end of the Yakima Canyon downstream to Selah Gap (~8 km). This floodplain reach is substantially modified by gravel mining, but has a nice upwelling zone at its lower end that probably could be rehabilitated by normative flows if gravel mining ceased. The Taylor Ditch, located within the Selah Reach, is a 4-5 mile long old right–bank side channel that has been converted to irrigation delivery (Renfrow). The channel is currently screened at the upper end, but salmonids are known to occur in the channel. Taylor Ditch offers good potential to provide side-channel habitat in this otherwise altered reach.
6. Yakima River Mouth – Including the lower portion of the Yakima River that is inundated by McNary pool (~3 km). This floodplain likely was very extensive and complex prior to the construction of McNary Dam on the Columbia River. Remnant riparian forests remain on exposed portions of the extensive alluvial delta (most of the original delta is submerged). The reach is substantially modified by inundation and erosion associated with McNary pool, but a substantial expanse of wetlands exists on the fringes. Surface and groundwater interactions appear to be dominated by infiltration of McNary pool water, which probably maintains the fringing wetlands. General Land Office maps from 1867 on file at the Benton County Assessor's Office show this reach to have large areas of "swamps" on either side of the river at that date (Freudenthal). Plan view changes in channel location over time have been very minimal in this reach since these 1867 maps, indicating that bank resistance to erosion in this reach has been very high (due to dense vegetation and lack of floodplain constriction) since prior to construction of McNary Dam and modification of the hydrologic regime of the Columbia and Yakima rivers. The source of water for upwelling in this reach is likely the combined Columbia River/Yakima River hyporheic zone, which extends well beneath the Hanford Site.

A key uncertainty in the ranking above is the relative importance of the meandering reach from the lower end of the Wapato floodplain reach (priority 4) and Prosser. The reach appears to have considerable habitat complexity (Snyder and Stanford 2000 DRAFT), and is very heavily used for overwintering by spring chinook (Fast et al 1991) and by steelhead pre-spawners (Fast et al. 1991; Hockersmith 1995). Figure 4 in Snyder and Stanford (2000 DRAFT) shows a groundwater divide drawn from Toppenish ridge to the north side of the valley wall. Channel pattern of the river indicates that this reach is an area of significant upwelling, which accounts for the channel complexity observable in historic maps/photos and today (Freudenthal). This reach was undoubtedly influenced by flow from the hyporheic zone upstream of Toppenish Ridge as channel pattern in this reach does not show changes in gradient, channel form, or vegetation associated with "losing" reaches or areas of discharge from the river to the surficial aquifer.

Prioritization of these floodplain reaches for conservation does not mean that the rest of the river corridor does not require restoration of normative conditions (Snyder and Stanford 2000 DRAFT). The premise is that if the most aggraded reaches are naturalized, the more constrained reaches (where change in river stage likely has relatively less spatial influence) will also be enhanced.

The general consensus of fish biologists working in the Yakima watershed is that the flood flows in 1996 significantly improved floodplain function throughout the Yakima mainstem. Dikes were breached at some locations, restoring floodplain function in areas previously isolated from the active floodplain by the dikes. Habitat complexity also increased, with increased braiding, side-channel creation, and delivery and transport of LWD, forming functional logjams. The 1996 flood also charged the alluvial aquifers of both the Yakima and Columbia rivers, allowing a more

"normative" flux of the surficial aquifer, and recharge to the rivers in late summer (Freudenthal). Unfortunately, little quantitative data exists indicating the extent to which floodplain/hyporheic zone function increased due to the 1996 flood. However, there is general agreement within the TAG that periodic normative peak flows are essential to maintaining and improving floodplain function on the Yakima River.

A specific project intended to increase floodplain connectivity and function in the upper Yakima River is the Hanson Ponds Floodplain Restoration Project, which will add 1 mile of side-channel habitat, improve floodplain connectivity, restore riparian habitat adjacent to the Yakima River, and improve channel complexity (YSS 2001 DRAFT). The project will involve removal of a 0.9-mile long armored levee, reworking of the levee to allow riparian vegetation growth, addition of LWD to the newly accessible ponds, and relocation of the levee a considerable distance from the river.

Although they are not fish passage barriers, increased accessibility due to road and railroad presence along many of the tributaries in the upper Yakima and Naches watersheds has resulted in increased susceptibility of adult salmonids to sport fishing, particularly to remnant populations of bull trout (USFS 1997). In addition, roads and railroads have significantly affected channel morphology, particularly the constriction of floodplain function by the routing of the railroad. Roads and campgrounds on riverbanks in spawning areas bring fish and people in close proximity. This likely increases poaching, but rock throwing, construction of small rock dams (for the sake of having something to keep occupied with while camping), clubbing, and simply disturbing spawning fish are also factors, and may be more of a factor the actual poaching (Cummins).

Channel Conditions

Channel conditions have been severely impacted by a long history of splash damming and log drives down the mainstem Yakima River. The earliest recorded large log drive occurred in the spring of 1880, when an enormous drive of logs and railroad tie timber was floated from Cle Elum to the Northern Pacific Co. mill at Ainsworth (Pasco)(Kittitas County Centennial Committee 1989). The first major commercial logging company was the Cascade Logging Co., formed in 1901. Logs were floated downriver on the spring thaw, up to 15 million board feet annually, with the log drive taking approximately 6 weeks to go from Easton to the mill in Yakima. The splash dams severely or totally eliminated anadromous fish passage, and the massive energy associated with water releases and large volumes of logs would have severely affected the bed, banks, and substrate of the Yakima River.

Some of the best spring chinook spawning and steelhead spawning and rearing habitat in the Yakima River watershed is found in the upper Yakima River from Keechelus Dam (RM 214.5) downstream to the confluence of the Teanaway River (RM 176.1)(CBSP 1990). There are many gravel bars and resting pools. The USFS (1997) estimated that the mainstem Yakima River ecosystem, upstream of the Teanaway confluence would be deficient in large diameter downed logs (both in-channel and upland) due to high levels of timber harvest on private and/or federal land, and recommended that downed logs in this area should be retained. Although there appears to be substantial LWD in this reach, LWD condition is rated as fair/poor, as much of the LWD is not in the channel at the lower flows at which spawning and initial rearing occurs (Renfrow, Fisher). The reach from the mouth of the Teanaway downstream to Wenas Creek lacks LWD, and associated channel diversity and complexity (CBSP 1990). The canyon area is primarily a transport reach that would naturally have low abundance of LWD, but the reach would benefit from additional instream cover (LWD, boulders) compared to what is currently present.

Channel conditions in the Yakima River from Wenas Creek downstream to the Naches River confluence are poor, with sparse riparian vegetation, collapsed streambanks, large width to depth ratio, and extremely scarce LWD presence (YSS 2001 DRAFT). However, the numerous deep pools and springbrooks upstream of Wenas Creek provide winter habitat for both salmon and steelhead juveniles, although low winter flows may adversely impact utilization of mainstem habitat. Historically, this reach consisted of a number of large, shifting channels, a large number of springbrooks, and scattered clumps of cottonwood. LWD was probably abundant, as the reach was the first structurally complex area downstream of the Yakima Canyon, which was a transport reach.

In general, the mainstem Yakima River between Sunnyside Dam (RM 103.8) and Satus Creek (RM 69.6) is considered to contain diverse habitat of good quality with adequate winter holding habitat (BOR 2000). The reach from Kiona to the mouth contains good riffles and pools (CBSP 1990); LWD is generally lacking (Watson).

A recent project to improve channel conditions was completed on a side-channel in the vicinity of the confluence with the Teanaway River. Boulder clusters and LWD were placed near the Teanaway junction boat ramp to increase channel complexity and rearing habitat quality along 100 yards of simplified side-channel habitat (YSS 2001 DRAFT). Additional LWD placement is anticipated at this location within the next year.

Substrate Condition

The conceptual foundation that cut and fill alluviation is directly correlated to maintenance of habitat heterogeneity clearly underscores the need to fully understand limitations on gravel recruitment and dynamics in relation to flow regime, because spawning gravels and floodplain backwater habitats (the shifting habitat mosaic) are so important to salmon and steelhead (Snyder and Stanford 2000 DRAFT). The supply and composition of gravels in the Yakima River has been affected by 1) construction of irrigation dams, 2) extensive levying, 3) removal of floodplain deposits of alluvial gravel by aggregate operators and for road and rail grades, and 4) alteration of the natural hydrograph. [The storage dams on the historic glacial lakes at Bumping, Cle Elum, Kachess, and Keechelus probably have not significantly affected sediment transport through the lake (Perala). Tieton Dam has interrupted the transport of coarse sediment through the reservoir to the Tieton River; much of the fine sediment is still transported downstream, but coarse sediment and an increased amount of fine sediment settles out in the reservoir. Diversion dams have changed the timing of sediment transport and bedload movement.] Although there has been sampling at several locations in the watershed to determine gravel size composition (particularly presence of fines that may impair egg survival), data are currently unavailable to determine whether various reaches are degrading or downcutting due to interruption of sediment routing processes (due to revetment, flow regulation, dams, etc.)(Snyder and Stanford 2000 DRAFT).

Substrate in the upper reaches of the Yakima River is composed mostly of cobble and large gravel, with some boulders, sand, and silt. There are many gravel bars upstream of the confluence of the Teanaway River (RM 176.1)(WDFW 1998). Substrate condition has been affected downstream of Easton Dam by past flushing of accumulated sediment through the sluice gates at Easton Dam (BOR 2000). Until recently, the flushing of sediment occurred in the fall, onto spring chinook spawning habitat when redds were present. Periodic maintenance on the dam gate also requires the lowering of Lake Easton (YSS 2001 DRAFT). This has resulted in exposure and erosion of lake bottom sediment, especially when fall rains erodes soft basin walls and re-suspends mud, with resulting sedimentation of important spring chinook spawning areas

downstream. The flushing of sediments has been modified by opening the sluice gates periodically throughout the year, with primary flushing occurring in spring when flows are high, so that sediment can be dispersed.

The USFS (1997) evaluated spawning habitat conditions in the mainstem Yakima upstream of the Teanaway confluence. From the Teanaway confluence to the Big Creek confluence, they rated 23 miles as good, 1 mile as fair, and 1 mile as poor spawning habitat. From the Big Creek confluence to Keechelus dam (includes some tributary habitat), they rated 42 miles as good, 4 miles as fair, and 18 miles as poor spawning habitat.

Fast et al. (1991, as cited in Snyder and Stanford 2000 DRAFT) analyzed the size characteristics of gravel located within three meters of spring chinook redds in the upper Yakima from Cle Elum to Easton, and found 11-16% fines (<0.85 mm). Resulting egg-to-fry survival rates of 59.6% are within the range of values reported by other researchers, indicating generally good substrate condition.

Substrate stability in the Yakima River at Cle Elum has been reduced as a result of highway construction (Interstate 90) from what would be otherwise expected for a stream in the Cascades ecoregion (Cuffney et al. 1997). Substrate instability is indicated by discharge rating curves that shift with storms.

The substrate downstream of Roza Dam was affected annually by flushing of large amounts of sediment that accumulated behind the dam (BOR 2000). Until 1998, the gates at Roza Diversion Dam were raised prior to screen maintenance every fall to dewater the screens for maintenance. As the sediment washed downstream, it adversely affected the biota downstream of the dam. In 1998, the dewatering process was revised to reduce the extent of lowering of the Roza forebay, thereby reducing the amount of sediment flushed downstream. Current operations include a decreased ramping down of the pool upstream of Roza at the end of the irrigation season, which reduces the entrainment of sediment (John Dyson, Walt Larrick, BOR, personal communication). Roza is managed for flow-through of peak winter flows, which passes accumulated fine sediments through the system, rather than at low flows where they previously settled in the reach downstream of Roza Dam.

Upstream of Granger Drain, the Yakima River is more riverine, with a fair number of riffles and less fine sedimentation of gravels (CBSP 1990). From Granger Drain downstream to Prosser Dam, the Yakima River is deep and slow moving, with a silt/algae bottom and very few riffles (CBSP 1990). The fall chinook population spawning upstream of Prosser Dam is likely more severely impacted by sedimentation of gravels than fall chinook spawning downstream of Prosser Dam, as there is some evidence (lower turbidity levels at Kiona than at Prosser (Mongillo and Faulconer 1980)) that suspended material settles out before reaching lower river spawning areas (CBSP 1990). One would expect less sedimentation below Prosser Dam because the very slow-moving, meandering reach from the mouth of Satus Creek downstream to Prosser Dam acts as a settling basin (Watson).

The six years during the period 1983-2000 with the lowest fall chinook production rates (1984, 1990, 1994, 1995, 1996, 1998; Yakima River and Marion Drain combined spawning upstream of Prosser Dam) encountered very high water and presumably some extent of redd scour during incubation (YSS 2001 DRAFT). It is speculated that flows of the magnitudes experienced in these years would not likely have caused the same extent of scour historically, when the river energy was able to expand laterally over a broad floodplain.

From Kiona to Prosser Dam, the river flows through a narrow valley, with swift current and few gravel beds; sedimentation is worse than found downstream, and overall substrate condition is poor (CBSP 1990). There are good pools and gravel riffles from the mouth to Kiona; spawning gravels contain deposited fine sediments, but the severity is less than in Yakima reaches further upstream.

Riparian Condition

Survey reports of riparian conditions along the Yakima river in the 1850s indicate that the lower 40 miles of the Yakima had no wood on its banks other than small willows and occasional poplars, with grass covering islands and the stream edge (U.S. Senate Ex. Doc. 1860, as cited by Harner in App. A of Snyder and Stanford 2000 DRAFT). Around RM 40 (interpreting this distance using a roughly straight line upstream from the historic confluence with the Columbia River would put this point at approximately Prosser, where there is a dramatic change in river shape (Freudenthal)), cottonwoods began to line the river, with pine occasionally interspersed and becoming more abundant higher up in the valley. At RM 55 (approximately near the mouth of Sulphur Creek (Freudentahl)), the surveyors noted the presence of oaks. They recorded "You pass up the main Yakima 70 miles (approximately at the upper end of the tortuous meanders about 4 miles downstream of Granger (Freudenthal)) before you reach the building pine, although cottonwood is found on its banks sufficient for camping purposes." Towards the base of the mountains they recorded that "Yellow pine appears, and gradually increases in amount on the banks of the streams, and at about 90 miles from its mouth (approximately at Union Gap (Freudenthal)) begins to appear on the mountain slopes, marking with rather a sudden and sharp line the border of the unwooded plains."

From Keechelus Dam to Easton, riparian condition is excellent. The riparian corridor is generally excellent from Easton to the mouth of the Teanaway River, except for clusters of summer homes, with associated removal of riparian vegetation and riprap armoring of the streambanks (WDFW 1998, CBSP 1990). From Taneum Creek (RM 166.1) downstream to Wilson Creek (RM 147.0), riparian condition is variable, with patches of severe bank sloughing. Where the river is close to I-90 in this reach, constriction of the floodplain has resulted in bank cutting as the river seeks a new equilibrium. Upstream of Damon Road, there is an unvegetated levee that was built to protect a couple of old gravel pits; the pits are now connected with the Yakima River at high flows, and there may be opportunities to restore riparian and floodplain function at this location through removal of the old levee (Renfrow). Riparian restoration was recently completed on ~1 mile of streambank just downstream of the gravel pits on the opposite bank (Brunson property). A riparian buffer width of 25-150 feet was initially planted, but has been modified to 60-80 feet as a result of channel movement. Downstream of Damon Road, riparian condition is generally good, although it is impaired by presence of unvegetated levees; a levee on the left bank was built to protect the feed lot (now closed), and a levee on the right bank exists to protect homes and pastures. There may also be some opportunities to restore riparian and floodplain function at one or both of these locations.

From Wilson Creek downstream to Roza Dam, riparian vegetation is sparse, often consisting entirely of reed canary grass on left bank (bordered by highway) and a low fringe of willows on the right bank (bordered by railroad)(Watson)

From Wenas Creek downstream to the City of Yakima, riparian condition is severely degraded where the riparian zone has been overgrazed and where the river has been channelized (CBSP 1990). There is minimal riparian buffer in the urbanized areas from Roza Dam downstream to Sunnyside Dam (e.g., City of Yakima)(WDFW 1998).

Riparian condition is brushy downstream of Granger (CBSP 1990). Riparian condition is poor/fair from Kiona to Prosser Dam, with impacts from unrestricted grazing. Riparian condition is fair from the mouth to Kiona, with riparian disconnection due to dikes and unrestricted grazing.

There are several reaches of the Yakima River, upstream of Satus Creek that have dense stands of mature cottonwoods, which are considered to provide good riparian function. However, close inspection of these mature cottonwood stands indicates they are missing characteristics of healthy cottonwood galleries (Jeff Braatne, CBFWA Study Presentation). Age classes in the existing galleries are primarily limited to only older cottonwoods, with little recruitment of younger age classes. In addition, the sex ratio of existing mature cottonwoods appears to be skewed, with a sex ratio of approximately 5M:1F. Natural cottonwood regeneration would occur in the spring, as seed is scattered on gravel bars that are inundated during spring runoff. As the natural hydrograph drops, cottonwood seedlings would be able to root and grow on the bars. Alteration of the natural hydrograph in the Yakima River for irrigation delivery has eliminated most of the natural cottonwood reproduction potential. In most years, the peak of spring runoff is significantly reduced, as the water is stored in the major reservoirs for irrigation releases through the summer. The irrigation releases result in high flows in late-spring/summer that keep the gravel bars inundated, precluding natural cottonwood regeneration. In addition, unrestricted livestock grazing in some areas has eliminated localized potential for cottonwood regeneration. Consequently, although some areas currently have good riparian function, future conditions are likely to deteriorate unless normative flows are reestablished to encourage natural cottonwood regeneration.

Water Quality

The Yakima River mainstem from the confluence of the Cle Elum River downstream to the mouth is designated as Class A (excellent) waters (WAC 173.201(a)), which determines which water quality parameters need to be met. The Yakima River mainstem upstream of the Cle Elum River confluence is designated as Class AA (exceptional) waters.

Alteration of the normal hydrograph, river/floodplain disconnection, channel simplification, and other factors act together to produce higher summer water temperatures, and also to reduce the number and extent of thermal refugia (Ring and Watson 1999, as cited in BOR 2000). Floodplain changes initiated more than 80 years ago may have shifted the temperature regime in the Yakima River watershed. Others have suggested that summertime stream temperatures in the lower river would have been moderated historically by inflow of groundwater, shading by riparian vegetation, and other factors (ISG 1996, Lichatowich and Mobrand 1995; as cited in BOR 2000). The effects of changing from normal spring runoff floodplain saturation to application and storage of groundwater via irrigation are not well understood (Lilga 1998, as cited in BOR 2000).

Water quality in the Yakima River watershed becomes progressively impaired as it moves from the headwaters to the mouth. As the river passes through the Kittitas Valley, it receives pollutants from irrigated pasture lands and municipalities (WDFW 1998). Although almost all water quality indices suffer a progressive deterioration through the Kittitas Valley, water quality is still considered to be generally good at Roza Dam. Similarly, water quality in the forested headwaters of the lower Yakima tributaries (e.g., Satus Creek) is good, deteriorating as it proceeds through the agricultural area in the lower watershed prior to entry into the Yakima River.

Numerous excursions from state water quality standards have been documented on the Yakima River. Seven reaches of the upper Yakima River are included on the CWA 303(d) impaired water

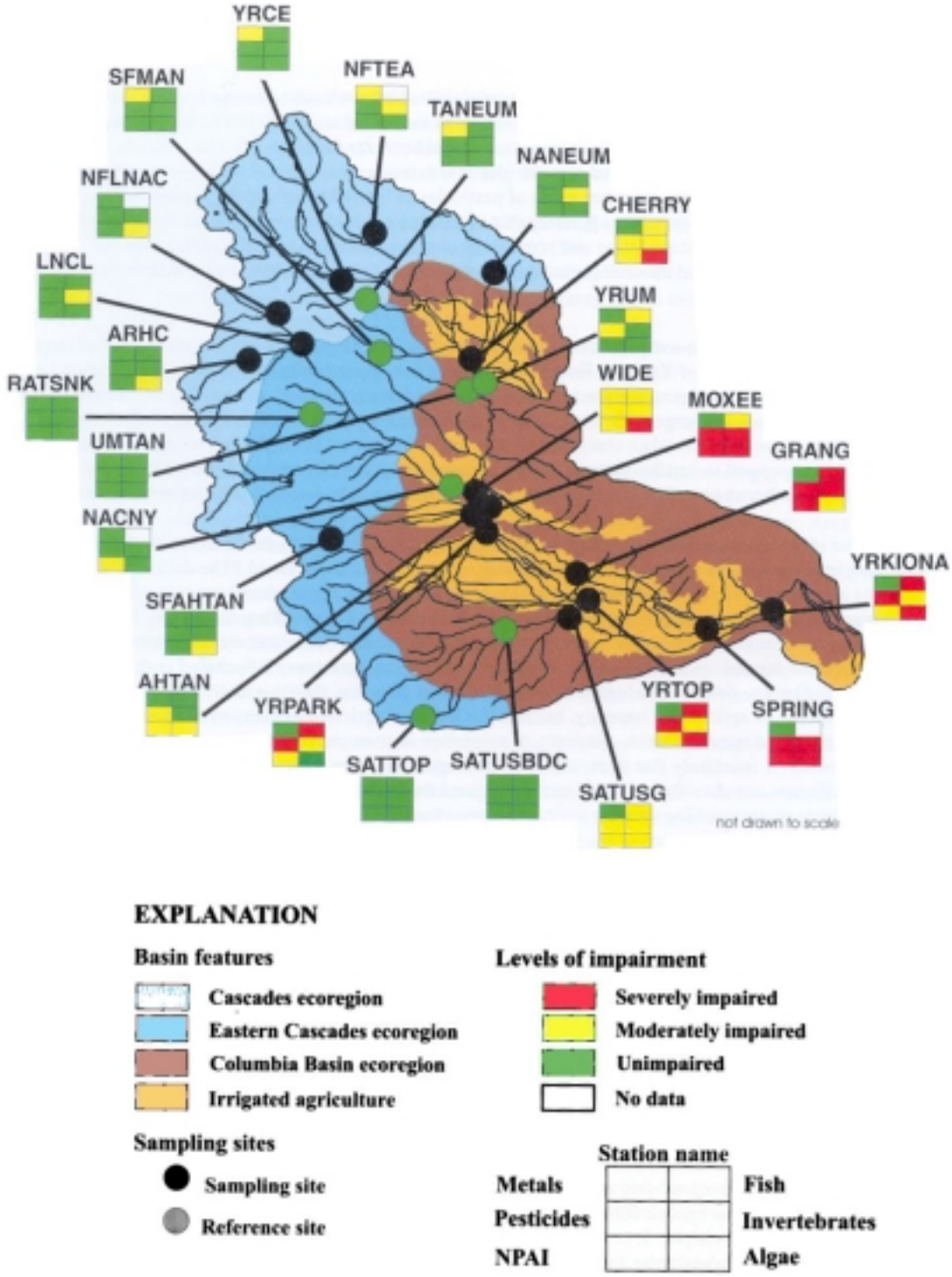
quality list, including: 4,4'DDE and DDT were documented in edible fish tissue near Roza and Cle Elum; Dieldrin was documented in fish tissue near Roza; reaches upstream of the Cle Elum River and at Lake Easton (mouth) are listed for water temperature; the reach upstream of the Cle Elum River is listed for dissolved oxygen; the reach near the mouth of the Teanaway is listed for Mercury and Cadmium (potential sample contamination raises quality concerns with these data); the reach upstream of Ellensburg is listed for copper (similar quality concerns); and the upper Yakima Canyon reach is listed for mercury, silver, copper, and cadmium (similar quality concerns). The specific effects of pesticide residue contamination on river ecology are less certain. However, samples of fish tissue in 1990, 1992, and 1995 found that nearly all concentrations exceeded 200-270 ug/kg, levels that exceed guidelines to protect wildlife from chronic carcinogenic risk (Joy and Patterson 1997). Furthermore, several studies have documented physical abnormalities on fish collected from agricultural drains and the lower Yakima River (Cuffney et al. 1997, USBR Denver Office Monitoring Project, as cited in Snyder and Stanford 2000 DRAFT). In 1995, water samples were analyzed for 46 pesticides at Granger Drain, Spring Creek, Sulphur Creek, and the Yakima River at Euclid Bridge as part of Ecology's TMDL evaluation (Joy and Patterson 1997, as cited in BOR 2000). Organochlorine, organophosphate, and nitrogen-containing pesticides were frequently detected at all sites. Total DDT was detected above the human health and aquatic life chronic toxicity criteria at all sites on three or more sampling dates. One sample collected at Granger Drain contained twice the previous high concentration of t-DDT detected since 1968.

Cuffney et al. (1997) conducted a multi-metric evaluation of water quality and instream resources in the Yakima River watershed. The evaluation looked at metals enrichment, pesticide contamination, fish health, invertebrate richness, and algal communities in relation to agricultural intensity (as measured by the NPAI index)(Figure 33). Yakima mainstem sample sites located downstream of the City of Yakima had moderate to severe levels of impairment. Severe impairment of fish communities at these sites was associated with high levels of pesticides in fish tissues and the presence of external anomalies on fish. External anomalies were found at only one other site in the Yakima watershed, Granger Drain, where the level of pesticides in fish tissue was high and there was substantial impairment of the fish community. High pesticide levels were not found in filtered water or suspended sediment at these severely impaired sites, suggesting that measuring assessment of fish community conditions and concentrations of pesticides in fish tissues were better indicators of ecosystem and human health for large river systems.

Use of multimetric community condition indices (such as percent tolerant species for fish or EPT richness and abundance for invertebrates) indicated that the upper Yakima (Cascades and Eastern Cascades ecoregions) were largely unimpaired (Cuffney et al. 1997). In the Columbia Basin, sites were generally impaired or severely impaired as measured by multiple indicators of conditions that were linked to nutrients and pesticides (e.g., agriculture). All lower Yakima mainstem sites were moderately to severely impaired, corresponding with high levels of pesticides in fish tissues and presence of external abnormalities.

Benthic invertebrates and algae appear to exhibit a threshold effect at relatively low levels of agricultural intensity, with condition of these communities degrading rapidly when the NPAI index exceeds 50 (Cuffney et al. 1997). Site rankings based on fish community conditions also were closely related to agricultural intensity (NPAI index)(Cuffney et al. 1997). Fish community condition ratings generally agreed with the NPAI index. The close relation between the NPAI index and the condition of fish communities suggests that fish are responding to the environmental factors that are directly affected by agricultural practices and that maintaining fish communities in high quality condition will depend upon how agriculture is managed.

Figure 33: Map showing site condition ratings based on fish, invertebrate, and algal community condition indices, and indices of metals enrichment, agricultural intensity, and pesticide contamination (from Cuffney et al. 1997)



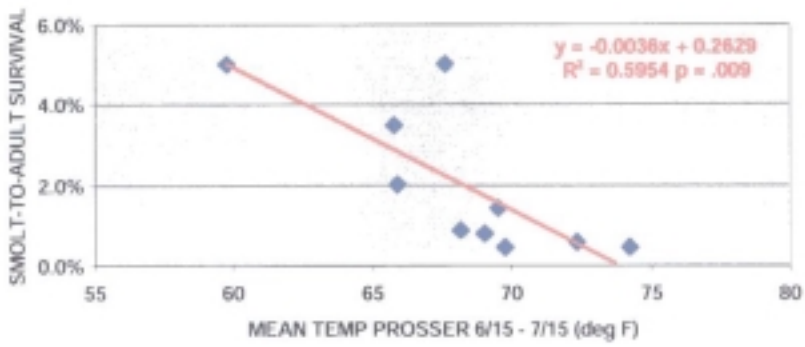
Basinwide and fixed-site water quality sampling (mainstem and tributaries) by USGS from May 1999 through January 2000 detected 25 pesticide compounds (Ebbert and Embrey 2001). Detection frequencies ranged from about 1 percent (ehtalfluralin, ethoprophos, and lindane) to 82 percent for atrazine. Maximum concentrations of azinphos-methyl, carbaryl, diazinon, lindane, and *p,p'*-DDE exceeded U.S. Environmental Protection Agency chronic-toxicity guidelines for the protection of aquatic life. Another 11 compounds were detected for which there are no established chronic-toxicity guidelines. Water quality sampling for pesticide presence in August 1999 found no pesticide compounds in Yakima River samples at Cle Elum, but detected the presence of 3 pesticide compounds in Yakima River samples at Umtanum, 2 pesticide compounds at Union Gap, 1 pesticide compound at RM 72, 9 pesticide compounds at Euclid Bridge, and 6 pesticide compounds at Kiona.

The Yakima River floodplain from Sunnyside Diversion Dam (RM 103.8) downstream to ~RM 65 is structurally complex with numerous side channels, braids, and backwater areas (BOR 2000). However, utilization of this habitat for rearing through the summer months is compromised by high water temperatures, particularly downstream of Marion Drain (RM 82.6). Water temperature may be the primary limiting factor in this entire reach, although there may be some cold water refuges from groundwater inflow, which would allow some summer rearing.

The reach from Kiona to Prosser Dam has the worst overall water quality in the watershed; water temperatures exceed the level suitable for salmonid rearing and may impair adult passage, dissolved oxygen is a problem in deeper areas in the summer, ammonia concentrations may reach toxic levels for 10 miles downstream of Prosser sewage treatment plant during low flows, and pesticide concentrations are the highest in the watershed (CBSP 1990). Overall, water quality is considered poor/fair from the mouth to Kiona, and poor from Kiona to Sunnyside (CBSP 1990). Lower Yakima River and seasonal streams in the vicinity of Richland suffer from many of the problems associated with urban streams; leaking septics, storm sewer pollution, and agricultural runoff (WDFW 1998). Numerous excursions from state water quality standards are documented in the lower Yakima River. Numerous reaches on the lower Yakima are included on the CWA 303(d) impaired water quality list for a variety problems, including: 4,4'-DDD, 4,4'-DDE, arsenic, DDT, Dieldrin, dissolved oxygen, Endosulfan, fecal coliform, mercury, PCB-1254, PCB-1260, pH, silver, instream flow, temperature, and turbidity. These water quality problems are mainly the result of the combination of irrigation return flows (that deliver warm water, turbidity, and contaminants), and water diversions (that result in low instream flows downstream of the diversions, and high water temperature and low dissolved oxygen in the low flow reaches).

Disparity between simultaneous smolt passage estimates at Chandler (RM 35.8) and at a screw trap fished at RM 8.0 in the spring of 1992 indicate a high estimated mortality in the this reach of the lower Yakima River (YSS 2001 DRAFT). Total estimated fall chinook passage at Chandler from May 26–June 10 totaled 174,624 smolts. Comparable estimated fall chinook smolt passage at RM 8.0 was 19,929. In addition, a significant portion (~50%, T. McCoy) of the Yakima fall chinook spawn downstream of Chandler, and should have passed through the screw trap, but not have passed by Chandler. During this period, mean daily water temperatures at the screw trap averaged 76°F, and ranged from 72°F to 81°F. Water temperatures at Chandler averaged 71°F, ranging from 69° to 73°F. Evidently, the smolts were able to cope with conditions associated with the water temperature at Chandler, but not those encountered further downstream. The effects of high water temperature are shown in Figure 34. This plot of smolt-to adult survival against mean water temperature at Prosser Dam during the period June 15–July 15 indicates lower survival with increasing water temperatures, and that every increase of 10°F in water temperature in late spring will lower smolt-to-adult survival by about half. However, this

Figure 34: Relationship between smolt-to-adult survival for wild Yakima fall chinook and mean water temperature (June 15-July 15) at Prosser Dam (from YSS 2001 DRAFT)



relationship may be a surrogate for survival problems in the remainder of the smolt's journey to marine waters (Monk).

Water temperatures in the lower Yakima River may delay upstream spring chinook and steelhead adult migration (BOR 2000). Numerous studies have cited water temperature in the lower Yakima River, particularly downstream of Prosser, as a serious barrier to salmonid migration and to completion of salmonid life histories (Lilga 1998, SOAC 1999, Conservation Advisory Group 1997, Vaccaro 1986, Pearsons et al. 1996, USBR 1999, Lichatowich and Mobrand 1995, Lichatowich et al. 1995, Fast et al. 1991, all as cited in Snyder and Stanford 2000 DRAFT). Lilga found that water temperatures in the lower river from June-November (1996) were lethal (>15.6^{o}C) for salmon egg and fry incubation 60-85% of the time, stressful for juveniles (>18.3^{o}C) 25-65% of the time, and stressful for adults (>15.6^{o}C) 60-85% of the time. In September 1987, daily temperature of the Yakima River at Prosser averaged 71.5^{o}F, with only 9.9% of the annual steelhead run reaching Prosser prior to September 30 (BOR 2000). The temperature of the Columbia River is less than that of the lower Yakima River during that period, and it is likely that adult steelhead would delay movement into the Yakima River under those conditions. The effect of temperature-related migration delays is not known. Stream temperatures in the lower Yakima River are not an issue after mid-October, when the mean daily temperature (1988-1998) falls below 58°F.

Water temperatures frequently exceed 75°F in the Yakima River downstream of Sunnyside Dam in July and August, precluding the ability of spring chinook to rear in the lower river in the summer (CBSP 1990); high water temperatures also impair coho and steelhead rearing (Visser). The main causes of high water temperature are large expanses of slow-moving, shallow water exposed to full sunlight, and warm, silt-laden irrigation return flows (Brad Caldwell, personal communication, as cited in CBSP 1990). Increases in instream flows in the middle and lower Yakima to improve fish passage would likely result in only "slight" improvements in water temperature (Yakima River Subbasin Early Implementation Program Executive Summary and Environmental Analysis 1987, as cited in CBSP 1990). There is also the possibility of localized areas of critically low dissolved oxygen in the lower river, particularly at the bottoms of deeper pools during periods of low flow (CBSP 1990). Water temperatures may also adversely impact the later segments of the fall chinook outmigration (CBSP 1990); as occurred in 1994.

Several studies (Lilga 1998, Vaccaro 1986, both as cited in Snyder and Stanford 2000 DRAFT) have evaluated the relationship between amount of instream flow and water temperatures. Lilga estimated that ~70% of the variation in water temperature could be explained by air temperature, but that several other variables that affect water temperature were not included in the analysis and that further assessment and model development were needed. Vaccaro modeled various instream flows (natural conditions and various reductions in irrigation withdrawals) and estimated that

natural flows would yield higher in-stream temperatures in August (compared to the regulated scenarios), but that mean temperatures throughout the irrigation season would be lower at Prosser and Kiona under natural flows. Snyder and Stanford (2000 DRAFT) indicate the temperature reduction for storage scenarios in August is directly an effect of hypolimnetic releases from four of the five storage reservoirs (all but Rimrock). Neither of these studies adequately considered the potential effect of groundwater inflow and the interaction between historic spring flooding and inundation of the alluvial aquifer with cool spring meltwater (Snyder and Stanford 2000 DRAFT), which was likely much greater prior to flow regulation, potentially providing thermal refugia for biota, including outmigrating smolts and returns adult salmon (Ring and Watson 1999, as cited in Snyder and Stanford 2000 DRAFT). Ring and Watson (1999) and Snyder and Stanford (2000 DRAFT) conclude that the natural ability of the alluvial floodplain to moderate instream temperatures has been seriously compromised because of the change in the natural flow regime, and because of the significant alteration and disconnection of the natural floodplain.

Fine sediment delivery to the Yakima River adversely affects substrate quality, impairing spawning and egg incubation success, reducing benthic invertebrate taxa richness, increasing the presence of toxics that bind onto the fine sediment particle size, etc. The movement of suspended sediment in streams is an important factor in the transport and fate of chemicals in the environment (Joy and Patterson 1997, as cited in USBR 2000). Many water quality constituents, including trace metals, organic compounds, indicator bacteria, and nutrients are associated with suspended sediment. Recent studies have identified a strong relationship between concentrations of DDT and suspended sediment in the Yakima River and tributaries draining agricultural lands. This finding suggests that DDT transport to the Yakima River can be effectively controlled by measures that reduce erosion of agricultural soils and limit sediment transport.

Because of listings for impaired water quality (temperature, pesticide residues, instream flow) Ecology conducted a study to determine total maximum daily load (TMDL) criteria in the lower Yakima watershed (Joy and Patterson 1997). Of particular concern are the high concentrations of DDT (and its breakdown products DDE and DDD) in fish tissue, which are among the highest concentrations recorded in the United States (Rinella et al. 1993, as cited by Stanford and Snyder 2001). Because of links between turbidity and concentrations of pesticide residues, turbidity standards were limited to an increase of 5 NTUs between the confluence of the Naches River and Benton City, in an attempt to meet the designated Class A water quality. In addition, recommendations were made to limit tributary and drainage turbidity concentrations to 25 NTUs (56 mg/L TSS). Implementation would result in a 70% reduction in TSS contribution from major irrigation drainage returns (Joy and Patterson 1997). To achieve this goal, the Roza-Sunnyside Board of Joint Control has established a 90th percentile target of <25 NTU increases at the mouths of all drains and tributaries within the project area by the end of the 2002 irrigation season. Significant reductions in fine sediment delivery have occurred from tributaries to the lower Yakima River, due to efforts of the irrigation districts (see tributary discussions later in this chapter).

The analysis by Joy and Patterson (1997) also indicated a high flux of TSS load (tons/day) early in the irrigation season, as compared to the period from July-October (Table 23). The mean TSS load from March-October was 2.4 times greater than the mean load from July-October in the reach from Naches to Parker. Similar trends were observed in the reach from Parker to Kiona. The reach from the mouth of the Naches River to the mouth of the Yakima generates 67 and 92% of the total TSS load carried from March to October and from July to October, respectively. The lower Yakima obtains >90% of the TSS load during July-October from sources within this reach. The early season TSS load is thought to mainly be a function of high TSS load carried by the Naches River during spring runoff, although increased TSS load from Yakama Reservation

Table 23: Summary of total suspended sediment load (TSS; tons/day) in two reaches of the lower Yakima River (data based on 1995 irrigation season, taken from Joy and Patterson 1997, as summarized by Stanford and Snyder 2001)

TSS Sources to Naches-Parker Reach									
Months	Yakima River	Naches River	Roza Return	Small tribs.	Municipal and industrial	Return drains	Moxee Drain	Other	Total
Mar-Oct	53	94	31	1.1	1.4	2.3	31	120	334
Jul-Oct	50	27	21	1.1	1.4	2.3	35		138
TSS Sources to Parker-Kiona Reach									
Months	Yakima River	Tribal reservation	Gaged Drains	Ungaged Drains	Municipal sources	Other		Subtotal w/o Yakima	Total
Mar-Oct	188	75	213	43	0.2	55		386	574
Jul-Oct	29	52	230	43	0.2			325	354

tributaries and drains contribute as well. The high TSS load in the Naches is likely due to logging activities and sediment releases from the reservoirs; however, further studies are necessary to distinguish the contribution from these sources vs. others (Snyder and Stanford 2000 DRAFT).

Estimates of TSS have been made for tributaries to the Yakima River in the Kittitas Valley (KCCD 1999). Estimates of annual TSS contribution to the Yakima River in the upper Yakima basin are shown in Table 24. The primary contributors of suspended sediment in the upper Yakima watershed are the Teanaway River and Wilson/Cherry Creek, which contribute 34% and 19%, respectively, of the total sediment load to the upper Yakima River.

The use of chemicals within agency guidelines to control vegetation growth in irrigation canals should not alter the water quality of the Yakima River or it's tributaries or affect steelhead or bull trout (Walsh et al. 1977, as cited in BOR 2000). However, these chemicals are designated primarily for use in non-fish bearing waters, and it has proven difficult to ensure that none of the treated water enters fish-bearing waters through irrigation spills and return flows (Renfrow).

Table 24: Estimated Annual Total Suspended Sediment (TSS) Contribution from Tributaries in the Upper Yakima River Basin (modified from KCCD 1999)

Tributary	**TSS Contribution (tons/year)**
Big Creek	630
Cabin Creek	9130
Cle Elum River	9835
Kachess River	2200
Keechelus Reservoir	1990
Manastash Creek	2700
Reecer Creek/Dry Creek	730
Swauk Creek	1620
Teanaway River	23,500
Taneum Creek	1850
Wilson/Cherry Creek	12,950
Misc. Tributaries (Little, Silver, Squaw, Tucker, Umtanum creeks)	2000
Total	69,135

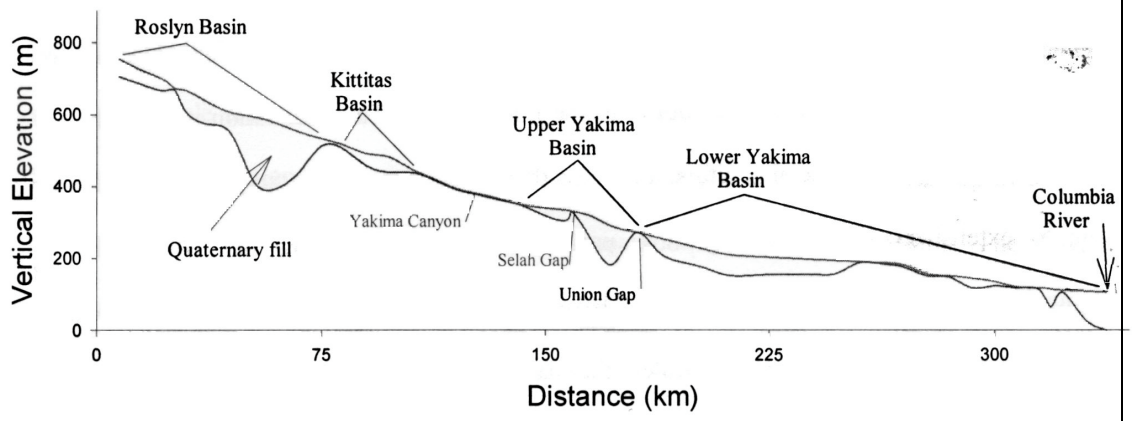
Water Quantity

Overall, streams in the Yakima River basin have been profoundly altered to support the development of irrigated agriculture (BOR 2000). Current available habitat is distinctly different from the conditions in which salmonids evolved in the Yakima watershed.

Spring snowmelt is impounded and stored for later release and diversion downstream in the mainstem Yakima and Naches rivers. The flow in many smaller tributaries without storage is often extensively utilized during drier parts of the year. These changes have affected the quality and availability of aquatic habitat in the Yakima watershed, particularly for anadromous salmonids. The overall impact of irrigation development on salmon and steelhead runs in the Yakima River Basin has been severe (Tuck 1993). The Department of the Army (1950, as cited in Tuck 1993) noted the impact of irrigation development on salmon and steelhead: "The Yakima River system was formerly one of the major salmon producing areas in the Columbia River system. However, most of the stream system drains a valuable agricultural area, where irrigation development began at an early date and has increased steadily to the present day. As a result, the anadromous fishery resources were greatly depleted as early as the year 1885."

Historically, the hydrologic cycle in each of the four major basins (Roslyn, Kittitas, Upper Yakima, and Lower Yakima) of the Yakima watershed was characterized by extensive exchange between the surface, hyporheic, and groundwater zones (Kinneson and Sceva 1963, Ring and Watson 1999, as cited in Snyder and Stanford 2000 DRAFT). This exchange would have occurred mainly in the vast alluvial valleys and floodplains, which would have functioned as hydrologic buffers, distributing the energy of peak flows and moving cool, spring melt water out onto the floodplain. This inundation would annually recharge the shallow, surficial aquifers, a process that would occur potentially well into the summer, due to extensive and long-lasting snowpack in the Cascades (Ring and Watson 1999, as cited in Snyder and Stanford 2000 DRAFT). Groundwater recharge of this nature would have provided a source of groundwater that would have maintained baseflow and cooler thermal refugia as summer progressed and air temperatures increased, as well as maintaining warmer winter temperatures that would prevent or reduce the risk of anchor ice (Parker and Story 1916, Kinnison and Sceva 1963, as cited in Snyder and Stanford 2000 DRAFT). The depth of alluvial deposits, and relative location and elevation in the Yakima watershed, are shown in Figure 35.

Figure 35: Cross-sectional profile of Yakima River watershed, showing depth of alluvial (Quaternary fill) gravel/cobble deposits (from Kinnison and Sceva 1963)



Limited water availability is a long-standing issue in the Yakima River watershed. By 1902, ~121,000 acres were irrigated in the Yakima River watershed (BOR 2000). The irrigated acreage was served by unregulated flows in the Yakima River and tributaries, and irrigation diversions exceeded the unregulated runoff during periods of low flow by the turn of the century. By 1905, all of the low water flows in the Yakima River had been appropriated and were diverted for irrigation (BOR 1976, as cited in Tuck 1993). During the summer irrigation season, only

irrigation return flows of poor quality and high temperatures provided water in the lower mainstem Yakima River. A petition was submitted in 1903 from the citizens of Yakima County to the Secretary of the Interior seeking federal assistance in irrigation (BOR 2000). Due to early over-appropriation of available water supply, no additional irrigation development was feasible unless existing claimants would agree to restrict their water usage. Settlement of existing and vested water rights was eventually accomplished and the Yakima River Project was authorized in 1905. In 1906, the BOR investigated additional water storage sites, which led to the development of the major storage reservoirs in the watershed. A detailed description of Yakima Project operations can be found in BOR (2000). Following is a timetable of the development of some of the larger irrigation districts (Perala):

- Sunnyside Irrigation District 1907
- Yakima-Tieton Irrigation District 1908
- Kittitas Reclamation District 1926
- Roza Irrigation District 1936
- Kennewick Irrigation District 1956

Six storage reservoirs have been constructed in the Yakima Basin: Keechelus Lake, Kachess Lake, Cle Elum Lake, Rimrock Lake, Clear Lake, and Bumping Lake (specifications for the major storage reservoirs are shown in Table 25). All except Rimrock Reservoir and Clear Lake were natural glacial lakes prior to impoundment. Together they capture approximately one-third of the annual basin-wide runoff. Storage volume equals 1.07 million acre-feet, leaving an average of 3.86 million acre-feet of unregulated runoff annually (BOR 1983, 1999, as cited in Snyder and Stanford 2000 DRAFT). All of the storage reservoirs are located in the headwaters of the upper basin. As such, the majority of the water sustaining the agricultural industry is transported to the lower basin during periods of the summer and early fall when the river would otherwise be approaching baseflow. The Yakima Project provides irrigation water for approximately 465,000 acres of irrigable land that extend along both sides of the Yakima River in south-central Washington (BOR 2000).

Table 25: Specifications of water storage reservoirs in the Yakima Project (from BOR 2000)

Dam	Reservoir	Construction	Active Storage (acre-feet)	Dead Storage (acre-feet)	Outlet Capacity (cfs)
Bumping Lake	Bumping Lake	1909-1910	33,700	13,987	1240
Kachess	Kachess Lake	1910-1912	239,000	671,272	3690
Keechelus	Keechelus Lake	1913-1917	157,800	156,173	3000
Clear Creek	Clear Lake	1914-1918	5,300	0	467+612
Tieton	Rimrock Lake	1917-1925	198,000	0	2760
Cle Elum	Cle Elum Lake	1931-1933	436,900	265,420	4600
Total			1,070,700		

Groundwater recharge occurs via precipitation and from the application of irrigation water, the latter of which increases recharge over pre-irrigation times by about a factor of 10 (Tom Ring). Kinnison and Sceva (1963) noted that water table elevations rose substantially during the onset of irrigation in the first half of the century. Because of this, drains often were cut to reduce high water tables and prevent the development of alkaline soils. Thus, the pattern of ground water recharge has been substantially altered with post-irrigation recharge following the seasonal patterns of irrigation. Historically, recharge would have occurred mainly in the winter and spring when evapotranspiration was low and precipitation was high. The result has been a reduction in the frequency, magnitude and duration of flood plain inundation because of reservoir storage.

Thus, recharge of cold, spring-melt water into the aquifer systems has been replaced by recharge of warmer water derived from irrigation later in the spring and summer.

The diversions at Sunnyside and Wapato typically divert one half of the entire river flow during the irrigation season (May-October), while Prosser diverts 1400 cfs (40 m^3/s) most of the year, both for irrigation and power production (YSS 2001 DRAFT). Because of regulation and withdrawals for irrigation, the Yakima River experiences periods of both dewatering and elevated flows relative to the historic discharge regime (Parker and Storey 1916; Vaccaro 1986a; Conservation Advisory Group 1997; SOAC 1999; USBR 1999; all as cited in YSS 2001 DRAFT). For example, at Union Gap and Parker, regulation has reduced annual discharge (mean based on data from 1926-77) from 4600 cfs (134 m^3/s) to 3700 cfs (108 m^3/s at Union Gap and 2230 cfs (65 m^3/s at Parker (Vaccaro 1986a). Declines of this magnitude would significantly affect the processes of cut and fill avulsion that historically maintained habitat heterogeneity. Furthermore, the average annual 7-day minimum mean discharge at Parker for the same time period was 125 cfs (3.7 m^3/s (Vaccaro 1986a). Vaccaro (1986a) estimated that composite error of historic discharge estimates was 12% relative to the 21% change in discharge by regulation at Union Gap and the 52% change at Parker. At present, legislation calls for flows below Sunnyside and Prosser to range from 300-600 cfs (8.5-17 m^3/s), depending on the estimated supply of water.

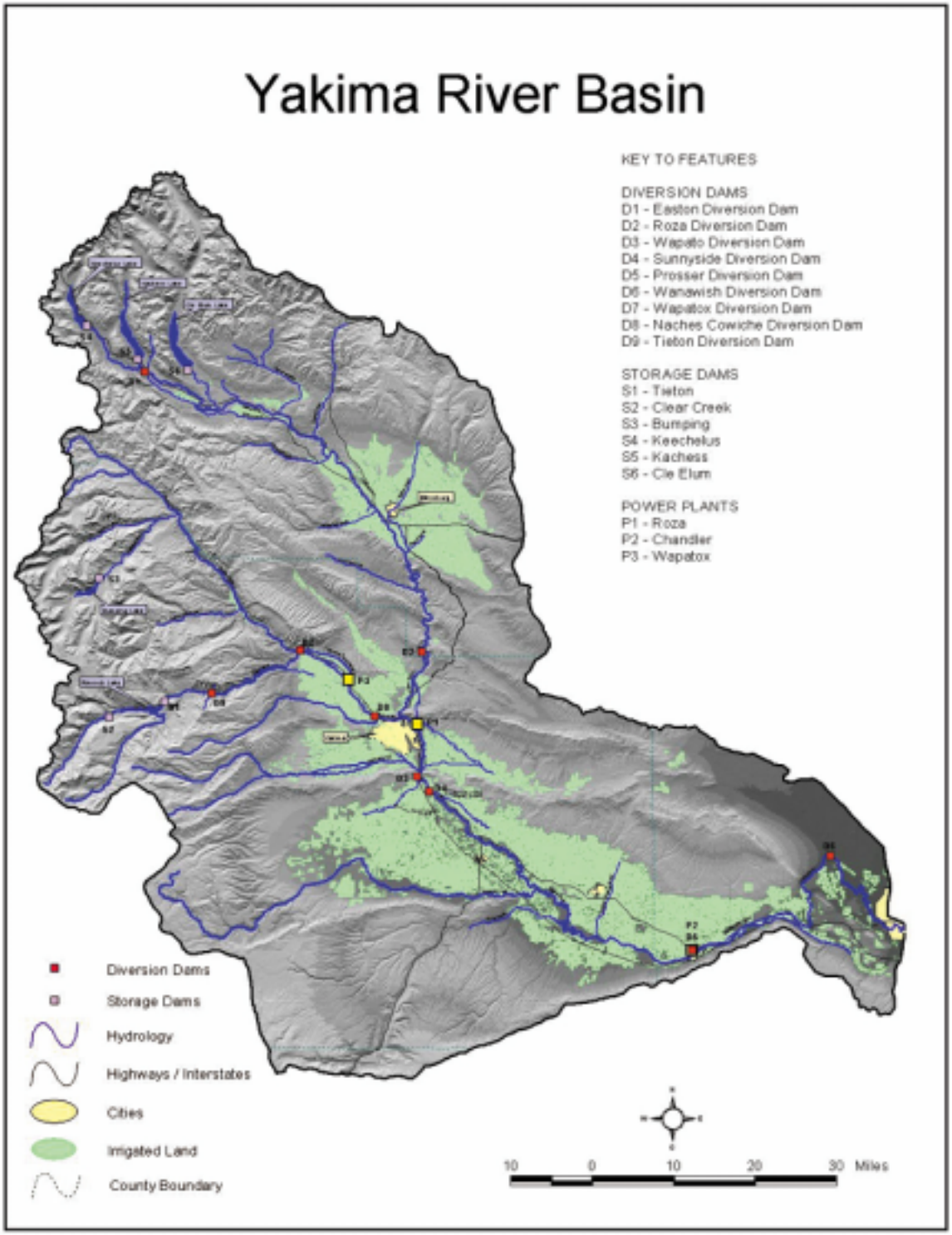
There are three small-scale hydroelectric projects, the Roza power plant, the Chandler power plant and the Naches Drop project on Wapatox Canal (YSS 2001 DRAFT). In 1999, the Roza and Chandler power plants contributed about 130.4 million kilowatt hours to the federal Columbia River power system. Figure 36 shows the basin's major storage, diversion and hydroelectric dams along with the basin's irrigated lands.

Other features of the BOR Yakima Reclamation Project include 420 miles of canals, 1697 miles of laterals, 30 pumping plants, 144 miles of drains, plus fish passage and protection facilities constructed throughout the basin (YSS 2001 DRAFT). Descriptions of each of the irrigation districts/divisions are included in the Biological Assessment of Yakima Project Operations and Maintenance (BOR 2000) and the Yakima Subbasin Summary (YSS 2001 DRAFT). There are other similar features operated by private entities or individuals for withdrawal of flow entitlements from the basin.

Yakima project operations could affect anadromous salmonid smolt mortality through alteration of streamflow quantity and timing (BOR 2000). Water temperatures also affect smolt development, migration rates, and timing. Diversion structures can entrain or physically damage smolts, and changes in streamflow could affect predator distributions and predation success on smolts. Streamflow modification may affect the food base on which downstream smolt migrants feed. Little factual information is actually known that would assist with identifying or quantifying these potential impacts (Monk).

Because of concerns regarding BOR operational dewatering of spring chinook redds in the upper Yakima River, the Yakama Indian Nation challenged the BOR's river operation scenario in Federal Court in 1980 (Snyder and Stanford 2000 DRAFT). The outcome, known as the Quackenbush decision, led to the implementation in 1981 of the "flip-flop" flow regime. Under "flip-flop", the quantity of water supplied for irrigation from the upper Yakima is reduced beginning in mid-September, providing base flows that can be maintained throughout the incubation period required by chinook eggs, coincident with the refilling of Keechelus Reservoir. The demand for irrigation water in the lower watershed after the mid-September reduction in upper Yakima releases is compensated for by increasing flows dramatically from Rimrock Lake on the Tieton River (Naches River watershed). Although spring chinook redds are saved in the

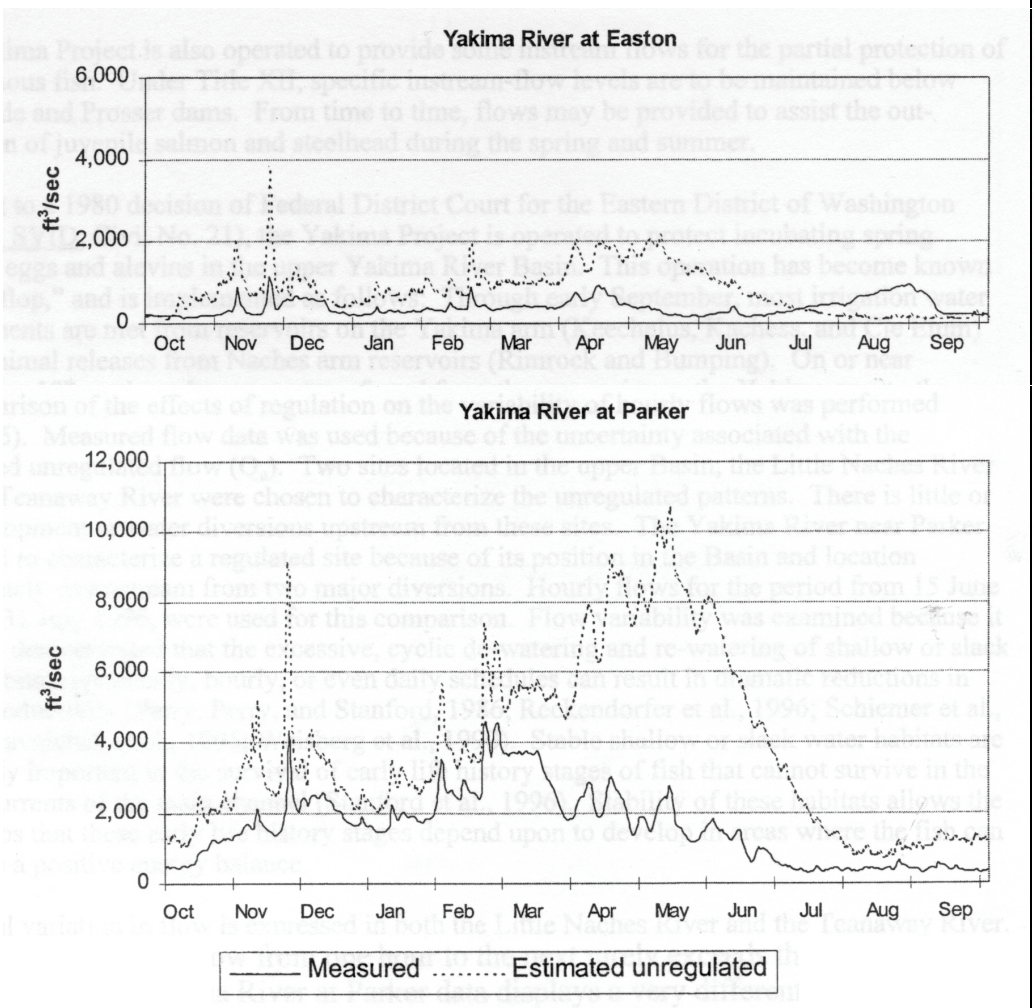
Figure 36: Yakima River Basin map showing major storage reservoirs, diversion dams, hydroelectric dams, and irrigated lands (from YSS 2001 DRAFT)



upper Yakima as a result of flip-flop management, there has been little or no effort to understand or monitor the effects of this flow regime on either the upper Yakima or on the lower Naches. In the upper Yakima, significant stranding of benthic invertebrates may occur and numerous side-

channel habitats critical to the completion of many different species life histories, including juvenile salmon, are disconnected. In the Naches River, sediment competent flows likely result in rapid rates of cut and fill avulsion. In both the upper Yakima and the lower Naches, organisms specifically adapted to the natural and predictable disturbance regime would likely be unable to adapt to the anthropogenic regime and would suffer declines in density and productivity (Resh et al. 1988, as cited in Snyder and Stanford 2000 DRAFT). This applies to the post-reservoir flowregime and particularly to the alteration of that regime via flip-flop. Snyder and Stanford (2000 DRAFT) strongly recommend that the flip-flop regime be re-examined carefully, although recognizing this as difficult due to the lack of quantitative data on resource impacts. A comparison of the recent regulated flow regime with the estimated historic unregulated flow regime is presented in Figure 37.

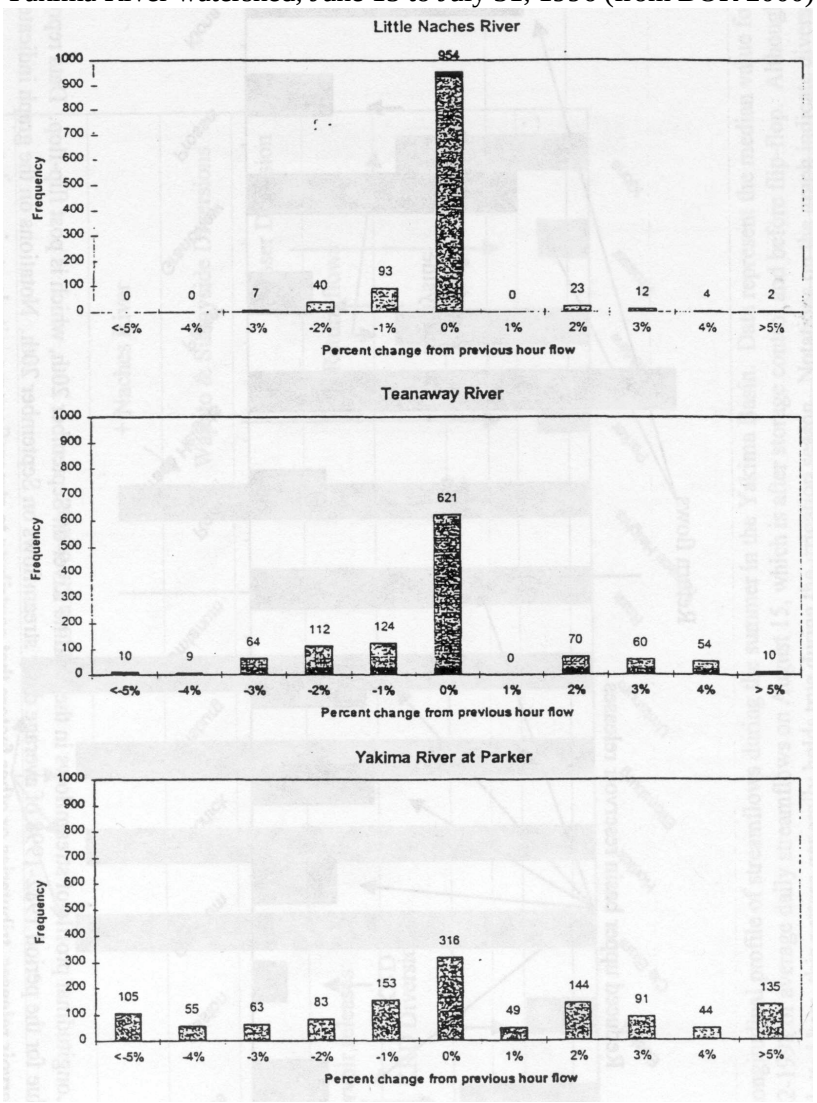
Figure 37: Comparison of average daily flows for the period 1986-1995 with the estimated unregulated flow regime for the Yakima River at Easton and at Parker (from SOAC 1999)



Spring chinook smolt emigration from the Yakima River is likely associated with rising flows during spring runoff (ISG 1996, as cited in BOR 2000). Increases in spring runoff flows have

been realized since 1995. Whereas April-June streamflows at Prosser were less than the SOAC recommendation of 1000 cfs 30% of the time from 1982-1999, operational changes have reduced this to <5% from 1995-1999.

Figure 38: Frequency distribution of percent change in hourly flows at sites where flow is unregulated (Little Naches River and Teanaway River) and regulated (Yakima River at Parker), in the Yakima River watershed, June 15 to July 31, 1996 (from BOR 2000)



Natural unregulated flows vary hourly (as represented by flow monitoring in the Little Naches and Teanaway rivers, Figure 38); however, the percent change in hourly flow rarely exceeds 3% (BOR 2000). In contrast, the highly regulated flows in the lower Yakima River (as represented by flow monitoring at Parker (Figure 38) display a very different pattern, with two-fold reduction and increase in flow often occurring over periods as short as one day. In addition to flow variation, hydrologic connectivity of the natural floodplain has been interrupted by dikes, levees, and roads, and by diversions of instream flows for irrigation. The loss or alteration of lateral hydrologic connections has resulted in loss of accessible habitat, reduced hydrologic connectivity, loss or change in nutrient flux, and reduction in the tempering affect of groundwater on stream temperature. These changes exert a significant influence on stream productivity.

Instream flow variation (cyclic de-watering and re-watering of shallow or slack water habitats on weekly, daily, or even hourly schedules) associated with the increase or decrease of flows through water diversion structures has been shown to reduce biotic productivity (Perry et al. 1986; Reckendorfer et al. 1996; Schiemer et al. 1991; Travinchek et al. 1995; Weisberg et al. 1990; all

as cited in BOR 2000). [NOTE: These studies are all associated with hydropeaking operations that change flows rapidly and substantially more than irrigation flow management in the Yakima (Monk).] Stable shallow or slack water habitats are especially important to the survival of early life history stages of fish that cannot survive in the strong currents of the main channel (Stanford et al. 1996, as cited in BOR 2000). Stability of these habitats allows the food webs that these early life history stages depend upon to develop in areas where the fish can maintain a positive energy balance.

About three-fourths of the Yakima Project water storage capacity is located within the upper Yakima (upstream of Roza Dam); Keechelus Lake (157,800 acre-feet), Kachess Lake (239,000 acre-feet), and Lake Cle Elum (436,900 acre-feet). Other major tributaries, such as Cabin Creek (RM 203.5), the Teanaway River (RM 176.1), Swauk Creek (RM 169.9), Taneum Creek (RM 166.1), and Wilson Creek (RM 147.0) are unregulated and add significant flows, particularly during spring runoff, when inflow to the storage reservoirs is being stored. Hydrology concerns identified in the upper Yakima are identified in Table 26 (WDFW 1998).

Table 26: Hydrology concerns in the upper Yakima River (WDFW 1998)

River Reach	**Altered hydrology concerns**
Roza to Wilson	Instream flows are unnatural
Wilson to Town	Low flows during winter and spring impede fry dispersal to primary rearing areas in the Canyon
Easton to Keechelus	Altered natural hydrology; instream flows too high in the summer and too low in winter; low flows in winter cause redds to become dewatered

Target flows have been established for the Yakima River mainstem from Easton to Lake Keechelus (BOR 2000). Beginning in August, Keechelus Dam releases are reduced to meet a 60 cfs target streamflow in the Yakima River at Crystal Springs. This reduction functions to keep streamflows low so that spring chinook will spawn in areas that can be kept watered throughout the winter, when most inflow to Lake Keechelus is retained to refill the reservoir. In October, when spring chinook spawning is complete, streamflows are further reduced to around 30 cfs (or half the spawning flow). This keeps all of the spring chinook redds under water throughout the winter, while facilitating irrigation storage in the reservoir. In addition, during the spawning period when flows are reduced downstream of Keechelus Dam (~September 1 through mid-October), additional flow is carried in the KRD Canal from Lake Easton and returned to the Yakima River through Wasteway 1146 (near the mouth of the Teanaway River). This allows transfer of irrigation flows to the mid and lower watershed, while meeting the target flow of 200 cfs in the Easton Reach downstream of the Easton Diversion Dam. The amount of flow bypassed through the KRD Canal (water for irrigation demand and instream flow) ranges from 20 to 400 cfs, with peak average monthly flow of ~300 cfs. Although this flow regime is designed to benefit spring chinook spawning, it affects the availability of steelhead and coho rearing habitat by controlling flows to an artificially low level (BOR 2000). These low flows could eliminate access to side channels and backwater areas.

Utilization of side-channel habitats and potential stranding of juvenile salmonids in these side-channel habitats is also affected by flow release variation at the storage and diversion dams. Ramping rates at Keechelus and Kachess Dams are not to exceed 2-inches per hour. Since 1998, flow manipulations at Easton have been conducted so ramping rates do not exceed 1-inch per hour (Perala).

Low flows in the Yakima River reach from the Cle Elum River to the Teanaway River are within the range of instream flow studies, and do not appear to limit the availability of juvenile steelhead rearing habitat (BOR 2000). High flows during the summer irrigation season are above the maximum range identified in the instream flow studies, and due to the extreme range of high flows, may limit the availability of summer rearing habitat for all rearing stages of juvenile steelhead. Low flows during the winter months in the reach from the Teanaway to Wilson Creek do not appear to limit the availability of steelhead rearing habitat; flows during the summer irrigation season are at the high end of the ranges indicated by instream flow studies, and may be high enough to affect the availability of rearing habitat. Winter flows in the reach from Wilson Creek to Roza are just above the range indicated by instream flow studies, and do not appear to limit availability of overwintering habitat. Flows during the spring and summer irrigation season are considerably higher than the ranges indicated by instream flow studies, and may be high enough to limit the availability of rearing habitat. Yakima Project flow management does have an effect on the quantity and quality of salmonid rearing habitat (BOR 2000), although the extent of effect has not been quantified. In the reaches immediately downstream of Keechelus and Cle Elum reservoirs, flows may be too low in the winter to provide good rearing conditions. Flows downstream of Keechelus reservoir, in the Cle Elum River, in the mainstem Yakima downstream of the Cle Elum River, and in the Yakima River Canyon may be too high to provide good rearing conditions during the irrigation season. [NOTE: Monk indicates that this discussion is irrelevant, because it discusses flows in the context of a percent range of optimum wetted useable area (WUA) habitat indices. He indicates that unless the flows under discussion are compared to unimpaired or other alternative flow regimes, they have no inherent biological meaning. "May be too high" and "may be too low" are purely judgmental.]

The effects of river regulation, and especially the diversion of flow at Roza Dam have substantially altered the hydrologic regime downstream of the dam (YSS 2001 DRAFT). The spring freshet has been totally eliminated in most years, winter flows are lower than natural flows, and flows during the peak of the irrigation season are slightly higher than natural flows (modified from YSS 2001 DRAFT). Hourly flow fluctuations upstream and downstream of Roza Dam, caused by variation of upstream irrigation return flows, can be as large as 6%, but are usually 2-3% (YSS 2001 DRAFT); hourly flow fluctuations below Roza are mostly related to the gate operations, not irrigation return flows (Monk). The non-normative hydrograph in this reach is believed to have an adverse impact on juvenile salmonids, either by displacing juveniles to downstream areas, or by dewatering shallow shoreline areas and stranding juvenile salmonids and their insect prey (YSS 2001 DRAFT). This hydrographic impact, to greater or lesser degree, is found in all portions of the upper Yakima River mainstem.

Target flows are established for Roza Dam (BOR 2000). The BOR implemented significant changes in river operations since 1994. These changes include the attempt to maintain minimum flows during winter reservoir refilling at certain locations and the attempt to constrain ramping rates to 1-2 inches/hour for flow decreases and two inches/hour for flow increases. When the Roza powerplant is operating, the minimum target flow over Roza Dam is 400 cfs. The power diversion is reduced and may be shut off completely, as necessary, to maintain the 400 cfs target flow. When the powerplant is not operating, the target flow downstream of Roza Dam is 300 cfs. Also of concern are prolonged excessively high flows downstream of Roza Dam through the summer irrigation season (CBSP 1990). An Instream flow Incremental Method (IFIM) analysis (Crase 1985, as cited in CBSP 1990) of the Yakima Canyon indicated that flows are higher than optimal for rearing chinook prior to the flip-flop portion of the irrigation season. Potential impacts to actual production from higher than optimal flows for rearing have not been determined (Monk).

In 1984, Roza Irrigation District implemented a modernization program, including the installation of ~10 miles/year of enclosed irrigation conduit, and by construction of automatic canal control structures and re-regulating reservoirs. As of 2000, approximately one-third of the district (27,000 acres) is served by enclosed conduits. Approximately two-thirds of the acreage in the district is irrigated by sprinkler, microjet, and drip systems, while the remaining one-third of the irrigated lands use rill irrigation.

Most of the instream flow in the Yakima River downstream of the City of Yakima during the summer is return flow from previously diverted irrigation water. Most irrigation return flow facilities collect and discharge both surface and subsurface water, which tends to be cooler than mainstem river water in summer (Vaccaro 1986, as cited in BOR 2000). In addition the irrigation return flows deliver substantial amounts of turbid water to the lower Yakima. Major tributaries to the lower Yakima, such as Satus (RM 69.6) and Toppenish (RM 80.4) creeks add significant flow, particularly during spring runoff.

The flow conditions from Sunnyside Diversion Dam downstream to Marion Drain are generally opposite that found in the upper reaches of the Yakima River, or in the Naches River (BOR 2000). The general pattern is lower flows throughout the irrigation season, and higher flows during the winter months after the irrigation season is over. Flow conditions improve with increasing distance downstream of Sunnyside Diversion Dam, as a result of irrigation return flows. Availability of rearing habitat may be limited downstream of Sunnyside diversion Dam when instream flows over the dam are <600 cfs. Flows during the winter months are generally in the range of recommended instream flows, and do not appear to limit rearing habitat.

Low minimum stream flows in the reach from Prosser Dam (RM 47) downstream to the Chandler Powerhouse (RM 36) are a concern (BOR 2000). In 1988, WDFW recommended an instream flow of 450 cfs in this reach. In 1989, the minimum flow recommendation was increased to 500 cfs. Since 1995, BOR has managed flows in this reach to achieve Title XII target instream flows of 300-600 cfs during the irrigation season. Subordination targets have also been set for the Chandler powerplant operations, with a 1000 cfs target from April to July, a 450 cfs target for July to September, and a target set annually, with input from SOAC, for October to March. There has been significant improvement in increasing minimum flow levels since 1995.

Relative to unregulated flows, the reach from Prosser Dam to Sunnyside Dam is the most dewatered reach in the Yakima mainstem. Low instream flow in April and May increase the inbasin travel time and vulnerability of outmigrating smolts (CBSP 1990). Delayed inbasin outmigration, even without large predatory losses, could have severe impacts, and would be further compounded if passage through the Columbia River were also slow; the available time window for successful ocean entry, while variable, appears to be limited, with both a clear beginning and end date (B. Watson).

The feasibility of moving the intake system for Kennewick Irrigation District/Columbia Irrigation District from the Yakima River to the Columbia River is currently being studied (Public Law 106-372, as cited in YSS 2001 DRAFT). The study is anticipated to occur over approximately 2.5 years, with completion in 2003. In summary, the project would increase flows in the lower Yakima River during the irrigation season (TRPA and Monk 2001). Flows during the base flow period would be increased over current conditions by about 700 cfs in the reach from Prosser Dam to the Chandler Powerhouse, by about 300 cfs from the Chandler Powerhouse to Wanawish (Horn Rapids) Dam, and by about 500 cfs from Wanawish Dam to the confluence of the Yakima and Columbia rivers. The minimum target flows specified by Congress in the YRBWEP

legislation could consequently increase by 700 cfs, providing a range of minimum flows below Prosser from 1,000-1,300 cfs.

Efforts are currently underway through YRBWEP and SOAC to restore normative flows. Normative is the functional norm, which ensures that we provide the essential ecological conditions and processes necessary to maintain diverse and productive salmonid populations (Uebelacker and Eitemiller 1996). Stanford et al. (1996, as cited in Snyder and Stanford 2000 DRAFT) identifies a normative condition as one that allows many, if not most, of the historic uses of rivers as well as re-establishing natural habitat forming processes through watershed partnerships. The premise of restoration activities in the Yakima watershed is that it is possible to determine and implement normative flows. In this case, normative flow may be defined as sufficient water flux through key reaches to produce enough quality habitat to significantly enhance the currently depressed abundance and life history strategies of anadromous salmonids. The primary bottleneck for salmon and steelhead in the Yakima River may well be lack of sufficient, high-quality, rearing habitat for juvenile salmonids, resulting from severed pathways between the backwater habitats on the floodplains and the channel (Snyder and Stanford 2000 DRAFT). However, this appears to contradict the premise of the Yakima Fisheries Project, which advocates that there is additional carrying capacity in the upper Yakima River that is currently underseeded under current management conditions (this is the management option the fish managers of the Yakima Basin have chosen to pursue, Monk).

Low instream flows during the period of reservoir refilling (roughly mid-October through early July) probably constituted the greatest constraint on spring chinook production in the Yakima watershed (CBSP 1990). Low flows from October to February probably did not impact incubation significantly in most years. However, critical low flows (<90cfs) after emergence (mid-April through early-July) strongly depressed smolt production in the Easton reach, probably by stranding or increasing the predation vulnerability of fry, especially in side channels and braids. Low flows in winter may have also reduced production by substantially reducing the availability of overwinter habitat, particularly since preferred habitat typically is associated with cover associated with the stream banks, many of which were dewatered (CBSP 1990). Since days of SOAC involvement, the low flow issue mentioned is not valid. The BOR keeps flows at incubation levels until flood control releases or irrigation releases begin. Swimup date is not known, nor is the BOR informed by the biologists when it occurs, so incubation level flows continue (Perala).

Lakes

Lake Easton is approximately 1 mile long, with a storage capacity of 4,000 acre-feet. It is primarily used to regulate irrigation diversion to the Kittitas Main Canal.

Biological Processes

Cuffney et al. (1997, as cited in Snyder and Stanford 2000 DRAFT) found that benthic invertebrate taxa richness and abundance of EPT taxa (clean water forms of mayflies, stoneflies, and caddisflies) declined from 32 to 29 and from 15 to 12 in the upper vs. lower Yakima watershed, respectively. Reductions are thought to be associated with increased anthropogenic impacts. Furthermore, no stonefly taxa were found in the lower basin. Nightengale (1998, as cited in Snyder and Stanford 2000 DRAFT) observed that the lower basin tended to be dominated by the caddisfly *Hydropsychidae*, and that the Naches watershed tended to contain the most diverse benthic community. Biomass estimates for the upper and lower watershed indicate that

salmonids likely are not food limited by the benthic macroinvertebrate community (e.g., upper basin from Selah to Easton =6,400 mg/m^2; lower basin from Toppenish to Benton City =12,605mg/m^2)(Nightengale 1998, as cited in Snyder and Stanford 2000 DRAFT). However, studies to date have focused on the mainstem, and these observations may not be reflective of side-channel areas that become disconnected during portions of the year due to regulated flows. Productive food webs cannot develop if the aquatic environment in which they live has constantly fluctuating flows. This is particularly true for insects such as stoneflies that must complete their life cycle by emerging as flying adults from the shoreline. In general, benthic invertebrate taxa richness was negatively related to the intensity of agricultural activity and positively related to canopy closure (Cuffney et al. 1997, as cited in Snyder and Stanford 2000 DRAFT).

Differences in algal community structure in the upper Yakima were explained by dominant rock type, and were correlated to the density of LWD and riparian structure (Leland 1995, as cited in Snyder and Stanford 2000 DRAFT). In the lower basin, differences in algal assemblages were explained by the degree of nutrient enrichment from irrigation return flows and subsurface drainage, and were correlated with altitude, turbidity, embeddedness and riparian structure.

Spring chinook smolt migration studies in 1988 indicated that essentially all losses in the reach investigated (release groups from upstream of Roza, and upstream and downstream of Sunnyside diversion) occurred between Sunnyside Dam and Prosser Dam, with the survival through this reach on the order of only 57% (CBSP 1990). It is speculated that the poor smolt survival is in large part attributable to predation in reaches of open river, particularly those reaches below major diversions, which can be rather severely dewatered during dry springs. The predator under greatest suspicion is the northern pikeminnow, although gulls are known to feed heavily on smolts in a few locations. The alteration of flow and habitat at these locations may increase the suitability of habitat or predation effectiveness of these predators.

A predation study conducted in 1997 in the lower Yakima River indicated that predation rates were unnaturally high, caused mainly by three predators in the lower reach; the northern pikeminnow, (*Ptychocheilus oregonsis*), the smallmouth bass (*Micropterus dolomieui*), and channel catfish (*Ictalurus punctatus*)(McMichael 1998). Northern pikeminnow were found to be relatively abundant between the City of Yakima and Prosser Dam, smallmouth bass were relatively abundant from Prosser Dam to West Richland, and channel catfish were relatively abundant from West Richland to the mouth of the Yakima River (McMichael 1998, as cited in BOR 2000). Smallmouth bass appear to migrate into the lower Yakima River in early spring, possibly due to 1-4°C higher water temperatures in the Yakima vs. the Columbia. Stomach content analysis indicated that 23% and 29% of northern pikeminnow and smallmouth bass, respectively, contained salmonids. Continued sampling and analysis in 1998 indicated that smallmouth bass predation on fall chinook parr and smolts was greater in May (when fall chinook density was lower) vs. mid to late April (the peak outmigration period). They estimated that the population of smallmouth bass would be able to consume ~500,000 smolts/year (18,840 smolts/day during outmigration) in the lower 68 km (42.5 miles) of the Yakima River (most of the predation appeared to be on fall chinook parr and smolts). This translates to 27% of the wild fall chinook produced in the lower Yakima watershed in 1998, and to a resulting adult loss of 1,350 chinook. They also noted that smallmouth bass abundance and consumption rates were substantially higher than values reported for other Pacific Northwest systems, attributed to relatively high water temperatures that lead to physiologically faster digestion rates (and associated increased predation rates), and the presence of irrigation dams and modified flow regime, both of which tend to select for nonnative species. Predation estimates for northern pikeminnow and channel catfish were not as reliable, although they estimated that 1,000 pikeminnows could consume 35-290 salmonids/day from Prosser upstream. Researchers also

captured large numbers of channel catfish, with 2.9% of the stomachs examined containing at least one salmonid. One channel catfish stomach contained 76 fall chinook, as well as several other species. Potential predation solutions were discussed, including removal by trapping and electrofishing, relocation, removal of angling restrictions, bounty implementation, and decreasing water temperatures by 2°C in the lower Yakima River during the juvenile salmonid migration period; the latter was deemed to likely be the most effective at reducing predation rates (McMichael 1999, as cited in Snyder and Stanford 2000 DRAFT). Restoration of normative flows might also be an effective solution to much of the nonnative predation problem. Studies have shown that scouring flows depress populations of nonnative fishes and enhance native fishes in alluvial rivers of the western United States.

Predatory birds (primarily gulls and herons) and predatory fish have been observed feeding on smolts downstream of the outfall from the Chandler Canal bypass (CBSP 1990). There is also a possibility the piscivorous fish are congregating in the canal upstream of the screens and consuming a considerable number of smolts (Yakama Nation, unpublished data, as cited in CBSP 1990). However, the situation at Prosser Dam and Chandler Canal may be unique. Unlike other mainstem bypasses, the outfall does not open into a deep, fast flowing part of the river, but rather into a run that is often no deeper than 1-2 feet during the smolt outmigration. This is exacerbated by the need for smolts to traverse 0.7 miles prior to encountering the screens, much of which is slow velocity suitable for northern pikeminnow predation (CBSP 1990).

Avian predation on juvenile salmonids in the Yakima River was studied from fall 1997 to summer 1998, with emphasis on spring chinook rearing areas (Phinney et al. 2000, as cited in YSS 2001 DRAFT). Floats through free-flowing index areas indicated that avian predation was low in the lower river during the spring smolt outmigration. Summer observations in the upper river suggested that common mergansers and their broods may consume large numbers of non-migrating chinook fry. Fall and winter observations suggested that mergansers were the major avian predator of rearing spring chinook. Highest avian (primarily gulls) predation was observed downstream of the Chandler Canal bypass outfall and Horn Rapids Dam. Estimates of predation were 0.20% of the spring chinook passing through the outfall at the Chandler Canal bypass, and 0.52% of the spring chinook passing over Horn Rapids Dam during the study period. Gull foraging was reduced or precluded at high flows. Under the higher than average spring flow conditions of 1998, avian predation did not appear to be a significant limiting factor of salmonid production in the Yakima River. The University of Washington is currently in the process of completing reports of avian predatory interaction studies conducted in 1999 and 2000, and has been collecting additional data in 2001 (Pearsons).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Yakima River:

- **Develop and implement, through SOAC, a "normative flow regime" for the mainstem Yakima River** (see definition of "normative" in Instream Flow section earlier in this report)
- **Restore floodplain function in historic anastomosing reaches (Snyder and Stanford 2000)**
- **Eliminate hydropower diversions whenever instream flows downstream of Prosser dam cannot otherwise be maintained at 450 cfs**
- **Reduce habitat suitability for invasive fish species, and associated predation on juvenile salmonids, in the lower Yakima (current option with greatest probability**

for success is reduction of water temperatures by 2°C during the outmigration, downstream of Parker)

- **Restore LWD presence to provide instream habitat diversity and cover; restore LWD transport downstream of mainstem and tributary storage and diversion dams**
- **Reduce operational spills of Yakima River waters from irrigation canals that result in false attraction of spawners**
- **Reduce delivery of fine sediment through irrigation returns by use of BMP programs of on-farm water and erosion control, the modernization and consolidation of smaller irrigation districts, construction of reregulating reservoirs on irrigation delivery systems, etc.**
- **Avoid "water holes" downstream of Sunnyside Dam through reports from private irrigation systems of anticipated changes in diversion, consolidation of smaller irrigation districts, modernizing delivery systems to increase efficiency and control, and construction and use of reregulation reservoirs**
- **Restore riparian condition along the Yakima River, particularly in the reaches from the Naches River confluence upstream to the mouth of Wenas Creek, from Wilson to Taneum creeks, and upstream of Terrace Heights; implement flow regimes necessary to restore cottonwood regeneration (Jeff Braatne)**

Amon Creek

General

Amon Creek is a right-bank tributary to the Yakima River, entering the river ~400-500m upstream of the SR 240 crossing, south of Richland. The watershed drains low-elevation shrub steppe agriculture, rural, and urban areas. The west fork (WF) is fed primarily by perennial spring flow. The majority of surface flow on the east fork (EF) is irrigation tailwater. Amon Creek has known chinook and coho rearing, and may also support spawning for these species; summer steelhead are also presumed to be present.

Fish Access

Presence of chinook and coho juveniles is documented to ~1.25 miles upstream of the confluence with the Yakima River. Salmonid presence should be presumed to extend throughout the WF, and up to the large railroad culvert in the EF (LaRiviere). Culverts on the WF are in poor condition, probably due to damage and channel effects from the major flood in 1996. Removal would be the simplest solution. They serve no public function other than recreational and emergency access. Historic conditions (pre-1945) are poorly documented. Natural barriers on the WF probably didn't exist, other than low flow. Salmonids probably were not able to access the EF prior to the dumping of irrigation tailwater.

The mouth of Amon Creek appears to be severely choked with vegetation (reed canary grass). Although salmonids do appear to find their way into the stream, the access channel is not clearly evident, and channel modifications at this location may improve salmonid access.

Floodplain Modifications

The lower mile of Amon Creek has been channelized, and the mouth relocated approximately 1.5 miles further upstream on the Yakima River, entering the Yakima River upstream of the SR 240 bridge (LaRiviere). This rerouting of the lower channel was done coincident with construction of the railroad, and actually increased channel length. Upstream, floodplain function is generally intact. Channel meandering is fairly wide on the mainstem and WF for such a small system; channel meandering on the EF is almost non-existent. Meandering is even common on the lower system, where the stream is confined by steep banks. Bank erosion is limited other than in the vicinity of the golf course. Some dry channels are evident on the EF, and were probably carved out during the 1996 flood event. Beavers are present throughout the watershed.

The lower mile (or less) of the stream flows across the Yakima River floodplain through the Chamna Reserve, which is owned by the Corp of Engineers (COE)(LaRiviere). The COE has indicated interest in turning this property over to Richland. If transferred, it should be done in a manner that ensures continued floodplain and habitat function.

Channel Condition

Most of the channel length flows through areas with little public access or immediate streamside development. No quantitative habitat assessment data are available, although channel condition in the lower 3 miles of the system (downstream of confluence of EF and WF) would rate as good with lots of LWD, some channel separation with small islands, and plenty of cover (LaRiviere).

Substrate

Spawning gravels are present from Broadmore Street to the mouth. The substrate is adversely impacted by presence of fines, especially in the upper reaches (LaRiviere). Rain-on-snow events have limited impacts to substrate stability; irrigation flow adjustments cause both high sediment deposition and gravel disturbance.

Riparian Condition

Amon Creek flows through arid shrub steppe desert, which is naturally devoid of large riparian vegetation. There is thick riparian cover (primarily Russian olive, with maturing cottonwood and willows) throughout the watershed, except through the Meadow Springs Golf Course, where the riparian vegetation has been removed (LaRiviere). The thick riparian cover provides excellent bank protection, and functioning cover for salmonids. The upper EF has a very mature population of cottonwoods (up to 80 ft in height).

Water Quality/Water Quantity

Year round flow exists from a spring/groundwater fed wetlands complex in the headwaters of the WF, and from surface water runoff in the EF (LaRiviere). In addition, substantial tailwater spills of irrigation water are made from the Kennewick Irrigation District (KID) Canal into the EF at the upper end of Amon Canyon (near I-82), and there is a limited contribution of overflow from the Badger Irrigation District into the KID holding pond adjacent to the WF. When KID tailwater spills are shut off during the irrigation season, the EF still has some surface water flow at the lower end, just upstream of the confluence with the WF. During the non-irrigation season, Amon Canyon receives enough groundwater to support a healthy riparian area and partial flow

depending on the season. Without the KID tailwater spills, and downstream of the Amon Canyon flows, water in the EF quickly goes subsurface. In normal winter conditions, there is no surface flow in the EF, other than through groundwater influence at the upper end of Amon Canyon.

Because of Amon Creek's local designation as a "wasteway", there was limited consideration of fish life in local land use decisions. Stormwater from the surrounding developed area is routed directly to Amon Creek for transport out of the area to the Yakima River. WDFW is aware of at least nine point discharges of untreated stormwater into WF Amon Creek (LaRiviere).

Lakes

There are no lakes in this watershed.

Action Recommendations

The following ranked salmonid restoration actions are recommended for Amon Creek:

- **Protect integrity of spring/groundwater fed wetlands in the headwaters of the WF**
- **Protect floodplain and riparian integrity in currently undeveloped areas adjacent to the stream**
- **Prioritize and correct identified fish passage barriers**
- **Restore riparian function through Meadow Springs Golf Course**
- **Provide stormwater bio-filtration and primary treatment facilities to prevent deleterious materials and fine sediments from entering into Amon Creek**
- **Assess benefits of channel modifications at the mouth, to improve salmonid access**

Corral Canyon Creek 37.0205

General

Corral Canyon Creek enters the left bank of the Yakima River at RM 33.8 and supports summer steelhead, fall chinook (presumed presence), and a naturally reproducing population of brown trout (WDFW 1998). Corral Canyon Creek has good summer irrigation return flows and good riparian conditions, and could have steelhead (and possibly coho) production. Corral Canyon Creek is downstream of the historic spring chinook production area (CBSP 1990)

There is ongoing debate as to whether anadromous salmonid access into Corral Canyon Creek should be encouraged or discouraged, primarily due to its altered flow that causes false attraction of salmonids that may be homing in on the upper Yakima water that is delivered through the irrigation system as operational spill. Resolution of this debate will determine the extent of habitat restoration actions in this watershed, although in either case it is important to address water quality concerns, as they impact conditions downstream in the Yakima River.

Corral Canyon Creek originates just above the Roza Canal, flows through an upper meadow, then through a heavily vegetated constrained valley before joining with the Yakima River (Monk). Corral Creek is located at the downstream end of the Roza Canal, and during the irrigation season flows are primarily the result of operational spills from the Roza Canal (Monk 2001). The creek flows in a southerly direction and is approximately 3 miles long. Beaver activity is present in the middle section (1.25 miles upstream) where small ponds are created by beaver dams with

abundant vegetation near the stream. Flows in the upper portion of this watershed are reduced to <2 cfs during the non-irrigation season. Corral Creek has no major tributaries contributing flow to the main channel.

Fish Access

Until 1996, salmonid access into Corral Canyon Creek was blocked at the crossing of Kiona Canal, just upstream of the mouth of the creek. The diversion from the Yakima River to Kiona Canal, located upstream of the mouth of Corral Canyon Creek, involved a berm across much of the left side of the Yakima River, which diverted flow into the intake canal, with the fish screen substantially downstream of the upper end of the canal. In the spring of 1996, as a result of flood damage to the Kiona Canal intake, the diversion was replaced with a screened pump station, located approximately 2 miles downstream of the Benton City bridge (at the end of Pendleton Rd.). Anadromous salmonids are currently able to access the lower 1.5 miles of the creek, to a point where prior unauthorized instream work has created a fish passage barrier at most flows (Harvester); there are ~0.75 miles of additional habitat available upstream of this point, although beaver dams may preclude upstream access during some flows/years.

Floodplain Modifications/Channel Condition

Subsequent to the 1996 flood, a landowner used a bulldozer in the creek (at RM 1.5) to alter the channel alignment to the opposite side of the narrow canyon and to dig some ponds in the old channel (Harvester). This work was done without necessary permits, but the violation was not pursued by WDFW Enforcement. Fish passage is impaired at this location at most flows.

Channel slope is about 1%, and beaver ponds make up about 10% of the habitat in Corral Canyon Creek. Beaver ponds have a mean depth of 0.56m (Romey and Cramer 2001).

Substrate Condition

Substrate in the lower portion of the creek is about 80% gravel and cobble, with about 20% fines. In the upper reaches more fine sediments are found (Romey and Cramer 2001, as referred by Monk).

Riparian Condition

Dense stands of Russian Olives are found on the lower portions of Corral Canyon Creek, and stream shading was high at 76% (Romey and Cramer 2001).

Water Quality/Water Quantity

Instream flows and water quality are thought to be good (CBSP 1990, WDFW 1998). Flows during the irrigation season are primarily the result of Roza Canal operational spills , which are much greater than natural pre-irrigation flows.

The temperature regime in Corral Canyon Creek falls within the range that will support salmon and steelhead (Romey and Cramer 2001).

The change in flow that occurs in this channel during the change from the irrigation to the non-irrigation season would influence its hydraulic suitability for anadromous salmonids (Monk).

The non-irrigation season begins in mid October, and flows drop to perhaps 1 cfs in Corral Canyon Creek. Actual gage data were not available for Corral Creek at the time of this report, but flows at the time of our survey appeared to be less in Corral Creek than in Snipes Creek (Monk 2001). These low flows would generally exclude adult fall chinook, although an occasional fall chinook has been observed to enter prior to the drop in flow. Coho entry and spawning tends to occur after the irrigation season, when spawning is likely more successful. Juvenile salmon and trout, particularly coho, are well known for their ability to migrate up and rear in small tributaries that are not used for spawning. Therefore, Corral Canyon Creek could be used for rearing by juvenile salmon and steelhead, but is not likely to support any significant spawning activity.

Lakes

No lakes exist in this watershed.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Corral Canyon Creek:

- **Assess salmonid habitat conditions; correct identified habitat limiting factors**
- **Correct identified fish passage barriers at RM 1.5**
- **Develop policy on salmonid access** *(action recommendations differ depending on utilization goal)*

Snipes Creek 37.0332 and Spring Creek 37.0333

General

Snipes Creek originates near the Roza Canal (~0.5mi above Hanks Road) and continues downstream, entering the left bank of the Yakima River at RM 41.8; Spring Creek is a right bank tributary to Snipes Creek, entering at RM 0.1. Surveys in the 1860s identified Snipes Creek as a dry channel; Spring Creek was not identified as a stream channel on the survey maps (Perala). Snipes Creek is thought to have historically been one of the better watersheds for salmonid production in the lower Yakima (Easterbrooks). These creeks currently support limited coho and steelhead spawning and rearing, spring chinook rearing, limited fall chinook spawning and rearing, as well as other salmonid and non-salmonid species (WDFW 1998). In addition, these streams support rainbow trout spawning and rearing, and there is a naturally reproducing population of brown trout in upper Spring Creek (Monk). These creeks are downstream of the historic spring chinook production area in the Yakima watershed (CBSP 1990). The stream flow in Snipes and Spring creeks consists primarily of operational spills from the Roza and Sunnyside canals and irrigation return flows during the irrigation season, which constitute a false attraction hazard to spring chinook adults (CBSP 1990), coho adults (Dunnigan), and summer steelhead returning to the upper Yakima. Coho spawning, production of large numbers of fry from fall 2000 spawning, and production of smolts from 1999 spawning, were documented in 2000-2001 (Cummins).

There is ongoing debate as to whether anadromous salmonid access into Snipes/Spring Creek should be encouraged or discouraged, primarily due to its altered flow that causes false attraction. Resolution of this debate will determine the extent of important habitat restoration actions in this

watershed, although in either case it is important to address water quality concerns, as they impact habitat conditions downstream in the Yakima River.

Fish Access

Adult salmonids are attracted upstream into Snipes Creek by the operational spill of upper Yakima water from Roza Canal into Snipes Creek. Roza Canal releases operational spills of ~1-17 cfs (typical of the last 20 years, Perala), attracting spring chinook homing to the upper Yakima River. The rate of operational spill was greater prior to construction of a small reregulating reservoir in the late-1980s – early-1990s. If the flow is sufficient, adult salmonids move upstream into a large constructed concrete stilling basin that functions as a large holding pool, where they become isolated as the spill is terminated (Easterbrooks). No recent estimates of spring chinook stranding are available, but the stranding of "several dozens" of adult spring chinook was observed in the 1980s (Easterbrooks). A temporary barrier was installed in Snipes Creek in 1987 to preclude adult spring chinook from entering, but the barrier was breached a number of times, and has not been replaced.

There are potential barriers in Spring and Snipes creeks that may block upstream migration of adults to spawning habitat (Monk). Snipes Creek has 2 barriers and Spring Creek has 3 barriers that are rated as either partial barriers at some flows or full barriers at most flows. Potential barriers on Spring Creek are of most concern; the first (Hess Rd.) is located just upstream (RM 0.4) of the confluence with Snipes Creek, and is rated as a barrier to adult salmonids at most flows (Romey and Cramer 2001). There is generally adequate flow for passage at Hess Road, but the culvert is a barrier to virtually all adults and all juveniles (Easterbrooks). There are also constructed in-channel farm ponds downstream of Roza Canal that would be complete fish passage barriers (Perala), although no salmon or steelhead presence is currently known upstream of Hess Road. No unscreened diversions are known to exist on Snipes Creek, but the system should be assessed.

Floodplain Modifications

The lower half of Snipes Creek runs through a broad floodplain (Monk). Land use is primarily private medium sized parcels (1-5 acres). The upper half enters a constricting valley constrained by hillslopes where land use is dominated by large vineyards, which are offset from the active channel 100+ meters. Much of this upper reach is dominated by a large beaver complex with multiple dams. Some reaches of Spring Creek run through pasture land. For approximately 0.75 miles the stream is channelized and runs adjacent to Old Inland Empire Hwy (Romey and Cramer 2001).

Snipes Creek and Spring Creek were altered to serve as irrigation wasteways (Tri-County 2000). Spring Creek was entirely excavated, modifying a natural low swale with no defined channel to run along county roads or individual parcel ownerships (Perala). Habitat conditions are poor due to channelization, elimination of normal riparian zones, and fish passage barriers.

Channel Condition

LWD is naturally low in the semi-arid setting of this watershed, particularly outside of the Yakima River floodplain (Visser, as cited in Tri-County 2000). Numerous beaver dams in Snipes Creek add habitat complexity. Channel slope is about 1%, and beaver ponds make up

about 21% of the habitat in Snipes Creek. Beaver ponds in Snipes Creek have a mean depth of 1.1m. Beaver ponds weren't found on Spring Creek in 2001 (Romey and Cramer 2001).

Substrate Condition

Spawning gravel is scarce (Cummins). Substrate and sedimentation are poor/fair, noted as mucky in many places (CBSP 1990). Substrate in the lower portion of the creeks is about 80% gravel and cobble, with about 20% fines. In the upper reaches more fine sediments are found (Romey and Cramer 2001).

Riparian Condition

Riparian condition is poor/fair (CBSP 1990). The Snipes/Spring Creek watershed is located mainly in a semi-arid desert. Growth of riparian vegetation is limited to within the Yakima River floodplain, with cottonwood and willow groves reported near springs in the headwaters and in riparian areas (Visser, as cited in Tri-County 2000).

Water Quality

The temperature regimes in these creeks fall within the range to support salmon and steelhead (Romey and Cramer 2001).

Spring Creek is rated as a severely impaired waterbody, with noted concerns including pesticides, invertebrates, algae, and overall impacts of agriculture (Cuffney et al. 1997). Snipes Creek is on the CWA Section 303(d) impaired water quality list for dissolved oxygen and temperature; Spring Creek is on the list for temperature. In addition, there have been single excursions from state water quality standards documented for both Snipes and Spring creeks for Dieldrin, 4,4'-DDE, DDT, and 4,4'-DDD, which do not meet the listing criteria for the 303(d) list. In 1995, water samples were analyzed for 46 pesticides at Granger Drain, Spring Creek, Sulphur Creek, and the Yakima River at Euclid Bridge as part of Ecology's TMDL evaluation (Joy and Patterson 1997, as cited in BOR 2000). Organochlorine, organophosphate, and nitrogen-containing pesticides were frequently detected at all sites. Total DDT was detected above the human health and aquatic life chronic toxicity criteria at all sites on three or more sampling dates. USGS has also documented presence of Aldrin in Spring and Snipes creeks (Yakima Valley Council of Governments 1994, as cited in Tri-County 2000). USGS water quality sampling for pesticide presence in August 1999 in Spring and Snipes creeks detected the presence of 1 pesticide compound (*p,p'*-DDE)(Ebbert and Embrey 2001).

Dense growths of filamentous green algae (*Cladophora*) were observed in Spring Creek by Cuffney et al. (1995), but abundance was probably underestimated by the sampling method used in the study. *Cladophora* and related filamentous green algae are important indicators of phosphorous and nitrogen enrichment, and are typically viewed as an aesthetic nuisance and indication of water quality degradation. Because the sampling procedures underestimated this group, the influence of agricultural sources of nutrients on algal communities also may have been underestimated.

Spring Creek was characterized as having very low total benthic invertebrate richness (<15 taxa) and very low EPT richness (<6 taxa) with no stonefly taxa. The low total and EPT benthic invertebrate richness are indicative of the effects of intensive agriculture as indicated by the NPAI and pesticide indices.

A sediment budget was developed for the lower Yakima River, because of the link between TSS and pesticide residues (Joy and Patterson 1997, as cited in Snyder and Stanford 2000 DRAFT). Results indicated that in 1995, inputs from tributaries and irrigation returns contributed a significant quantity of the sediment load of the Yakima River. The estimated TSS contribution during the irrigation season from Spring and Snipes creeks was estimated to be 46 tons/day. Please refer to the Yakima mainstem water quality section for a discussion of the TMDL recommendations to reduce the effects of agricultural runoff. Reductions in turbidity and TSS in Snipes Creek since the implementation of the TMDL is shown in Figure 39; reductions in Spring Creek are shown in Figure 40.

Figure 39: Turbidity reductions in Snipes Creek in recent years (courtesy of Perala)

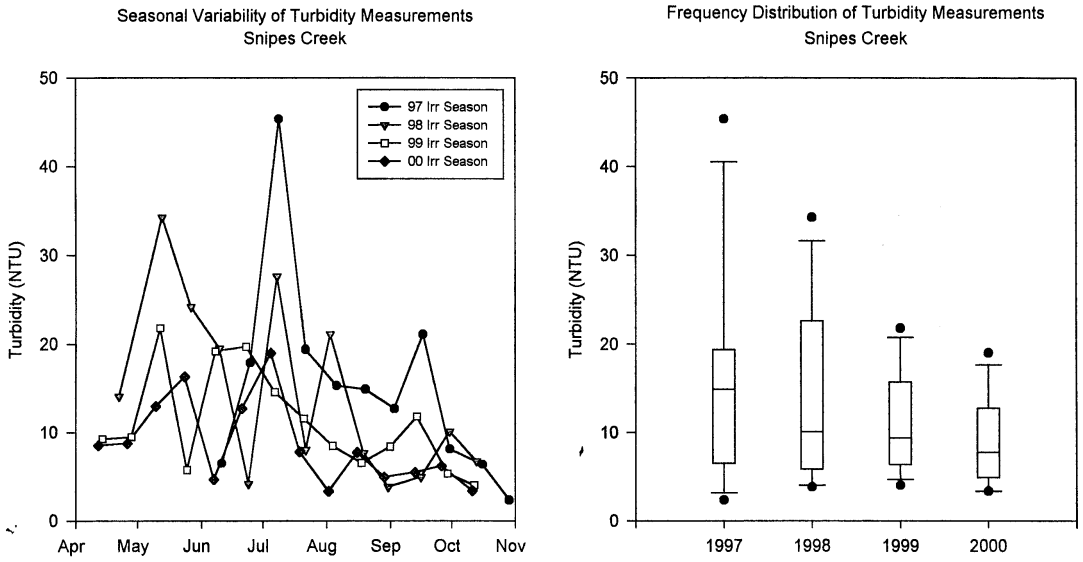
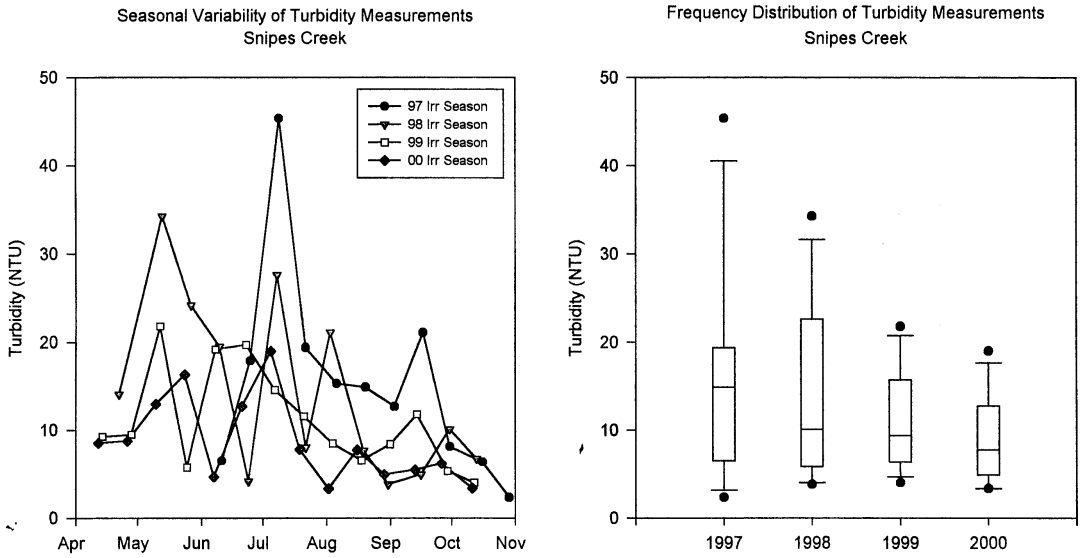


Figure 40: Turbidity reductions in Spring Creek in recent years (figures courtesy of Perala)



Water Quantity

Instream flows are primarily the result of irrigation return flows (surface and groundwater). Instream flows are poor/fair; this creek is a wasteway conduit in the summer and creates false attraction flow for spring chinook (CBSP 1990, WDFW 1998). The Spring Creek Wasteway (operational spill from SVID only) has an average irrigation season flow of 50 cfs, which is primarily combined Sunnyside Irrigation District irrigation return flows and operational spills (BOR 2000). Outside the irrigation season, discharge is reduced to ~10 cfs.

The change in flow that occurs in these channels during the change from the irrigation to the non-irrigation season would influence their hydraulic suitability for anadromous salmonids (Monk). The non-irrigation season begins in mid October, and flows drop to about 5 cfs in Spring Creek, 1-2 cfs in Snipes Creek. These low flows would generally exclude adult fall chinook, although an occasional fall chinook has been observed to enter these channels prior to the drop in flow. Coho entry and spawning in these streams tends to occur after the irrigation season (Monk 2001), when spawning is likely more successful. Spring Creek has enough flow at 5 cfs to provide for migration and spawning of coho, steelhead, and trout. Juvenile salmon and trout, particularly coho, are well known for their ability to migrate up and rear in small tributaries that are not used for spawning. Therefore, these channels could be used for rearing by juvenile salmon and steelhead, and there is potential for Spring Creek and lower Snipes Creek to support significant spawning activity.

Lakes

No lakes are present in this watershed.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Snipes and Spring creeks:

- **Identify and reduce/eliminate the mechanism causing false attraction of adult salmonids**
- **Retain beaver presence in Snipes Creek** (Monk indicates that beaver dam presence may minimize false attraction)
- **Reduce fine sediment delivery to the Yakima River from Snipes/Spring creeks**
- **Develop policy on salmonid access in Snipes and Spring Creeks** *(action recommendations differ depending on utilization goal)*
- **Restore riparian function to lower temperature of inflow to Yakima River**

Sulphur Creek 37.0453

General

Sulphur Creek enters the left bank of the Yakima River at RM 61.0, supports spring chinook rearing, summer steelhead and coho spawning and rearing, possible fall chinook spawning and rearing, and rainbow trout. Land use along Sulphur Creek and its laterals is primarily agricultural, with some urban areas around the city of Sunnyside. Water quality is the key limiting factor in this stream; irrigation return flows of very poor quality are discharged through

Sulphur Creek to the Yakima River, substantially degrading the overall water quality of the lower Yakima River (WDFW 1998). In addition, the potential for anadromous salmonid utilization is severely constrained by lack of habitat due to channelization and by lack of riparian vegetation. Sulphur Creek was entirely excavated from Scheller Road to the mouth, and did not follow a natural drainage (Perala). Although the upper portion of the Sulphur Creek watershed historically was a natural drainage, the stream likely ended in a pocket wetland well away from the Yakima River.

There was no evidence of spring chinook rearing during electroshocking surveys in 2000 and 2001 (Cummins, WFDF file data). Several adult steelhead were observed, but no juveniles. Many coho spawned in the fall of 2000, but heavy siltation of redds evidently reduced survival to almost nothing, as only several fry were found in early through late spring 2001 during electrofishing surveys downstream of Sheller Road.

Fish Access

The accessible anadromous portion of Sulphur Creek extends 7.5 miles upstream from the Yakima River to the concrete flume at Sheller Road, which is a barrier to both anadromous and resident fish. However, there is no suitable habitat upstream. There are no other barriers in the channel up to Sheller Road.

Adult salmonid access into Sulphur Creek is primarily a problem of false attraction of spawners that are naturally destined for other more suitable streams and habitat in the Yakima watershed. Irrigation return flows through Sulphur Creek can cause false attraction flows for spring chinook, coho, and steelhead, particularly when flows in the lower Yakima River are very low (CBSP 1990). Fish are attracted to the irrigation spills because the waters have similar characteristics to upper Yakima water. Sunnyside and Roza canals release 250-500 cfs into Sulphur Creek in April and May; a reduction of spill during adult migration periods would substantially reduce false attraction.

Floodplain Modifications

Sulphur Creek is channelized, and serves as an irrigation wasteway and provides irrigation return drainage and storm drainage/effluent disposal for the City of Sunnyside (Tri-County 2000). Sulphur Creek is a constructed drain/wasteway; therefore, it is more incised than a natural creek, and does not have a historic floodplain from Scheller Road to the mouth (Perala). The mainstem of Sulphur Creek is continually maintained to reduce the chance of water eroding the steep channel bank and flooding private land during the irrigation season when flows are at their highest.

Where Sulphur Creek crosses the Yakima River floodplain, the channel is incised to such a degree that it acts as a drain for the Yakima River floodplain itself (Freudenthal), altering hyporheic connectivity and function downstream of Sulphur Creek. Variation in flow, due to fluctuations in irrigation spill, creates a highly unnatural (almost inverted) hydrograph in Sulphur Creek and the floodplain of the Yakima River. This hydrograph encourages invasion by non-native vegetation (knapweed, purple loosestrife, reed canarygrass), which is better adapted to rapid fluctuation in water level and flow than native vegetative communities. Non-native vegetation inhibits growth of beneficial riparian vegetation, and serves as a seed source of non-native vegetation that impairs Yakima River riparian condition downstream of the mouth of Sulphur Creek.

Channel Conditions/Substrate Condition

In general, Sulphur Creek has a gradient of approximately 0.4%, and is dominated by glide habitat. Pool habitat is limited with Sulphur Creek having an estimated 10% pools (Romey and Cramer 2001). LWD is absent from the channel, with negligible potential for recruitment.

The substrate in Sulphur Creek is rock lined and the base is shotrock overlying angular riprap (Perala). The section of drain just below the concrete flumes is lined with crushed rock to reduce erosion (Monk). Sulphur Creek flows across deep deposits of glacial clays and silts, with no availability of natural spawning gravels (Monk). Both the percentage of fines in the substrate (categories of silt and sand combined) and the percentage that gravels in the riffles were embedded were often in the range that severely impairs egg incubation and juvenile rearing. Fines suffocate eggs in the gravel, and embeddedness blocks flow of water and movement of invertebrates through streambed gravels. Embeddedness was measured in the riffles, because that is where drifting invertebrates (food for salmonids) would be produced, where some spawning would occur, and where water velocity would keep gravels cleaned in a productive stream. Embeddedness in the few riffles present averaged 64% in Sulphur Creek. Further, the frequency distribution of embeddedness observed in individual riffles indicated that over half of the riffles in the Sulphur Creek were over 50% embedded. The percentage of fines and embeddedness were similarly high in all of the lateral channels. These findings indicate that the amount of fines and embeddedness within Sulphur Creek would effectively prevent any meaningful production of salmonids in those channels (Romey and Cramer 2001). Angular rock has been placed in the bottom of the channel in an attempt to minimize further downcutting of the channel. In addition, Sulphur Creek carries high fine sediment loads resulting from irrigation return flows and operational water releases from Sunnyside Canal.

Riparian Condition

Riparian condition is poor to non-existent, with limited potential to restore riparian function due to the deeply incised nature of Sulphur Creek.

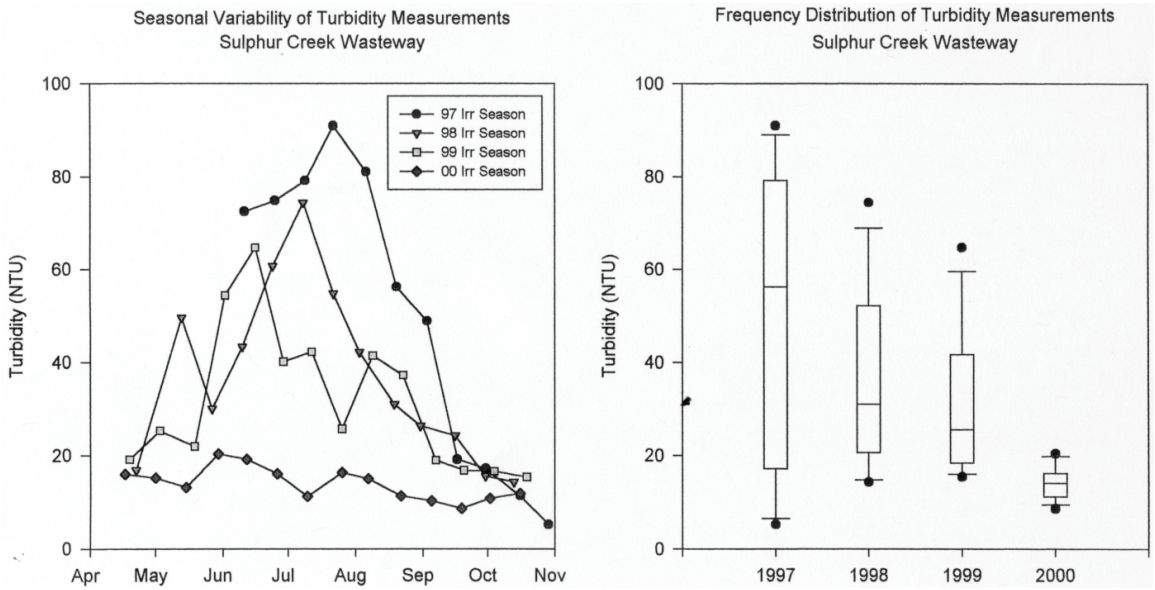
WDFW manages an 88-acre parcel on Sulphur Creek that was purchased to mitigate for losses of riparian habitat resulting from the development of the Snake River Hydropower system (YSS 2001 DRAFT). Intended benefits are primarily to wildlife, with minimal benefit to salmonids due to limited amount of suitable habitat in Sulphur Creek.

Water Quality

Water quality in Sulphur Creek is impaired. Sulphur Creek is on the CWA Section 303(d) impaired water quality list for 4,4'-DDD, 4,4'-DDE, DDT, Dieldrin, Endosulfan, and temperature. Impaired water quality likely affects juvenile and adult salmonids in Sulphur Creek, as well as in the Yakima River downstream of the mouth of the creek. In 1995, water samples were analyzed for 46 pesticides at Granger Drain, Spring Creek, Sulphur Creek, and the Yakima River at Euclid Bridge as part of Ecology's TMDL evaluation (Joy and Patterson 1997, as cited in BOR 2000). Organochlorine, organophosphate, and nitrogen-containing pesticides were frequently detected at all sites. Total DDT was detected above the human health and aquatic life chronic toxicity criteria at all sites on three or more sampling dates. USGS water quality sampling for pesticide presence in Sulphur Creek in August 1999 detected the presence of 12 pesticide compounds (Ebbert and Embrey 2001).

A sediment budget was developed for the lower Yakima River, because of the link between TSS and pesticide residues (Joy and Patterson 1997, as cited in Snyder and Stanford 2000 DRAFT). Results indicated that in 1995, inputs from tributaries and irrigation returns contributed a significant quantity of the sediment load of the Yakima River. The estimated TSS contribution during the irrigation season from Sulphur Creek was estimated to be 110 tons/day (TSS contribution reduced to 48 tons/day in 2000 (Perala)). Please refer to the Yakima mainstem water quality section for a discussion of the TMDL recommendations to reduce the effects of agricultural runoff. Reductions in turbidity and TSS in Sulphur Creek since the implementation of the TMDL are shown in Figure 41.

Figure 41: Turbidity reductions in Sulphur Creek in recent years (courtesy of Perala)



Water Quantity

In July, Sulphur Creek discharges an average of 250 cfs, including mostly agricultural runoff (BOR 2000). The flow in Sulphur Creek may be increased as necessary by operational spills from the Roza Irrigation District and Sunnyside Irrigation District. Outside of the irrigation season, discharge is reduced to <100 cfs.

Lakes

No lakes are present in this watershed

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Sulphur Creek:

- **Identify and reduce/eliminate the mechanism causing false attraction of adult salmonids** (if operational spill delivery to the Yakima River could be eliminated, no access policy would likely be necessary)

- **Reduce fine sediment delivery to the Yakima River from Sulphur Creek**
- **Develop policy on salmonid access** (additional action recommendations differ depending on utilization goal*)*

Mabton Drain, Drain 301, South Drain

General

No information was available regarding habitat conditions and salmonid habitat limiting factors in these agricultural drains. USGS water quality sampling for pesticide presence in August 1999 detected the presence of 12 pesticide compounds in South Drain, 13 pesticide compounds in Subdrain 35, and 4 pesticide compounds in East Toppenish Drain (Ebbert and Embrey 2001).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for these drains:

- **Assess habitat conditions in these drains and correct identified limiting factors**

Satus Creek 37.0478, Mule Dry Creek 37.0482, Dry Creek 37.0650, Logy Creek 37.0849, Kusshi Creek, Wilson Charlie Creek

General

Satus Creek enters the right bank of the Yakima River at RM 69.6, and supports spring chinook, fall chinook (presumed), coho, steelhead, and rainbow trout. Satus Creek is 49 miles in length, with the major tributaries including Mule Dry Creek (18 miles long), Dry Creek (39 miles long), Logy Creek (14 miles long)[T. McCoy indicates that Logy Creek is 22 miles long], and Kusshi Creek (11 miles long)(CBSP 1990). Mule Dry Creek is a right bank tributary to Satus Creek, entering at RM 8.5. Dry Creek is a left bank tributary to Satus Creek, entering at RM 18.7. Logy Creek is a left bank tributary to Satus Creek, entering at RM 23.6. Kusshi Creek is a left bank tributary to Satus Creek, entering at RM 37.2. The watershed is located within the Yakama Indian Reservation, and drains an area of 612 mi^2 (T. McCoy). The average elevation of the lowlands in the eastern portion of the basin is 650 feet; the maximum elevation in the southwest portion of the basin is 5,800 feet at Potato Butte. Only Logy Creek has sufficient fall flows for salmon spawning (CBSP 1990); all of the identified tributaries support summer steelhead spawning.

Spring chinook were reported to be abundant in Logy Creek before 1910, and there have been unverified reports of spawning chinook in Logy Creek in recent years (CBSP 1990). With the exception of Logy Creek, the Satus watershed is not a current or historic significant producer of spring chinook. However, Satus, when combined with adjacent Toppenish Creek, produce approximately 75% of the steelhead in the entire Yakima River watershed (T. McCoy).

The Satus Creek watershed is topographically steep, ranging from 5,500 feet at the headwaters of Satus Creek on the north slope of the Simcoe Mountains to 650 feet at its confluence with the Yakima River (T. McCoy). Dominated by the rain shadow of the Cascades, precipitation follows

a similar gradient from 35+ inches annually in the headwaters of Satus and Logy Creeks down to 7± inches at Satus Creek's confluence with the Yakima River. The forest edge ecotone occurs at approximately 18 inches of precipitation, marking the division between forest and sagebrush steppe.

Typical of the east side of the Cascades, cool winters and hot dry summers are characteristic of the Satus watershed (T. McCoy). On the average, 60 % of the annual precipitation falls during the winter period (November through February). Precipitation is delivered as snow in the higher elevations and as rain lower down, with the transient snow zone usually near the forest edge. The mid-elevation portion of the watershed, including the dry forest edge and upper elevation rangelands, lie in the rain-on snow zone, where nearly all of the major flood water is generated.

The Satus Creek watershed features a diverse and complex array of plant species and communities (T. McCoy). The watershed can be broken into four basic zones: 1) subalpine/montane forest, 2) dry forest/forest edge, 3) shrub-steppe rangelands, and 4) the agricultural valley. Each zone displays a high degree of diversity, depending on the site-specific interactions of climate, soils, aspect, and past land use.

Approximately 25% of the watershed is forested (T. McCoy). The headwaters of Satus Creek and all of its major tributaries are derived from this zone. The majority of the watershed (approximately 75% of the total area) is comprised of shrub-steppe rangelands. Streams run through deep canyons, which dissect this zone. The lower 8 stream miles of Satus Creek flow through an irrigated agricultural valley to the confluence with the Yakima River.

Fish Access

There were three unscreened diversions on Satus Creek: the Wapato Irrigation Project (WIP, RM 10.0), the nearby Shattuck diversion, and the Holwegner diversion (RM 28)(CBSP 1990). These diversions have all been abandoned (David Lind, YN).

Natural low stream flows in lower Mule Dry, Dry, and Kusshi creeks impair spawner, post-emergent fry, and parr movement and survival; low stream flows in these creeks may be exacerbated by upslope land-use practices. Preliminary observations indicate that steelhead fry and yearlings move upstream into perennial reaches as lower portions of the subwatershed become dry (CBSP 1990).

Barrier falls are located in the upper reaches of Satus, Logy, and Dry Creeks. All totaled there are approximately 100± stream miles available to anadromous fish throughout the watershed.

Floodplain Modifications

The Satus Creek floodplain remains generally intact. The largest impacts from floodplain confinement are associated with SR 97 construction and prior presence of Lakebeds Road in upper Satus Creek (YSS 2001 DRAFT). Large portions of the Lakebeds Road and associated diking have been decommissioned and removed within the past 5 years, and Lakebeds Road no longer represents a significant constriction of the floodplain (G. McCoy).

SR 97 exerts a major influence on mainstem Satus Creek (T. McCoy). Construction included five crossings of Satus Creek, the shortening of a stream segment by relocating it into a straight channel blasted through bedrock, and the constriction of the stream with dikes and riprap. Two of

the bridges span bedrock-constrained stream segments and have little influence on the stream. However, the other three cross alluvial stream segments and have destabilized and degraded the channel in these vicinities. A new bridge, constructed in 1994, proved within two years to have inadequate capacity, necessitating engineering of the upstream channel to protect the bridge. Current effects of the road on Satus Creek are most noticeable between Wilson-Charley Creek and the County Line Bridge, where the stream has been deprived of a substantial part of its floodplain. This stream reach has the potential to provide high quality spawning and rearing habitat, but the constricting influence of the highway maintains the creek in a degraded condition.

Channel Condition

The lower six miles of Satus Creek are slow moving with a mud/sand streambed and a few isolated riffles. The remainder of the watershed contains considerable spawning area and substrate for steelhead. Stream gradient is 0.2-0.3% in the lower 8.5 miles of Satus Creek, increasing to 0.5-1.0% between river miles 8.5 and 37, and further increasing to 1-2% upstream of river mile 37 (G. McCoy). The gradient in the headwater reaches of Satus Creek and its tributaries can exceed 5% (T. McCoy).

Satus Creek and its tributaries have undergone both vertical and horizontal cutting (T. McCoy). Exhibiting the cumulative effects of watershed changes, mainstem Satus and the lower reaches of Dry, Kusshi, and Wilson Charley creeks exhibit typical channel responses to increased bedload and peak flows, and a trend to widening and straightening. Analysis of aerial photographs has revealed changes in both channel structure and the stabilizing of riparian vegetation between 1949 and 1995 along the mainstem of Satus Creek.

The channel has widened substantially throughout the unconfined reaches of Satus Creek, as shown by the increase in gravel bars (both mid-channel and pint bars) between 1949 and 1995, with the trend increasing in the downstream direction (Table 27). These changes, often occurring despite the presence of a robust riparian plant community, are indicative of a cumulative loss of channel stability, due to increased high flows and/or bedload. Two floods, occurring between 1995 and 1997, were the driving force, causing the large increase in gravel bars. Channels in semi-arid systems typically have a pattern of greater disturbance, followed by longer recovery periods than do streams draining more mesic watershed of similar size. The magnitude of the recent increase in gravel bars suggests that the natural ability of the stream to recover from disturbance is being exceeded by the disturbance factors now operating on the stream. The result is channel destabilization.

Table 27: Total Area (acres) of exposed gravel bars in fowr reaches of Satus Creek in 1949 and 1995

Reach	**1949**	**1995**
Satus 1	0	0.35
Satus 2	0	4.45
Satus 3	0.8	4.34
Satus 4	0	0.35

Headwater meadow systems, critical to the water storage capacity of the upper watershed, central to multiple land uses, and essential to a variety of fish and wildlife species, have experienced channel incision as a result of past grazing and culvert installation associated with road construction (T. McCoy). Although ongoing grazing impacts have been addressed, road/culvert impacts to meadows remain a concern. Examples of degraded meadow systems in the Satus Creek watershed include Starvation Flats, Seattle Springs, Indian Springs, Camas Patch and Renschler's Meadow, and collectively account for nearly 1,000 acres.

Major floods in 1996 and 1997 extensively destabilized the channels throughout the mid-elevations of the Satus Creek watershed (G. McCoy). Much of the available LWD was transported out of the active channel by floodwaters and stranded on the floodplain. Channel changes have since occurred during relatively small high flow events, indicating low channel stability during the early part of the post-flood recovery period. Riparian condition, and channel and bank stability are all improving.

Substrate Condition

Substrate condition in Satus Creek is rated as good, with sedimentation rated as fair/good (CBSP 1990). Satus Creek has excessive fines throughout, but improves somewhat in the upper reaches upstream of High Bridge (RM 30.1).

The presence of fines is highly variable throughout the Satus Creek watershed (YSS 2001 DRAFT). Mule Dry Creek has excessive fines (CBSP 1990, WDFW 1998, YSS 2001 DRAFT) and bedload movement during flood events (YSS 2001). Logy Creek substrate condition is generally good, with the exception of the lower reach in the Sheep Camp area, where grazing has resulted in presence of excess fines in the gravels. Dry Creek has excessive fines in the lower portion, and improves significantly in the upper reaches. Kusshi Creek has significant bedload movement and the channel is highly unstable. Presence of fines varies within Kusshi Creek, and substrate size is generally large, as smaller material has been scoured out by past flood events.

In the Satus Creek Watershed, landslides are rare; surface and stream bank erosion are the dominant erosional mechanisms (T. McCoy). These forms of erosion, when accelerated over natural levels, tend to be self-reinforcing. Increased sediment delivery often moves in pulses during high flow events, and is stored within the channel between these high flow events. In the same way that a given watershed produces a characteristic streamflow regime, it also has a characteristic sediment budget. The natural sediment budget is largely a reflection of the climate, geology, landform, and disturbance regime across the watershed; land use becomes an additional factor affecting the sediment budget. Although the measurement of bedload transport was beyond the scope of this document, observation and aerial photograph interpretation indicate that the movement of bedload in Satus Creek and its tributaries has greatly accelerated in the latter half of this century.

Land use has undoubtedly accelerated surface erosion in the Satus Creek watershed (T. McCoy). Excessive grazing by horses, cows, and sheep, beginning in the 1860's has caused the interacting effects of reduced vegetative cover, soil compaction, and soil sealing across substantial areas of the watershed. The resulting overland flow has caused surface, rill and/or gully erosion, depending on the sensitivity and resilience of the soil and vegetation at the affected sites. Where overland flow eroded the surface sufficiently to become channelized, drainage densities have increased, sometimes dramatically. For example, between 1949 and 1995, a 57% increase in the drainage density has occurred in Starvation Flats, an important forest edge headwater meadow system in NF Dry Creek. These changes are attributable to both grazing and culvert installation associated with road building.

Extensive road building associated with timber sales was the next land use further accelerating erosion (T. McCoy). Many of the roads in the Satus Creek watershed are poorly located, designed, constructed and maintained. Bad roads have not only contributed excessive sediment loads to the stream system through erosion of road surfaces, cut and fill slopes, and road ditches, they have also increased the erosiveness of the stream environment by channelizing diffuse flow and delivering it rapidly to the stream, thereby increasing peak flows.

The effect of forestry activities on erosion is largely associated with the creation and use of the transportation system, especially during wet periods (T. McCoy). Selective harvest practices and riparian buffers effectively minimize the direct delivery of sediment to streams from logging practices.

Riparian Condition

Fairly large areas of the Satus watershed have suffered riparian damage from past "unrestricted streamside grazing" (CBSP 1990), and from irrigation drains, which have lowered the water table along the creek (YSS 2001 DRAFT). The term "unrestricted streamside grazing" is used instead of overgrazing because most of the reservation land along Satus Creek was previously managed as open range; the numbers of cattle on the reservation were not actually excessive, but because of the lack of water and shade, and the lack of streamside fencing, the cattle that were present spent virtually all of their time in and around streams (Bruce Watson). The Satus Creek corridor is now leased and grazing is excluded (G. McCoy).

Overall riparian condition is rated as poor/fair in Mule Dry Creek, fair/good in Dry Creek, fair/good in Logy Creek, good in Kusshi Creek (CBSP 1990, WDFW 1998). Riparian damage is not uniformly distributed (G. McCoy), with much of the damage consisting primarily of bank sloughing; many impacted areas still support fair numbers of large trees that often provide adequate shading. These areas have been prioritized by productive potential and need for restoration (in descending order of importance) as follows (CBSP 1990):

- Satus Creek from Dry Creek (RM 18.7) to High Bridge (RM 30.1)
- Dry Creek, from the mouth to 3 miles upstream of Elbow Rd. crossing (~RM 27)
- Logy Creek, mouth to the first crossing upstream of Sheep Camp (~RM 2.5)
- The entire Mule Dry Creek drainage
- Lower Satus Creek, mouth to Mule Dry Creek (RM 8.5)

Much of the unvegetated, unstable sections of Satus, Dry, and Mule-Dry creeks are downwelling zones where the natural declines in the water table through the growing season seriously reduce the potential for establishing riparian vegetation (G. McCoy).

Analysis of aerial photos circa 1949 confirms that rangeland riparian plant communities were generally intact and functional (T. McCoy). However, from 1949 to 1995, there has been little recruitment of black cottonwood and various riparian shrubs into the overstory vegetation along Satus Creek. There has been extensive conversion to more xeric vegetation (e.g., big sagebrush), or to post-disturbance colonial species such as sitka and thinleaf alder or unvegetated gravel bars. These vegetative changes are consistent with the evolution of livestock management, observed changes in flow regime, and subsequent channel change. It is important to note the change in age structure of the black cottonwood population from almost entirely young and mature in 1949, to predominantly mature and decadent in 1995. In an ecological sense, this is a very important shift and indicates a change (likely a decline) in riparian/floodplain function and overall watershed health. In combination, these changes are also exerting a deleterious influence on beaver habitat.

Because of the larger diameter trees and proximity to roads, many riparian areas in the Satus watershed have been subjected to selective tree harvest. Removal of large overstory trees, including snags, has deprived the stream network of the bank-stabilizing influence of the tree roots, shade, nutrients, and the energy-dissipating effects of the large woody debris. These alterations have directly influenced both the headwater source areas and spawning and rearing habitat in the forested portions of the anadromous fish bearing streams.

Riparian proper functioning condition (PFC) assessment (Barrett et al. 1995) is a qualitative method for assessing the physical interactions among soil (sediment), water, and vegetation in the stream/riparian system (T. McCoy). Riparian PFC assessments were conducted on 25 miles of streams in the Satus Creek watershed. Ten miles of the surveyed reaches were assessed as seriously degraded and not functioning properly; approximately eight miles were assessed as impaired but functional; approximately seven miles were assessed as being in good condition and functioning properly. The general trend in the assessments indicates that riparian function is degraded in the lower watershed, but improves with increasing elevation. This is partly due to less disturbance and cumulative effects high in the watershed, and partly due to the increasing sensitivity of the lower gradient, alluvial stream reaches in the lower watershed.

Water Quality

Water quality throughout the Satus Creek watershed is generally considered to be good, with the possible exception of lower Satus Creek (downstream of Plank Road) where the creek flows through developed agricultural lands (YSS 2001 DRAFT). Developed agriculture is mainly limited to the lower watershed; therefore, most of the watershed is not exposed to the application of agricultural related chemicals. Single excursions from state water quality standards for 4,4'-DDE and Dieldrin have been documented on Satus Creek at two different locations (Department of Ecology 1998). USGS water quality sampling for pesticide presence in August 1999 found no detections at Satus Creek above SR 97 or below Dry Creek, but 11 pesticide compounds were detected in Satus Creek at Satus (Ebbert and Embrey 2001).

Water temperatures in lower Satus and Dry creeks in the late spring through summer often approximate 26°C (YSS 2001 DRAFT). The minimal surface flow that remains in Mule Dry Creek is 15-20°C in the shaded reaches. Logy Creek has optimal temperatures in the summer, as well as good instream flow. Kusshi Creek has reasonable water temperatures for steelhead where surface flow persists. Satus Creek, above Kusshi Creek, has reasonable water temperatures, which may occasionally become sublethal during the summer.

A sediment budget was developed for the lower Yakima River, because of the link between TSS and pesticide residues (Joy and Patterson 1997, as cited in Snyder and Stanford 2000 DRAFT). Results indicated that in 1995, inputs from tributaries and irrigation returns contributed a significant quantity of the sediment load of the Yakima River. The estimated TSS contribution during the irrigation season from the Yakama Reservation (Satus and Toppenish Creeks combined) was estimated to be 75 tons/day. Please refer to the Yakima mainstem water quality section for a discussion of the TMDL recommendations to reduce the effects of agricultural runoff.

Periodic measurements of turbidity throughout the stream system have been conducted since January 1997 (T. McCoy). Although this is not a sufficient record to fully characterize suspended sediment transport within the watershed, analysis of turbidity data reveals trends in sediment production and transport along Satus Creek. Suspended sediment concentrations through the length of Satus Creek, as represented by turbidity values, are generally inversely related to valley gradient. This pattern can be expected under natural conditions in the moderate- to high-gradient stream reaches found above RM 11. Maximum natural surface erosion rates are observed in the 15-18 inch precipitation zone. This is the interface between rangelands and the forest, where there is incomplete coverage of the ground surface by vegetation, combined with adequate precipitation to cause substantial erosion. The tributaries draining the forest edge (e.g., Wilson-Charley, Kusshi, and Dry creeks) would naturally contribute high sediment loads relative to those

with alpine headwaters (i.e., Satus and Logy creeks). However, natural erosion processes usually cause the great majority of suspended sediment transport to occur during the ascending stage of a runoff event, as the system flushes out the fines accessed by rising flows and expanding stream systems. Observations indicate high suspended sediment concentrations throughout high flow periods, indicating accelerated erosion. The primary sources appear to be from road surfaces, cut and fill slopes, road ditches, and erosion of unstable streambanks.

Cuffney et al. (1997) identified that sites in the Satus Creek drainage had unusually high algal abundance (>3,300,000 cells/cm^2). The abundance of algae in Satus Creek at Toppenish (9,910,000 cells/cm^2) was approximately an order of magnitude larger than other streams in the Cascades and Eastern Cascades site groups. Total algal abundance in Satus Creek downstream of Dry Creek and at the gage were the largest observed in the Columbia Basin. No cause has yet been identified (T. McCoy).

The condition of invertebrate communities in Satus Creek downstream of Dry Creek was ranked as unimpaired, and as one of the highest quality sites in the Yakima watershed for benthic invertebrates (Cuffney et al. 1997).

Water Quantity

Average annual precipitation ranges from ~35 inches in the headwaters to <10 inches near the mouth (YSS 2001 DRAFT). The greatest period of precipitation occurs from October through March, when 84% and 66% of the annual precipitation occurs in the highlands and lowlands, respectively (Murdorff et al. 1977, as cited in YSS 2001 DRAFT). Mean precipitation for June-August is only 0.81 inches for the basin.

Mule Dry, Dry, Kusshi, and Wilson Charly creeks normally dry up in one or more downstream reaches by September at the latest (CBSP 1990); Logy Creek maintains permanent year-round stream flow. The permanent annual streamflow in Logy Creek is due to its location in the high precipitation portion of the watershed and the large amount of the Logy Creek watershed that is within the Simcoe Mountains Basalt region, which is relatively permeable and capable of storing large amounts of precipitation (Murdorff et al. 1977, as cited in YSS 2001 DRAFT). Instream flows in Logy Creek are good, with sufficient fall flows to support spring chinook spawning (CBSP 1990, WDFW 1998). Instream flows in Mule Dry Creek are naturally poor, becoming intermittent in one or more reaches between May and July, creating barriers to upstream fish passage (T. McCoy). Instream flows in Dry Creek are fair/poor (poor below Elbow at RM 27), becoming intermittent in one or more reaches by July (T. McCoy). Instream flows in Kusshi Creek are poor in the lower reach, usually going intermittent in one or more downstream reaches by August (T. McCoy).

Instream flows in Satus Creek are fair/good, except for low summer flows (particularly from RM 24-30), which limit the productivity of the middle reaches Satus Creek (CBSP 1990, WDFW 1998). There have been no active irrigation diversions of Satus Creek since 1990 (T. McCoy).

Analysis of flow records indicates changes in the flow regime in Satus Creek since gaging began (T. McCoy). Runoff characteristics during the high flow season have become more extreme. The post-1950 period has had average annual water yields approximately 38% higher than the pre-1950 period. In addition to higher yields, the post-1950 period exhibits earlier peak runoff, greater variability among years, and greater relative variation among the high flow months,

December through May. In summary, flood flows from the watershed are generally earlier and flashier.

Although changes observed in runoff patterns support the hypothesis that land use has altered watershed functioning, causing earlier runoff and higher peaks, the climatic data indicate changes in precipitation, which may be driving some or all of the observed changes in the flow regime (T. McCoy). Intensive analysis of other climatic parameters, such as temperature, wind speed, and relative humidity may help clarify the influence of the observed increase in precipitation on streamflow.

One land use effect with the potential to reduce both peak flows and overall runoff is vegetative conversion (T. McCoy). In the Satus watershed there has been large-scale vegetative conversion in two of the vegetation zones: the shrub steppe, and the dry forest. Both these conversions have been toward more water consumptive vegetative communities, with greater interception capacity. These vegetative changes may have, to a degree, offset other changes in the watershed, which would tend to increase the rapid runoff of water.

Action Recommendations

Watershed restoration activities should be prioritized by first implementing passive restoration treatments where management activities are causing degradation of watershed functioning (T. McCoy). Second, site-specific disturbances should be addressed. Finally, active restoration should be undertaken where necessary to reestablish natural processes that have been interrupted by human activities. The following specific salmonid habitat restoration actions are recommended for the Satus Creek watershed. The recommendations are summarized from a more detailed list presented by the Yakama Nation (T. McCoy); please contact the Yakama Nation for further details, if desired.

- **Develop specific grazing plans for individual range units, with emphasis on simple management techniques that minimize capital inputs and maintenance/operation costs**
- **Address transportation needs of the YN in the Closed Area through development of a comprehensive transportation system plan that includes**
- **Replace poorly designed stream crossings with undersized culverts, and/or culverts installed below grade**
- **Incorporate provisions for overtopping of stream crossings by high flows**
- **Ensure that upstream and downstream passage of adults and juvenile is provided at crossings of fish-bearing streams, preferably with bridges or arched culverts with natural bottoms**
- **Use of armored fords in place of culvert crossings**
- **Improve road drainage structures (i.e., ditches, ditch-relief culverts, and waterbars) on the forest road network**
- **Surface all arterial and collector roads in the transportation system with good quality gravel**
- **Remove dikes in riparian areas and relocate riparian roads out of the floodplain**
- **Relocate or rebuild roads in meadows to allow flow-through drainage and to eliminate channelization of runoff and lowered streambed elevation**
- **Study the feasibility of relocating S.R. 97 out of the Satus Creek floodplain between the bridge below the mouth of Wilson-Charley Creek and Kusshi Creek**
- **Develop a plan (using minimal site preparation, prescribed burning, etc.) to restore vigorous natural vegetation communities in the watershed that have a lower**

transpiration demand than the altered upland and riparian vegetation communities currently in place

- **Focus near-term habitat restoration efforts in:**
  - **NF Dry Creek/Seattle Creek area to restore the ability of these areas to store runoff and deliver strong base flows to the spawning and rearing areas in Dry Creek**
  - **Improve channel stability in Satus Creek to enhance and connect spawning and rearing habitat**
- **Focus Long term, large scale restoration efforts on increasing watershed 'roughness' and retentiveness in order to moderate flow regimes to the greatest degree possible**

Toppenish Creek 37.1178

General

Toppenish Creek flows easterly from the foothills of the Cascade Mountains, entering the right bank of the Yakima River at River Mile 80.4. Draining the Toppenish Creek watershed are two major subwatersheds, Toppenish Creek to the south, and Simcoe Creek to the north. Broad, gently sloping plateaus (Lost Horse and Lincoln) form the headwaters of Toppenish Creek (G. McCoy). The eastern extent of the plateaus is dissected by numerous steep rocky canyons which carry Toppenish and Simcoe Creeks and their tributaries to their confluence in the agricultural valley. The watershed is readily subdivided into two topographic portions; the upper watershed is comprised of largely undeveloped forest and rangelands, and the lower watershed is agricultural valley bottom.

Mean elevation of the divide between Toppenish Creek and the Klickitat River watershed to the west is approximately 4,650 ft (G. McCoy). The watershed slopes easterly to 1,300 ft where Toppenish and Simcoe Creeks enter the agricultural valley. Below the confluence with Simcoe Creek, Toppenish Creek flows east along the toe of Toppenish Ridge, entering the Yakima River at an elevation of about 800 ft.

The Toppenish River watershed drains an area of 265 mi^2, and is located entirely within the Yakama Reservation (YSS 2001 DRAFT). Toppenish Creek is 70 miles long, with the major tributaries including Simcoe Creek (18.9 miles, NF Simcoe (13.9 miles), SF Simcoe (12.8 miles)), NF Toppenish Creek (18 miles), and SF Toppenish (6 miles)(CBSP 1990). Habitat conditions in Simcoe Creek and tributaries are discussed separately later in this chapter. The upper half of the drainage (upstream of ~RM 48 on Toppenish Creek), and the entirety of the NF and SF of Simcoe Creek, are canyon streams, draining heavily forested plateaus and mountains. The mid-elevation portion of the watershed encompasses shrub-steppe rangelands; the lower portion is now a broad, agricultural valley, bounded to the north and south by ridges. Precipitation declines along with elevation, ranging from ~35-inches in the upper headwater areas to ~7-inches near the mouth (G. McCoy). Toppenish Creek and tributaries in the upper portion of the watershed are fast-flowing, pocketwater streams, with gradients in accessible reaches ranging from 1.7% to >3%, that flow through deep (several hundred feet) and often precipitous canyons. The lower half of the watershed has a gradient of 0.1% or less, except for the reaches immediately below the canyons, and water velocity is much slower. Toppenish Creek was historically a producer of all species except sockeye (YSS 2001), and currently supports spring chinook, fall chinook (presumed), summer steelhead, and coho. Toppenish Creek is not a current

or historic significant producer of spring chinook (CBSP 1990), but does support some fall chinook spawning (presumed) in the lower few miles. Steelhead spawning surveys conducted since 1998 indicate that the Toppenish Creek watershed appears to be a much larger producer of steelhead in the Yakima watershed than previously thought, and that steelhead production may actually rival or even exceed that from Satus Creek (YSS 2001 DRAFT). There is currently no conclusive evidence of the existence of resident rainbow trout in Toppenish Creek (YSS 2001 DRAFT).

This watershed is quite large, and has the potential to be a major producer of steelhead and perhaps coho. It is currently one of the two largest tributary producers of steelhead in the Yakima River watershed (Evenson/Lind). However, the watershed is heavily impacted by the Wapato Irrigation Project (WIP). The watershed suffers from several distinct types of habitat problems (first four are directly attributable to WIP operations), including:

- Dewatered reaches
- Degraded water quality (i.e., temperature, suspended sediment, agricultural chemicals)
- Fish passage problems
- Altered and simplified channels in middle and lower Toppenish and Simcoe creeks
- Hunting club waterfowl ponds
- Riparian degradation
- Loss of floodplain, riparian wetlands, and multiple channels

Fish Access

Toppenish Creek and Simcoe Creek are part of the drainage and delivery system for the Wapato Irrigation Project. The WIP Toppenish Lateral Canal (RM 44.2) can dry up 5.3 miles of Toppenish Creek downstream of the diversion dam, although diversions were lessened in 2000 and 2001 to maintain instream flows below the dam (Evenson/Lind). The dewatered reach extends from the dam to a spring near Pom Pom Road (RM 38.9). The dam no longer blocks access, as it has filled in with cobble. Prior fish passage problems associated with the Toppenish/Marion drain flood control ditch, which entrained outmigrating smolts, have not been a concern in recent years, as the ditch has not been recently operated. Other fish passage problems include several gun club diversions that can hinder adult passage and entrain smolts. The Toppenish Creek Pump diversion was screened in 1995, but there are lingering adult passage problems at the pump site's two diversion dams.

There are at least eight braids on Toppenish Creek from approximately RM 42.5 downstream to about half a mile upstream of Slayton Road (RM 6)(CBSP 1990). Many of these channels dry up every spring after the high water period, and all of them dry up occasionally, constituting a stranding hazard for juvenile salmonids. Five of the alternate channels branch off Toppenish Creek downstream of the Toppenish Creek Pump diversion. Operation of the diversion can cause early dewatering of the alternate channels downstream, increasing the probability of stranding juvenile salmonids. Furthermore, some of these channels feed numerous small, unscreened diversions, resulting in additional entrainment hazards. Screening of the Toppenish Pump Unit II pump canal addresses the problem of entraining smolts into the Unit II canal, but does not address problems of dewatering alternate channels and the stranding of the smolts in those channels, nor of other unscreened diversions (G. McCoy).

There are ~10-15 private waterfowl hunting clubs (Lind) and one large federal waterfowl refuge on Toppenish Creek, almost all of which fill their hunting ponds by erecting small dams on Toppenish Creek (CBSP 1990). These small gun club diversions on middle and lower Toppenish

Creek are constructed in mid-October, and are present at least through the end of the hunting season in January (many are frozen in place at the end of the hunting season and not actually removed until after high water in late-May or June)(Lind, Evenson). These diversions are not screened, and divert salmonids into the ponds. Although most of the diverted water is ultimately returned to the creek, the return path may be tortuous, including virtually impenetrable sections of dense vegetation and brush. The potential for smolt loss through entrainment and stranding in the gun club ponds is obvious. A study of smolt entrainment in a Toppenish National Wildlife Refuge pond off the Snake Creek distributary of Toppenish Creek in the spring of 2001 counted significantly more fish entering the test pond than exiting the pond.

The WIP diversion to the Satus Unit impounds Toppenish Creek and commingles it with flow from Marion Drain (G. McCoy). Control of water levels is crude, due to out-dated taiter gates in use. This results in the loss of Toppenish Creek water during part of the year, and inadequate flow through the fish ladder at other times. This is of particular concern in regards to fall-migratory fish.

Habitat conditions in the uppermost 25 miles of Toppenish Creek, as well as NF and SF Toppenish creeks, are good, with the major problem in these upper reaches being a number of large, slightly perched culverts (CBSP 1990) that may present partial or complete barriers to upstream juvenile or adult fish passage. Closure of a major riparian road along Toppenish Creek and reconstruction of several culverts across tributaries between 1997 and 2000 have demonstrably improved upstream passage conditions.

Floodplain Modifications

Historically, Toppenish Creek was one of the most complex drainages in the entire Yakima watershed (YSS 2001 DRAFT). The 1909 Indian Irrigation Service map (see map in YSS 2001 DRAFT) illustrates that Toppenish Creek and the mainstem Yakima River were commingled over approximately the lower 20 miles of what is now called Toppenish Creek. Annual flooding, cool baseflows, high habitat complexity associated with dense riparian vegetation, and massive accumulations of LWD were as applicable to lower Toppenish Creek as they were to the mainstem Yakima. In addition, even the upper portion of the watershed inside the canyon was very complex, with multiple anastomosing channels resulting from a massive quantity of LWD and massive amounts of trapped gravel. From the headwaters to the lowermost point of commingling with the mainstem Yakima, Toppenish Creek provided virtually the entire spectrum of salmonid habitat types: steep, cold, pocketwater/step-pools in the Simcoe forks and upper tributaries; fast, complex pool/riffle/run habitat in mainstem Toppenish Creek in the canyon; and slow, pool/glide/riffle habitat in the lower reaches (YSS 2001 DRAFT).

The lower ~22 miles of Toppenish Creek lie within Holocene alluvium deposited by both Toppenish Creek and the Yakima River (Freudenthal). As such, much of the area between Toppenish Creek and the Yakima River lies in the hyporheic zone of both streams. Marion drain (discussed separately below) parallels Toppenish Creek through this entire reach, and lowers the water table and storage capacity of the hyporheic zone and water table over a large area of both Toppenish Creek and the Yakima River. Undoubtedly, this lower portion of the creek was an area of upwelling in the lower Yakima River valley and was supplied water by the surficial aquifer of the Yakima valley. Based on the soil survey, large areas of lower Toppenish creek developed under conditions where the water table was at or near the surface for significant periods during the year. Early in the 20th century, the area of the valley where the water table was near the surface expanded due to increased water inputs to the valley floor from irrigation. Marion drain was constructed to lower the water table to prevent the formation of additional

alkaline soils. The constructed drain lowered the water table in the areas where the water table had been raised as a result of irrigation, and in areas with pre-existing alkaline soils (naturally developed over time due to high evapotranspiration, and the presence of water at or near the surface). While Toppenish Creek and Marion Drain are discussed separately in this report, the two actually lie within the same watershed, and activities which benefit one stream for fish habitat could have severe negative effects in the other.

Except for upper Toppenish Creek (upstream of RM 48), the Toppenish Creek of today bears little resemblance to historic condition (YSS 2001 DRAFT). Historic alluvial anastomosis in the Wapato reach of the mainstem Yakima has been obliterated, eliminating the "mainstem river' character of lower Toppenish Creek. Most of the surrounding wetlands have been drained, and WIP has transformed segments of lower Toppenish Creek into an irrigation ditch. Base flows during the irrigation season are reduced to the extent that remaining side-channels in the lower watershed are dewatered. The channel in almost the entire reach from the WIP Lateral Canal dam (RM 44.2) downstream to Pom Pom Rd. (RM 38.9) has been relocated, channelized, and diked (CBSP 1990), eliminating virtually all normal floodplain function in this reach. The resulting large, highly-fractured bed material within the channelized section allows considerable subsurface flow. WIP personnel have observed that spills of 6-7 cfs over the dam go subsurface prior to reaching Pom Pom Rd. (CBSP 1990); Yakama Nation personnel have observed that flows up to 17 cfs go subsurface within 2 miles downstream of the dam (Evenson/Lind). The dike system upstream and downstream from the Toppenish Lateral Canal was damaged in a 1996 flood. Planning and engineering of a mitigation project for this reach is nearly complete in 2001. The project will include reopening historic floodways, reversing channel degradation, and rebuilding the Lateral Canal diversion to restore head differential for screen bypass function without degrading upstream passage.

With one relatively short exception, the channel from 0.5 mile upstream of Pom Pom Road downstream to 0.5 mile below Island Road (a distance of approximately 12 miles) is severely incised and isolated from its former floodplain (G. McCoy). This is largely due to past channelization, presumably conducted to reduce flooding.

The channel from the Simcoe confluence (RM 32.7) downstream to the Toppenish Creek Pump diversion (RM 26.5) was deepened and straightened to pass return flows from Mud Lake Drain to the pump station (Evenson/Lind), and appears to also have headcut further upstream (Freudenthal). Consequently, almost half of this reach consists of "runs", with velocities of 3-4 feet/second during the irrigation season, with the remainder consisting of glides and pools having velocities of ~1 foot/second. Through most of the reach, velocity and depth are excessive for steelhead fry, given the lack of LWD or boulders that would provide habitat diversity (CBSP 1990, Evenson/Lind). Upstream of the mouth of Simcoe Creek, floodplain function is impaired by dikes to protect property and constriction associated with bridges (Freudenthal).

Channel Condition

Toppenish Creek throughout the irrigated valley is severely degraded by past and ongoing land and water management (G. McCoy). Channelization, diking, diversions, wastewater return flows, unmanaged grazing, and 'to the bank' farming have all adversely affected channel condition. Riparian and channel recovery are inhibited by unnaturally low summer flows, a water table lowered by nearby drains, and by concentration of high flows in the channel rather than accessing the surrounding floodplain. The remaining large riparian cottonwoods in the valley are largely concentrated in a 1.0 mile-long reach between Pom Pom and Yost Roads. Others are stranded on

terraces well above the incised channel; in such cases the tree is not contributing to bank stability and is unlikely to fall in a way that will strongly interact with the channel.

Toppenish Creek is wide and shallow, with an unstable cobble bed, throughout much of the moderate-gradient reach flowing down the alluvial fan from the mouth of the Toppenish Canyon to Shaker Church Road (approximately 9 miles)(G. McCoy). Riparian vegetation presence is limited by annual dewatering that occurred until 1999. Shortly below Shaker Church Road, the stream reaches the lower extent of the alluvial fan. The gradient decreases and the stream becomes severely incised (i.e., channelized). Gravels become intermittent, with the rest of the bed composed of a resistant clay layer. The channel is relatively featureless – wide, and shallow, spanning the width between the vertical banks. There is virtually no LWD, few pools, and very little riparian vegetation. The high banks provide some topographic shading. These conditions prevail past the confluence with Simcoe Creek and down to Island Road (approximately 5.5 miles).

Below Island Road, the stream develops into an extremely low-gradient system (G. McCoy). The depositional nature of this part of the system aggrades the channel to the point that it is again connected with its floodplain. Multiple channels are in evidence across the floodplain, and only continuing management (i.e., diking, dredging, and diversion) maintains the stream in a single channel. Riparian vegetation throughout much of the reach is limited to a narrow, intermittent strip of willows and shrubs; many of the willows are old and decadent. Channel complexity varies according to degree of manipulation – not surprisingly, the dredged and channelized segments are extremely simplified. The bed material is generally fine-grained, although in some areas the moderately-incised channel has cut down to a resistant clay layer. Large woody debris is generally lacking. Beaver activity, formerly a key component in the creation and maintenance of habitat complexity and wetlands, is very limited. There are few significant sources of LWD downstream of the mouth of Simcoe Creek (Evenson/Lind).

Habitat conditions in the uppermost 25 miles of Toppenish Creek, as well as NF and SF Toppenish creeks, are good (CBSP 1990). Toppenish Creek, upstream of the SF, probably represents the best steelhead habitat in the entire Yakima River watershed (YSS 2001 DRAFT). Base flows exceeding 15 cfs are sufficient to provide surface flow. Spring floods, in conjunction with abundant LWD and abundant gravels, results in the development of complex suitable habitat conditions for spawning and rearing.

Substrate Condition

The quality of substrate in Toppenish Creek from the Simcoe Creek confluence (RM 32.7) downstream to the Satus II diversion (RM 31.5) ranges from poor to extremely poor. There is heavy deposition of fine sediments and organic silts resulting from the erosion of lacustrine deposits on the bench area of the Wapato Irrigation Project (Evenson/Lind). Rocks or gravel are rarely visible from the pump diversion to the Satus II diversion; the bottom is coated with several inches to a foot or more of viscous muck. Gravel and cobble are visible in the uppermost portion of the affected area, as well as below the Satus II diversion, but even there the substrate is fairly heavily embedded with fine sediment. The only area in this reach with substrate remotely approaching spawning quality is Snake Creek, a 3.5 mile long braid (CBSP 1990). Although the large quantity of suspended sediment in WIP irrigation return flows contributes to the substrate problem, irrigation is not wholly to blame; numerous small diversion dams and widespread riparian degradation probably play a role of equal importance. Nevertheless, substrate conditions would benefit from elimination of the discharge of tens of thousands of tons of sediments from drains such as Mud Lake Drain.

There are approximately ~10-15 private waterfowl hunting clubs and one large federal waterfowl refuge on Toppenish Creek, almost all of which fill their hunting ponds by erecting small dams on Toppenish Creek (Evenson/Lind). The dams are constructed in mid-October, and are present at least through the end of the hunting season in January (some are frozen in place at the end of the hunting season and not actually removed until after high water in late-May or June). These diversions likely exacerbate the problem of accumulation of fine sediment in the substrate by creating small impoundments in the channel through much of the high water period of fall and winter, and a somewhat smaller number through the entire annual period of high water. This series of impoundments slows water velocities and increases deposition of fine sediments, rather than allowing the high flows to flush deposits from the system. Some long-time residents of the Toppenish watershed recall that 40-50 years ago, prior to the establishment of most of the gun clubs, middle Toppenish Creek contained gravelly riffles (CBSP 1990). The prolonged slowing of flows during the high water season likely exacerbates the fine sediment problem in middle and lower Toppenish Creek (CBSP 1990).

Substrate condition is excellent in the upper 25 miles of Toppenish Creek, as well as NF and SF Toppenish creeks, with abundant gravel of very high quality (CBSP 1990, WDFW 1998).

Efforts are underway in the upper Toppenish watershed to restore soil retentiveness in areas such as headwater meadows and floodplains (YSS 2001 DRAFT). Efforts include improved grazing practices, stabilizing headcuts and constructing sediment traps in headwater areas, revegetating eroding upland areas, and enhancing stream/floodplain interaction.

Riparian Condition

Degraded riparian condition in the middle and lower portions of Toppenish Creek exacerbate the problem of excessive water temperatures (CBSP 1990). Degraded riparian habitat condition along Toppenish Creek is generally due to channelization and irrigation drains (which have lowered the water table along the creek) and excessive livestock grazing (Evenson/Lind, YSS 2001 DRAFT). Riparian vegetation is generally absent in the channelized/diked reach from the 3-Way diversion downstream to Signal Peak Highway (G. McCoy). The middle and lower portions of Toppenish creek have many small, fenced, private pastures. Although patches of very dense riparian vegetation exist downstream, they are interspersed with larger areas (primarily pasture) with little or no vegetation, resulting in few reaches with extensive shade. There has not been an exhaustive riparian inventory in the Toppenish Creek watershed. However, the areas of worst damage, in decreasing order of significance to salmonids (G. McCoy) are:

- Toppenish Creek from the mouth to the Simcoe confluence (RM 32.7)
- Toppenish Creek from the Simcoe confluence to Yost Road
- Toppenish Creek from Pom Pom Rd. (RM 38.9) to the Toppenish Lateral Canal (RM 44.2)
- Toppenish Creek from the Toppenish Lateral Canal to the upstream end of the Olney dike
- Simcoe Creek from the confluence with Toppenish Creek to the confluence of the NF and SF, and
- Wanity Slough from the headworks to the Marion Drain outfall

Part of the problem with riparian condition in the 2 miles upstream of the Lateral Canal diversion is the diking and road construction that was done, which effectively confined and straightened the creek (YSS 2001 DRAFT). Toppenish Creek was relocated to the south side of the canyon and diked for a distance of about a mile upstream of the Toppenish Lateral Canal (G. McCoy). Excluding the stream from its floodplain and straightening it caused serious deepening and

widening. The vertical banks are up to 12 feet high. The substrate is large cobble and small boulders. This reach now forms a 'gap' in the spawning habitat in Toppenish Creek. Riparian vegetation is limited to a discontinuous fringe of alder along the edge of the active channel. Reconnection of the creek to the floodplain and riparian restoration are being planned.

Riparian condition is excellent in the uppermost 25 miles of Toppenish Creek, as well as in NF and SF Toppenish creeks, except for the stretch of several miles just upstream of the WIP diversion (CBSP 1990, WDFW 1998).

Water Quality

Water quality impairments have been documented in Toppenish Creek (Ecology 1998). Documented water quality excursions that may be consistent with CWA 303(d) listing criteria include fecal coliform, 4,4'-DDE, and Dieldrin. In addition single water quality excursions have been documented for DDT, 4,4'-DDD, and Parathion, which did not meet the 303(d) listing criteria. USGS water quality sampling for pesticide presence in August 1999 detected the presence of 9 pesticide compounds in Toppenish Creek near Granger (Ebbert and Embrey 2001). Toppenish Creek is entirely within the boundaries of the Yakama Nation, and does not fall under the jurisdiction of the state for water quality, and water quality excursions are not included on the State 303(d) list. Water quality impairments likely adversely impact juvenile and adult salmonids in Toppenish Creek, as well as in the Yakima River downstream of the mouth of the creek.

Water temperatures in Toppenish Creek, from the confluence of Simcoe Creek (RM 32.7) to the mouth, are excessive for salmonid rearing, and may occasionally be lethal (CBSP 1990, WDFW 1998). Instantaneous observations (most within a couple hours of noon) indicate that the mean temperature in July and August in this reach is 66-68°F (19-20°C); maximum temperatures observed have been as high as 85°F (31°C) just below the Satus II diversion. Diel fluctuations are quite large, 27°F (15°C) near the Simcoe confluence, and up to 36°F (20°C) downstream of the Satus II diversion (CBSP 1990). The median diel temperature (79°F, 26°C) in this portion of Toppenish Creek exceeds (by 3°C) the temperature at which steelhead populations lose biomass (23°C)(CBSP 1990). More importantly, it may not be possible for steelhead to survive at all in much of this reach, as the upper incipient lethal temperature for steelhead is about 26°C. Observed rearing steelhead are likely residing only in localized thermal refuges, such as spring seeps (CBSP 1990). As is the case with the lower mainstem Yakima River, there are multiple causes associated with the thermal pollution in lower Toppenish creek; the elimination of annual spring flooding, the draining of wetlands, and riparian degradation are three of the more important factors (YSS 2001 DRAFT). Reduced summer flow, due to irrigation diversions and, perhaps more importantly, to the interception of surface and ground water by deep agricultural drains, is a major cause of elevated water temperatures throughout much of the course of lower Toppenish Creek (G. McCoy). Another cause of the high water temperatures in Toppenish Creek is the large volume of warm irrigation water routed down Simcoe and Toppenish creek to the Toppenish Creek Pump and Satus II diversions (CBSP 1990). This water, which comprises as much as 80-90% of the flows approaching the Toppenish Creek pump diversion, has mean summer temperatures ranging from 68-73°F. This problem is further compounded by poor riparian conditions and the east-west orientation of the stream, both of which contribute to a severe lack of shade in the middle and lower portions of Toppenish Creek.

Water quality in Toppenish Creek above the uppermost irrigation diversions is rated as good (G. McCoy).

A sediment budget was developed for the lower Yakima River, because of the link between TSS and pesticide residues (Joy and Patterson 1997, as cited in Snyder and Stanford 2000 DRAFT). Results indicated that in 1995, inputs from tributaries and irrigation returns contributed a significant quantity of the sediment load of the Yakima River. The estimated TSS contribution during the irrigation season from the Yakama Reservation (Satus and Toppenish Creeks combined) was estimated to be 75 tons/day. Please refer to the Yakima mainstem water quality section for a discussion of the TMDL recommendations to reduce the effects of agricultural runoff.

Water Quantity

The WIP Toppenish Lateral Canal (RM 44.2) can dry up 5.3 miles of Toppenish Creek downstream of the diversion dam, although diversions were lessened in 2000 and 2001 to maintain instream flows below the dam (Evenson/Lind). The dewatered reach extends from the dam to a spring near Pom Pom Road (RM 38.9). The large, highly-fractured bed material within the channelized section allows considerable subsurface flow; WIP personnel have observed that spills of 6-7 cfs over the dam go subsurface prior to reaching Pom Pom Rd. (CBSP 1990), Yakama Nation personnel have observed that flows up to 17 cfs below the Lateral Canal go subsurface within 2 miles of the dam (Evenson/Lind). The low gradient, anastomosed reaches of Toppenish Creek (i.e., from the mouth to the confluence with Simcoe Creek) are heavily impacted by WIP diversions and return flows, and by the proximity of deep drains that intercept ground water and surface flows emanating from the Yakima River (G. McCoy). The uppermost 25 miles of Toppenish Creek maintain adequate year-round flows; instream flows in NF Toppenish are rated as good (CBSP 1990, WDFW 1998). Contemporary

Figure 42: 1980-1991 (WIP data) and estimated historic (HKM 1990) mean monthly flow in Toppenish Creek below the Simcoe Lateral Canal (From YSS 2001 DRAFT)

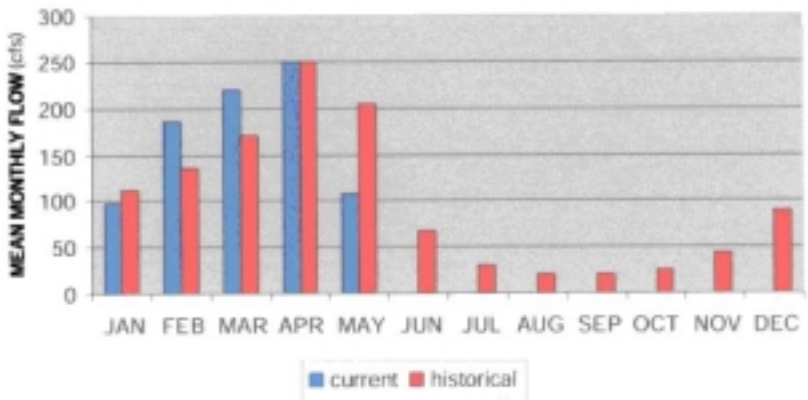
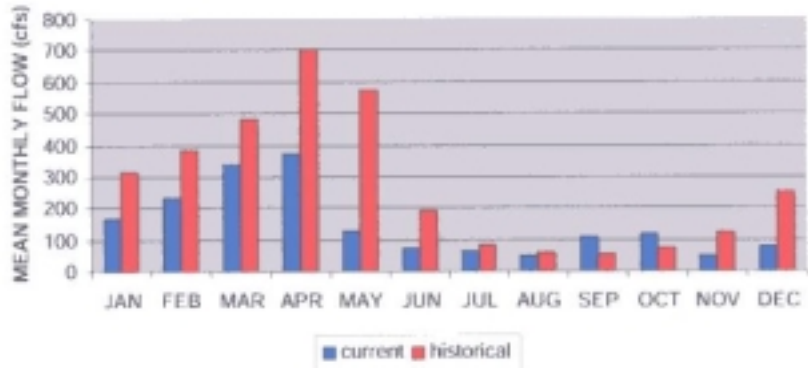


Figure 43: 1980-1991 (WIP data) and estimated historic (HKM 1990) mean monthly flows in Toppenish Creek near the mouth (from YSS 2001 DRAFT)



(1980-1991) and estimated historic unregulated mean monthly flows in Toppenish Creek are shown for downstream of the Toppenish Lateral Canal (Figure 42) and near the mouth (Figure 43). The impacts of water withdrawals, which reduce peak flows in the lower watershed and eliminate flow downstream of the Toppenish Lateral Canal, and increased irrigation return flows near the mouth, are clearly evident.

Instream flow recommendations were developed in the mid-1980s (see Instream Flow section at beginning of this chapter), but the TAG does not support implementation of those recommendations at this time. Rather, the TAG supports continued work to develop and implement a normative flow regime that combines "the goal of sustaining ecological integrity of the watershed, while also maximizing use of water resources by humans" (SOAC 1999).

A BPA-funded project was initiated in 1998 to collect baseline data, modeling of a water budget, and management planning (YSS 2001 DRAFT). Subsequent implementation will attempt to restore instream flows through lease or purchase of land with water that can be returned to streams and/or through water substitution. If lease or acquisition is not possible, the project will attempt to work with landowners to restrict surface discharge to periods when surface discharge is not limiting.

Lakes

There are no significant lakes in this watershed.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Toppenish Creek:

- **Increase instream flows downstream of Toppenish Lateral Canal**
- **Eliminate the delivery of low quality irrigation return flows to the creek**
- **Reestablish historic base flow through augmentation with high quality water**
- **Identify, prioritize, and correct fish passage barriers**
- **Reduce/eliminate construction of diversion dams to create waterfowl ponds**
- **Prioritize and install juvenile fish screening**
  - **Screen consumptive-use diversions**
  - **For non-consumptive diversions through the floodplain (such as waterfowl ponds), establish safe fish passage back to the creek, where feasible. Where fish passage cannot be feasibly established, screen the diversions.**
- **Remove dikes and other floodplain constrictions**
- **Restore hydrologic function through the stream corridor**
- **Restore riparian function, using prioritization identified by YN staff**
- **Eliminate unrestricted livestock access to channel; implement grazing management throughout the stream corridor**
- **Reduce/eliminate the flooding of waterfowl ponds during the natural low flow period**
- **Implement upland BMPs to reduce erosion of fine sediment to streams**
- **Reestablish meanders in channelized sections of Toppenish Creek**

Simcoe Creek 37.1289, NF Simcoe Creek, SF Simcoe Creek, S. Medicine Creek, Agency Creek 37. 1295, Wahtum Creek, Yesmowit Creek

General

Simcoe Creek is a left bank tributary to Toppenish Creek, entering at RM 32.7. These streams are entirely within the boundaries of the Yakama Indian Reservation. Simcoe Creek and tributaries support summer steelhead and coho (historic). There is currently no conclusive evidence of the existence of resident rainbow trout in the Toppenish Creek watershed (YSS 2001 DRAFT).

Fish Access

Simcoe Creek is diverted at the Simcoe Feeder Canal (RM 13.9), and can dry up a 4-mile reach downstream (Evenson/Lind). At the lower end of the dewatered reach, springs (¼ mile west of Wesley Rd.) maintain surface flow. Diversions were limited in 2000 and 2001 to help maintain instream flows, but there was no instream flow above the diversion point in 2001 despite some improvement in management of four private diversions upstream. The Simcoe Feeder Canal diversion was screened in 1999 (Schille), but the spillways that carry excess water in the spring are partial barriers to adult steelhead. Returning adults must swim up one of two spillways in order to ascend upstream of the diversion dam. Permanent adult passage facilities are necessary to ensure continued upstream passage of adults.

The Hoptowit diversion (~RM 1 of NF Simcoe) can divert the entire flow and dewater the creek from the diversion to the confluence with SF Simcoe from mid-June to mid-December (Evenson). The entire stream is diverted into a ditch containing a crude headworks with no means of controlling flow. A project to correct the passage problems was funded by BPA in 2001, and interim restrictions on diversion quantities were implemented by YN in 2001.

The SF feeder canal diversion is located on SF Simcoe, 0.1 mile upstream of the confluence with NF Simcoe (Evenson/Lind). There is no diversion dam, and approximately half of the flow enters the diversion ditch. The Smartlowit Ditch (RM 16.9), the Hubbard Ditch (100 yards upstream of the Smartlowit diversion), and the Miller Ditch (RM 5.1) are all unscreened, and all are presumed to entrain smolts (YSS 2001 DRAFT). The YN is currently working to resolve screening concerns on these diversions, with assistance from BPA beginning in 2001 (Schille).

There is a dam on lower Agency Creek, at the Jen Weld Mill in White Swan, which poses a passage problem at low flows. However, steelhead are known to pass the dam, as numerous redds and live spawners have been observed in Agency Creek in recent years (YSS 2001 DRAFT).

Floodplain Modifications

Most of the historic complex floodplain surrounding Simcoe Creek has been drained of historic wetlands, side-channels, and sloughs, and cleared and converted to pastures, or row crops (Evenson, YSS 2001 DRAFT). Much of the Simcoe Creek channel is moderately to severely incised and effectively disconnected from its historic floodplain, resulting in channel erosion, straightening, and simplification (G. McCoy).

Channel Condition

Overgrazing has caused extensive bank failure along most of Simcoe Creek (YSS 2001 DRAFT).

Substrate Condition

The quality of substrate in Simcoe Creek ranges from poor to extremely poor from the mouth to Olney Flat Drain (RM1.0)(CBSP 1990). Dominant particle size of the substrate in mainstem Simcoe is good, but sedimentation of gravels is poor/fair (WDFW 1998). Substrate and sedimentation in NF Simcoe are good (WDFW 1998). Substrate condition is good in Agency Creek, with sedimentation of gravels rated as fair (WDFW 1998).

Riparian Condition

Simcoe Creek has many small, fenced, private pastures. Although there are patches of very dense riparian vegetation, they are interspersed with larger areas (primarily pasture) with little or no vegetation, resulting in few reaches with extensive shade (CBSP 1990). There has not been an exhaustive riparian inventory in the Toppenish Creek watershed. However, the area of worst damage on Simcoe Creek is from the mouth to Wahtum Creek (RM 14.4)(YN Fisheries personnel, as cited in CBSP 1990). This reach rates as the second worst riparian impact to salmonids in the entirety of the Toppenish Creek watershed. Riparian condition in mainstem Simcoe is poor/fair. Riparian condition in NF Simcoe is good, although there are some impacts from grazing. Riparian condition in Agency Creek is poor in the lower part and good upstream (WDFW 1998).

Water Quality

Water quality is generally good upstream from the Wapato Irrigation Project, but is degraded downstream by project spills and return flows (Evenson/Lind). Water quality in Agency Creek is generally good, but is affected by spills from the Toppenish Lateral Canal.

Water Quantity

The entire flow of Simcoe Creek can be diverted at the Simcoe Feeder Canal diversion (RM 13.9) from mid-June to mid-December, drying up a 4-mile reach downstream to the mouth of Agency Creek (Evenson/Lind). Instream flows are generally good in NF Simcoe, except downstream of the Hoptowit diversion (~RM 1 of NF Simcoe), which can divert the entire flow and dewater the creek from the diversion to the confluence with the SF from mid-July to mid-December. Diversions to the Simcoe Feeder Canal were limited in 2000 and 2001, and the Hoptowit Ditch upstream was also controlled in 2001, to help maintain instream flows.

Flow in Agency Creek is perennial in its lower reaches, a result of irrigation return flows from the Toppenish Lateral Canal (Evenson/Lind). Both Agency and Wahtum creeks are perennial in their upper reaches, but often dry up near their mouths (YSS 2001 DRAFT). It is unclear whether this is natural or anthropogenic, perhaps being caused by the many local wells lowering the water table (Evenson/Lind). However, strategic use of stock water wells can eliminate summer diversions in some locations, and a BPA-funded project is beginning in 2001 to substitute wells for surface diversions from Simcoe Creek and its tributaries.

Lakes

There are no lakes in this watershed.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Simcoe Creek and tributaries:

- **Maintain instream flows downstream of Simcoe Feeder Canal Diversion**
- **Maintain instream flows downstream of Hoptowit Diversion on NF Simcoe; provide unrestricted juvenile passage through the bypass**
- **Prioritize and correct adult and juvenile passage at Simcoe Feeder Canal, Hoptowit, Smartlowit, Smartlowit Ditch, Hubbard Ditch, and Miller Ditch diversions**
- **Eliminate the delivery of low quality irrigation return flows to the creek**
- **Restore historic side-channel and wetland connectivity within the Simcoe historic floodplain, where possible**
- **Exclude unrestricted livestock access to Simcoe Creek; manage grazing throughout the historic floodplain**
- **Restore riparian function in impaired areas throughout the watershed, with initial emphasis on Simcoe Creek, from the mouth to Wahtum Creek**
- **Implement upland BMPs to reduce erosion of fine sediment to streams**

Marion Drain, Wanity Slough, Harrah Drain

General

Marion Drain is a 19 mile long drainage ditch for the Wapato Irrigation District (WIP), which was dug early in the 20th century to drain wetlands, and subsequently enlarged over the years to serve as a major delivery canal for WIP (YSS 2001 DRAFT). It discharges to the Yakima River at RM 82.6, 2.2 miles upstream of the mouth of Toppenish Creek. Wanity Slough is a historic side-channel of the Yakima that has been modified for irrigation. Wanity Slough historically flowed into the lower portion of Toppenish Creek, but is currently intercepted by Marion Drain, eliminating the historic connection with Toppenish Creek. Harrah Drain is a north-south extension of Marion Drain, entering Marion Drain at the western (upstream) end. Toppenish Creek water is diverted into the upper end of Marion Drain (at the junction of Marion and Harrah drains), resulting in false attraction of adult salmonids into Marion Drain, and possibly also into Wanity and Harrah drains.

It is believed that the number of salmonids that spawn and rear in Wanity Slough is currently quite small, although potential fall chinook and coho production may be significant (CBSP 1990). Marion Drain and Wanity Slough support fall chinook, summer steelhead, and coho. Harrah Drain supports fall chinook and summer steelhead. It is probable that all of the steelhead that spawn in Marion Drain are, or were, ancestrally Toppenish Creek fish, attracted by the Toppenish Creek water (YSS 2001 DRAFT).

Fish Access

A ditch running from the Toppenish Creek pump diversion on Toppenish Creek to Marion Drain was constructed in the 1970s to drain flood waters in the vicinity of the pump diversion into Marion Drain (CBSP 1990). The ditch enters Marion Drain where it merges with Harrah Drain (RM 19). The discharge from the ditch is through a large pipe that is perched about 5-feet above the water surface. The discharge of Toppenish Creek water into Marion Drain is thought to result in false attraction of Toppenish Creek origin adult salmonids into Marion Drain. Some of these fish are regularly seen attempting to jump into the pipe that carries Toppenish Creek water. In addition, this has been a site where poaching has been regularly observed. The resulting loss of fish is particularly significant when considering the depressed status of salmonids in these watersheds.

Habitat restoration and enhancement in Wanity Slough for fall chinook and coho may best be deferred until three large diversions (the Track Lateral (120 cfs), the Spencer Lateral (41 cfs), and the Lateral Four Extension (140 cfs)) are screened. As the two larger diversions take the majority of the flows, entrainment risk for juveniles spawned upstream is extreme (CBSP 1990).

Floodplain Modifications

Marion Drain and Harrah Drain are constructed agricultural drains. Although Marion Drain is an entirely artificial channel, it was excavated through the historic Yakima River/Toppenish Creek floodplain, and likely now carries water that would have otherwise entered lower Toppenish Creek. Marion Drain Road, on the south (Toppenish Creek) side of the drain was constructed atop spoil material from the drain excavation. This dike effectively redefined the northern extent of the floodplain of Toppenish Creek (G. McCoy).

Channel Condition/Substrate Condition

No information was located on channel or substrate conditions in these channels. All of the channels are actively maintained as irrigation delivery or drain conduits; resulting habitat conditions are likely poor.

Riparian Condition

There has not been an exhaustive riparian inventory in the Toppenish Creek watershed. However, the area ranked as fourth in salmonid restoration importance significance (Yakima Nation Fisheries personnel, as cited in CBSP 1990) was Wanity Slough, from the headworks to the Marion Drain outfall.

Water Quality

Marion Drain is totally fed by groundwater through the winter, and is often 10°F warmer than the mainstem Yakima (YSS 2001 DRAFT). Accordingly, emergence occurs several weeks earlier for Marion Drain salmon, ranging from mid-February for eggs deposited by early spawners (mid-October) to late-March for late spawners (mid-November). USGS water quality sampling for pesticide presence in August 1999 detected the presence of 9 pesticide compounds in Marion Drain at Granger (Ebbert and Embrey 2001).

Wanity Slough is plagued by low dissolved oxygen (DO) concentrations in the summer. Fretwell (1979) found DO to fluctuate from 10.8 ppm (1400 hours) to 5.6 ppm (0600 hours), and theorized that DO probably drops to <5.0 ppm during warm/hot summer months (CBSP 1990). He attributed the diel fluctuation in DO to photosynthesis and respiration, and believed that luxuriant plant growth in Wanity Slough was stimulated by elevated nutrient concentrations, combined with the relatively clear water of Wanity Slough, the cobble substrate, and a large surface area to volume ratio. The mean nitrate (including nitrite) concentration was 1.4 ppm, and the mean total phosphorous concentration was 0.12 ppm. Lower Wanity Slough receives point source effluents from fruit and vegetable processing plants and a meat packing plant, has illegal discharges of domestic sewage, as well as a significant non-point input attributable to cattle grazing in and alongside the channel. These effluents stimulate algal growth and also generate a biological oxygen demand of their own.

Water Quantity

As much as 100 cfs of irrigation water (middle Yakima water diverted at Wapato Dam, with a considerable component of Toppenish Creek water) is released in Marion Drain, attracting spring chinook and steelhead homing to other areas of the Yakima watershed.

The six years (during the period 1983-2000; 1984, 1990, 1994, 1995, 1996, 1998) with the lowest fall chinook production rates (Yakima and Marion Drain combined spawning, upstream of Prosser Dam) encountered very high water, and presumably some extent of redd scouring during incubation (YSS 2001 DRAFT). It is speculated that flows of the magnitudes experienced in these years would not likely have caused the same extent of scour historically, when the river energy was able to expand laterally over a broad floodplain.

Lakes

There are no lakes in the Marion Drain watershed.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Marion and Harrah drains and Wanity Slough:

- **Eliminate/reduce the diversion of Toppenish Creek and upper Yakima surface and sub-surface waters to Marion/Harrah Drain.**
- **Reconnect Wanity Slough to lower Toppenish Creek, restore hydrology of springbrooks in lower Toppenish Creek**
- **Install screening at water diversions on Wanity Slough**
- **Implement upland BMPs to reduce nutrient loading and erosion of fine sediment to streams/drains**
- **Restore riparian function along entirety of Wanity Slough**

Granger Drain

General

Granger Drain originates in the low hills approximately 8 miles east of the town of Granger, entering the left bank of the Yakima River at RM 83.0. From Liberty Road to the confluence with the Yakima River, Granger Drain flows through irrigated land and along the railroad. Land use in the lower section is mostly urban as the drain passes through the town of Granger. Overall, Granger Drain is characterized by silt and sand substrate and an artificially constrained channel. There is likely some salmonid rearing utilization in the lower several hundred feet of Granger Drain, but the primary importance of Granger Drain is the impact to water quality in the Yakima River.

Fish Access

Fish access is naturally limited to the lower several hundred feet of Granger Drain. There is no intent or desire to promote salmonid habitat upstream within Granger Drain (Visser). Granger drain is not accessible upstream of the City of Granger due to seven road culverts within the city (Monk).

Floodplain Modifications

The middle and upper reaches run near or along Interstate 82 and the railroad resulting in a channelized ditch with little or no sinuosity. Portions of the main section of Granger Drain were originally excavated to drain the wetlands that the railroad passed through.

Channel Condition/Substrate Condition

The lower several hundred feet of Granger Drain is low gradient, and may provide some utilization for salmonid rearing. The gradient increases significantly upstream, as the stream passes through the town of Granger. Upstream of the town of Granger, the stream gradient is low.

In general, Granger Drain has a gradient of approximately 0.4%, and is dominated by glide habitat. Pool habitat is limited, with pool presence estimated at 18% (Romey and Cramer 2001).

Through the town of Granger, the channel is very confined, with numerous undersized culverts that have created scour pools downstream of the culvert. Upstream of the town of Granger the substrate is composed of fine silts only.

Granger Drain is an artificially constructed drain channel, which is incised and lined with silt; there is no gravel or rock in this area (Perala). Both the percentage that fines compose of the substrate (categories of silt and sand combined), and the percentage that gravels in the riffles were embedded, were often in the range that severely impairs egg incubation and juvenile rearing (Romey and Cramer 2001). Embeddedness was measured in the riffles, because that is where drifting invertebrates (food for salmonids) would be produced, where some spawning would occur, and where water velocity would keep gravels cleaned in a productive stream. Fines composed 45%-100% of substrate in every reach of Moxee, Granger and Sulphur drains. Embeddedness in the few riffles present averaged 46% in Granger Drain. Further, the frequency

distribution of embeddedness observed in individual riffles indicated that about one third of the riffles in Granger Drain were over 50% embedded. The percentage of fines and embeddedness were similarly high in all of the lateral channels. These data indicate that the amount of fines and embeddedness within Granger Drain would effectively prevent any meaningful production of salmonids.

Riparian Condition

Riparian condition is generally poor. Granger Drain has been actively managed by the irrigation community as an agricultural drain, with active removal of trees or shrubs.

Water Quality

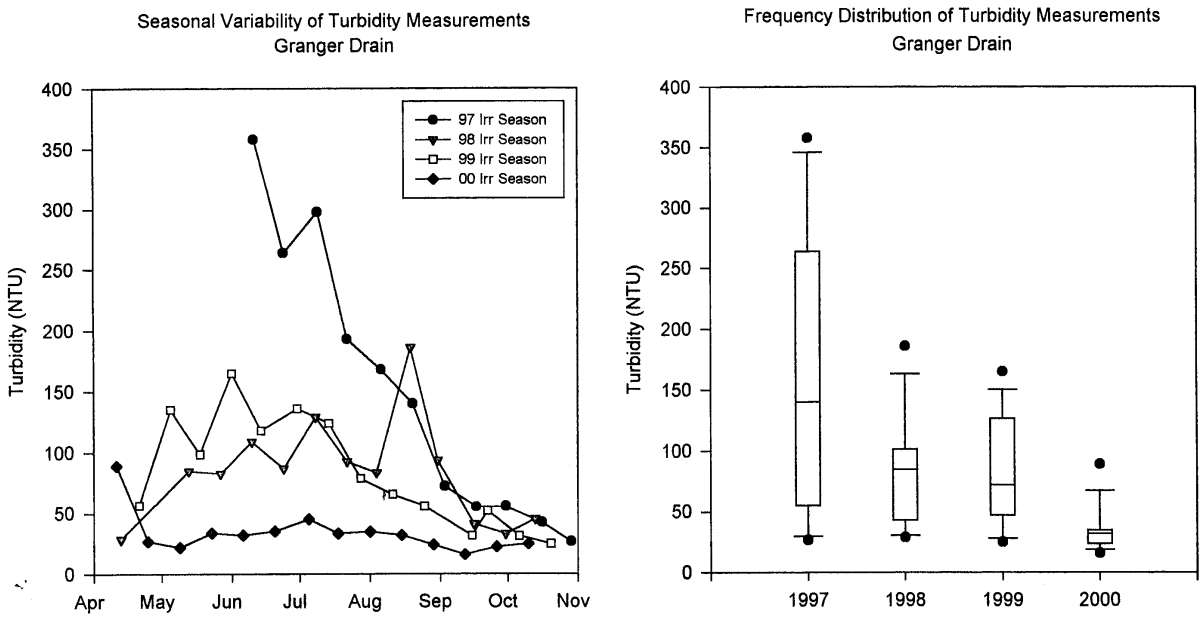
Water quality is the major habitat issue of concern in Granger Drain, which is on the 303(d) list for impaired water quality for the following: 4,4'-DDD, 4,4'-DDE, Ammonia-N, DDT, Dieldrin, dissolved oxygen, Endosulfan, fecal coliform, pH, and temperature. Most sampling has occurred in the vicinity of the mouth, and therefore likely affects water quality in the mainstem Yakima River downstream. In 1995, water samples were analyzed for 46 pesticides at Granger Drain, Spring Creek, Sulphur Creek, and the Yakima River at Euclid Bridge as part of Ecology's TMDL evaluation (Joy and Patterson 1997, as cited in BOR 2000). Organochlorine, organophosphate, and nitrogen-containing pesticides were frequently detected at all sites. Total DDT was detected above the human health and aquatic life chronic toxicity criteria at all sites on three or more sampling dates. One sample collected at Granger Drain contained twice the previous high concentration of t-DDT detected since 1968. USGS water quality sampling for pesticide presence in August 1999 detected the presence of 12 pesticide compounds in Granger Drain at Granger (Ebbert and Embrey 2001).

Dense growths of filamentous green algae (*Cladophora*) were observed in Granger Drain by Cuffney et al. (1995), but abundance was probably underestimated by the sampling method used in the study. *Cladophora* and related filamentous green algae are important indicators of phosphorous and nitrogen enrichment, and are typically viewed as an aesthetic nuisance and indication of water quality degradation. Because the sampling procedures underestimated this group, the influence of agricultural sources of nutrients on algal communities also may have been underestimated.

A sediment budget was developed for the lower Yakima River, because of the link between TSS and pesticide residues (Joy and Patterson 1997, as cited in Snyder and Stanford 2000 DRAFT). Results indicated that in 1995, inputs from tributaries and irrigation returns contributed a significant quantity of the sediment load of the Yakima River. The estimated TSS contribution during the irrigation season from Granger Drain was estimated to be 60 tons/day. Please refer to the Yakima mainstem water quality section for a discussion of the TMDL recommendations to reduce the effects of agricultural runoff. Reductions in turbidity and TSS in Granger Drain since the implementation of the TMDL are shown in Figure 44. Sediment loading has been reduced from 100 tons/day in 1995 to 16 tons/day in 2000 (Perala).

Granger Drain was characterized as having very low total benthic invertebrate richness (<15 taxa) and very low EPT richness (<6 taxa) with no stonefly taxa (Cuffney et al. 1997). These low total and EPT benthic invertebrate richness are indicative of the effects of intensive agriculture as indicated by the NPAI and pesticide indices.

Figure 44: Turbidity reductions in Granger Drain in recent years (courtesy of Perala)



Water Quantity

Granger Drain is likely a highly modified natural drainage system, although it probably carried only spring/storm runoff prior to irrigation. Granger Drain is not a wasteway, but is fed primarily by irrigation return flows. There are potential benefits associated with reducing the return flows through Granger Drain.

Lakes

There are no lakes in the Granger Drain watershed.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Granger Drain:

- **Implement upland BMPs to reduce nutrient loading and erosion of fine sediment**
- **Develop policy on salmonid access** *(additional action recommendations differ depending on utilization goal)*

Moxee Drain

General

Moxee Drain is located southeast of the City of Yakima, entering the left-bank of the Yakima River at RM 106. The Moxee Drain watershed is 97,000 acres in size, with 19,000 acres irrigated (NYCD). Land use throughout this drain is primarily agricultural. Moxee Drain has no significant tributaries. Moxee Drain is a historic natural drainage that has been highly modified

to function as a drain for adjacent agricultural lands. Preliminary electroshocking in the lower 0.5 miles of Moxee Drain found rearing coho and steelhead (Harvester); chinook, coho, and steelhead rearing is presumed from the mouth to the edge of the Yakima floodplain near Birchfield Road, based on stable flows and water quantity, particularly through the winter (NYCD). It is unknown whether the historic distribution of these species may have extended further upstream.

Fish Access

Moxee Drain is accessible up to about Birchfield Road, where a 0.6m high concrete weir restricts fish access (Romey and Cramer 2001). Outside the irrigation season, Moxee Drain is fed by springs, providing warm clear water through the winter.

Floodplain Modifications/ Channel Conditions

In general, Moxee Drain has a gradient of approximately 0.4%, and is dominated by glide habitat. Pool habitat is limited, with pool presence between Granger Drain (18%) and Sulphur Drain (10%)(Romey and Cramer 2001).

The current channel configuration of Moxee Drain is significantly incised in comparison to the historic natural channel or original excavated drain (NYCD), with the bottom 10-15 feet lower than natural creeks in the area (Perala). Although the channel is incised, the width of the hydraulic floodplain is probably similar to historic condition, as spring-fed flows were very stable and likely did not create a wide floodplain except near the confluence with the Yakima (NYCD). Rain-on-snow floods over frozen ground in 1959 and 1970 (a major impact from the 1970 flood occurred in the vicinity of the SR 24-Beane Road intersection (NYCD, Perala)) caused extensive channel downcutting of approximately 20 feet, also widening the channel bottom above the Yakima River floodplain. The deep channel incision across the Yakima River floodplain likely intercepts hyporheic flow, adversely impacting Yakima River and Moxee Drain floodplain function through this reach. A meander channel has since formed in the bottom of the incised channel, with spawning gravels (heavily embedded with fine sediment), pools, and riffles. The resulting channel is generally stable. Pools are associated with bedrock sills that cross the channel bottom. Willows have grown along the meandering channel in the bottom of the incised ravine; there are landowner concerns that the presence of willows impedes the capability of Moxee Drain to effectively carry peak flows and may contribute to further bank sloughing.

The U.S. Bureau of Reclamation is in the process of attempting to acquire ~200 acres of Yakima River floodplain in the reach from Union Gap to Selah Gap (Tracy Yerxa, BOR). The lower portion of Moxee Drain, located in the Yakima River floodplain, is included as part of this proposed acquisition.

Substrate Condition

There are pockets of substrate spawning gravels, although they are heavily embedded with fine sediment. In the lower sections of Moxee Drain, on the floodplain of the Yakima River, the channel meanders and has a substrate of cobble and gravel with some fines. Where the channel flows through agricultural areas, it is channelized, meanders less, and has a substrate dominated by silt, sand, and some hardpan (Romey and Cramer 2001). Both the percentage that fines compose of the substrate (categories of silt and sand combined), and the percentage that gravels in the riffles were embedded were often in the range that severely impairs egg incubation and juvenile rearing. Embeddedness was measured in the riffles, because that is where drifting

invertebrates (food for salmonids) would be produced, where some spawning would occur, and where water velocity would keep gravels cleaned in a productive stream. Fines composed 45%-100% of substrate in every reach of Moxee, Granger and Sulphur drains. Embeddedness in the few riffles present averaged 32% in Moxee Drain. Further, the frequency distribution of embeddedness observed in individual riffles indicated that about one third of the riffles in Moxee Drain were over 50% embedded. The percentage of fines and embeddedness were similarly high in all of the lateral channels. These data indicate that the amount of fines and embeddedness within Moxee Drain would effectively prevent any meaningful production of salmonids (Romey and Cramer 2001). Fine sediment entry has been reduced in recent years, but resulting changes to substrate condition have not been monitored (NYCD).

Riparian Condition

Riparian condition is poor to non-existent (NYCD). Although there is some water shading from the banks and grasses, Moxee Drain has been actively managed by the irrigation community as an agricultural drain, with active removal of trees or shrubs that may impair ability to carry peak storm flows.

Water Quality

Water quality is impaired in Moxee (Birchfield) Drain, with CWA Section 303(d) water quality impairment listings for 4,4”-DDD, 4,4”-DDE, Chlorpyrifos, DDT, Dieldrin, dissolved oxygen, Endosulfan, fecal coliform, pH, and temperature. The USGS has also documented presence of Diazanon in Moxee Drain (Yakima Valley Council of Governments 1994, as cited in Tri-County 2000). USGS water quality sampling for pesticide presence in August 1999 detected the presence of 7 pesticide compounds in Moxee Drain (Ebbert and Embrey 2001).

Dense growths of filamentous green algae (*Cladophora*) were observed in Moxee Drain by Cuffney et al. (1995), but abundance was probably underestimated by the sampling method sued in the study. *Cladophora* and related filamentous green algae are important indicators of phosphorous and nitrogen enrichment, and are typically viewed as an aesthetic nuisance and indication of water quality degradation. Because the sampling procedures underestimated this group, the influence of agricultural sources of nutrients on algal communities also may have been underestimated.

Moxee Drain was characterized as having very low total benthic invertebrate richness (<15 taxa) and very low EPT richness (<6 taxa) with no stonefly taxa (Cuffney et al. 1997). These low total and EPT benthic invertebrate richness are indicative of the effects of intensive agriculture as indicated by the NPAI and pesticide indices.

A sediment budget was developed for the lower Yakima River, because of the link between TSS and pesticide residues (Joy and Patterson 1997, as cited in Snyder and Stanford 2000 DRAFT). Results indicated that in 1995, inputs from tributaries and irrigation returns contributed a significant quantity of the sediment load of the Yakima River. The estimated TSS contribution during the irrigation season from Moxee Drain was estimated to be 35 tons/day. Please refer to the Yakima mainstem water quality section for a discussion of the TMDL recommendations to reduce the effects of agricultural runoff. Of note is that the estimated TSS contribution from Moxee Drain was higher than from the Naches, even though discharge in the Naches is 14 times greater.

Significant reductions in turbidity and TSS have been realized in recent years, as a result of revision of on-farm irrigation practices (NYCD). Of the 19,000 irrigated acres, 7500 were furrow irrigated in 1994; 6271 of these acres have been converted from furrow to drip irrigation. Table 28 shows the reductions in turbidity and TSS load that have been achieved during the irrigation season (April-September) from 1994 to 2000. Mean turbidity measurements meet the TMDL goals, although maximum turbidity measurements indicate remaining reductions need to be achieved.

Table 28: Irrigation-related sediment delivery reductions in Moxee Drain (NYCD)

Year	Mean Turbidity (NTU)	Max. Turbidity	Min. Turbidity	Sediment Delivery (tons/day)
1994	41.9	120	6.8	24
1995	23.1	78	3.5	24.5
1996	33.0	86	4.2	37.3
1997	28.5	54	6.1	29.0
1998	22.1	57	7.4	17.4
1999	26.1	45	5.5	14.1
2000	18.1	32	7.3	9.3

Water Quantity

Irrigated acreage in the Moxee Drain watershed is served by five irrigation delivery ditches (Roza Canal, Selah-Moxee Canal, Moxee Canal, Hubbard Ditch, and Union Gap/Fowler Ditch) and some wells in the upper portion of the drainage. Baseflows in Moxee Drain generally range from 7-13 cfs, increasing to 50-65 cfs (primarily operational spill) during the irrigation season (NYCD). Although there have been significant on-farm water savings with conversion from rill to drip irrigation in this drainage, these savings don't translate to instream flow benefits in either Moxee Drain or the Yakima River due to delivery system limitations that don't allow the delivery canals to effectively function at reduced flows.

Lakes

There are no lakes in this system.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Moxee Drain:

- **Continue implementation of upland BMPs to reduce nutrient loading and erosion of fine sediment**
- **Modify irrigation delivery systems to be able to transfer on-farm water savings to instream flow**
- **Restore hyporheic/floodplain function where Moxee Drain flows across the Yakima River floodplain**
- **Restore riparian function throughout watershed**
- **Develop policy on salmonid access, particularly in the reach located on the bench above the Yakima River floodplain** *(additional action recommendations differ depending on utilization goal*

Ahtanum Creek 37.1382, NF Ahtanum Creek, SF Ahtanum Creek, MF Ahtanum Creek, Foundation Creek, Nasty Creek

General

Ahtanum Creek is a right bank tributary to the lower Yakima River, entering at RM 106.9. Ahtanum Creek is 46 miles in length, including the NF (CBSP 1990). The NF and SF merge to form Ahtanum Creek at RM 23.1; the NF is 23 miles long, and the SF is 15 miles long (CBSP 1990). Salmonids are present in at least 50 miles of SF, MF, and NF Ahtanum Creek and tributaries (DNR 2001, Ahtanum Landscape Planning Area Map; as cited in YSS 2001 DRAFT). Ahtanum Creek forms the northern boundary of the Yakama Reservation. The primary land use in the lower Ahtanum (downstream of Tampico) is agriculture (WDFW 1998). There is considerable housing and industrial development taking place along the lower mainstem (YSS 2001 DRAFT). The Ahtanum Creek watershed, upstream of the forks, includes state-owned (DNR) lands and commercial timber company holdings. Predominant land uses in the upper watershed include forestry, livestock grazing, and outdoor recreational activities. Low elevation riparian areas are easily accessible, roads are built close to streams, and some riparian areas have been logged (DNR 1997, as cited in Tri-County 2000). Overall, habitat conditions in the Ahtanum watershed are in a disturbed state, although some stable, healthy channel segments or reaches can be found in NF and MF Ahtanum (Dominguez 1997). The presence of these stable sections provides examples for recovery potential of the disturbed channels.

Ahtanum Creek supports spring chinook, coho, summer steelhead, and bull trout, as well as other resident salmonid species and non-salmonids (WDFW 1998). Although bull trout are present in mainstem Ahtanum Creek, they are probably more abundant in the upper portion of the drainage, particularly in the NF, MF, and SF, where habitat conditions are more favorable (USFWS 2001 DRAFT). However, even in the upper drainage, bull trout abundance appears to be at an extremely low level. Coho and steelhead spawn and rear in Ahtanum Creek, while spring chinook use the lower portion as rearing habitat. Except for passage and flow problems associated with water diversions from Tampico downstream, Ahtanum Creek would likely be a major steelhead producer (CBSP 1990). Historic letters from the Ahtanum Mission in 1853 and 1855 indicate that substantial numbers of salmon (most likely spring chinook, based on date of the letter) returned to upper Ahtanum Creek (upstream of RM 20) to spawn (Tuck 1993).

Surveys of the Ahtanum by USFWS in the fall of 1935 documented channel gradient as slight to moderate, with a large amount of mud and sand in the lower 8.5 miles (USFWS 1950, as cited in Tri-county 2000). The low concrete diversions to Hatton and Bachelor creeks were already present; a total of 23 irrigation diversions were mentioned, many with 3-4 foot high dams without fishways or fish screens, creating fish passage barriers at low flows and downstream juvenile migrant losses. An additional 33 unscreened diversion were identified on Hatton Creek, and 38 diversions on Bachelor Creek. NF Ahtanum Creek was surveyed in November 1935. It was noted as sluggish in the lower 3 miles and flowed through several channels with occasional beaver dams. Flows ranged from 12 to 45 cfs, with spring runoff flows of 125-175 cfs. The upper reaches of NF Ahtanum had good riffles with suitable spawning area. There were 5 unscreened diversions and 1 low (4-foot) diversion dam that was a barrier during low flow. Resident rainbow and cutthroat were reported, but the NF was considered inaccessible to anadromous salmon due to fish passage barriers. SF Ahtanum Creek was also surveyed in November 1935. The stream gradient was fairly uniform with many small riffles. Flows ranged from 5 to 20 cfs, with spring runoff flows of 90 cfs. There were 6 unscreened diversions, two of

which were brush dams considered passable by fish. Many of the diversions on the NF and SF likely no longer exist; only three irrigators (Herke, Bates, and one other) are known to currently be operating (NYCD). Although irrigation barriers were noted in the lower 2 miles of SF Ahtanum in the 1935 survey, no barriers are known to currently exist in lower SF Ahtanum (NYCD).

Fish Access

Fish passage has been a long-standing problem in Ahtanum Creek. In a letter from the Ahtanum Mission (RM 20) in 1855, it is stated: "The Attanem dam, since the month of January, has remained without fish. … The ambassador arrived saying that he saw the dam near the mouth of the river, and that the people didn't try to hide it from him" (Tuck 1993). Many miles of good to excellent habitat for steelhead, coho, and spring chinook are unused in Ahtanum Creek because of relatively easily correctable fish passage problems (CBSP 1990). There are 13 unscreened diversions on Ahtanum Creek, 15 unscreened diversions on Hatton Creek, and nine unscreened diversions on Bachelor Creek (Schille)(Table 29). In addition, the Upper Wapato Irrigation Project facility at RM 19.6 diverts all or most of the stream flow from July 10 through mid-October, drying up the natural streambed downstream for 7-8 miles, precluding adult salmonid access to high quality spawning habitat upstream (WDFW 1998, CBSP 1990). The lower Wapato Irrigation Project diversion (RM 9.8, near the community of Ahtanum) is a total passage barrier to migrating adult salmonids (CBSP 1990). WIP reduced their water diversion, at least temporarily in 2000, due to steelhead ESA concerns, but long-term fish passage status has not been resolved (YSS 2001 DRAFT). Adult passage is typically only possible from November (when winter storm runoff begins) through May (when irrigation diversions are activated and spring runoff subsides)(YSS 2001 DRAFT).

The natural floodplain of lower Ahtanum Creek has been highly modified. Concrete dams at RM 18.9 and 18.2 diverted flow into prior natural left-bank high water side-channels named Bachelor Creek and Hatton Creek, respectively, which now serve as irrigation conduits for the Ahtanum Irrigation District during the irrigation season (NYCD). As water was shifted between these three channels, one or more of the streambeds was frequently dry. There are numerous pumps and gravity ditches that divert water from these "creeks" during the irrigation season (April 15-July 10). The diversions into Bachelor and Hatton Creeks were merged in 1994 at the diversion site for Bachelor Creek, the old diversion to Hatton Creek eliminated, and Hatton Creek linked to Bachelor Creek via a 500-foot long enclosed pipe. Bachelor Creek is screened at the diversion site, and both channels have barriers at the downstream end to prevent anadromous salmonid entry into the channels (prevents entry of juvenile and adult salmonids except during peak flows in Ahtanum Creek, which can backwater or overflow over the exclusion structures at the lower end (NYCD)). The fish screens and barriers were designed by USBR and WDFW in cooperation with YN, NMFS, and others. This screening approach was done as an alternative to having to screen each of the numerous small irrigation diversions from Bachelor (9 diversions) and Hatton (15 diversions) creeks. NMFS has identified the desire to restore salmonid access and rearing in these historic side-channels, provided that sufficient flows can be maintained to avoid fish stranding and mortality. Restoration of access and rearing would also require screening of all of the individual irrigation diversions from these two creeks.

There are three diversions on NF Ahtanum; the John Cox diversion (~13 cfs) is located at RM 3, the Shaw-Knox ditch (~2 cfs) is located at RM 2, and the location of the Lesh Ditch was not available. The John-Cox Ditch is screened; the Shaw-Knox and Lesh ditches are thought to be unscreened (NYCD). There is one diversion (upper WIP, ~2 cfs) on SF Ahtanum at RM 3 (CBSP 1990); screening status is unknown.

The Shellneck Creek Road crossing on Shellneck Creek has inadequately sized culverts to pass peak flows and limits upstream migration, particularly for bull trout (USFWS 2001 DRAFT).

Table 29: Irrigation diversions in Ahtanum Creek watershed (data courtesy of WDFW)

Diversion #	T-R-S	1/4 Section	Name	Creek*	Acres Served	Flow (cfs)
1	18-12-02			A	50	1
2	18-12-02			A	21.4	0.4
3	18-12-02			A	14.8	0.3
4	18-12-04			A	13.4	0.3
5&6	18-12-04		Shropshire Ditch	A	237.9	4.8
13	17-12-15			A	100	2
14	17-12-16			A	514	10.3
15	17-12-16			A	40.8	0.8
21	17-12-17		Wilkinson Diversion	A	Screened	
23	16-12-13		Bachelor Creek	A	Screened	
24&25	16-12-14		Herke Ditchs	A	80	1.6
26	16-12-15		Herke Ditchs	A	50	1
27	16-12-16		Lesh Ditch	A	145	2.9
31	16-12-17			A NF	60	1.2
35	15-12-12		John Cox Ditch	A NF	Screened	
36	16-12-07		Shaw Knox Ditch	A NF	175	3.5
37	18-12-08			H	51.8	1
40	18-12-07	NW1/4NW1/4		H	67.6	1.4
50	17-12-11	NW1/4SW1/4		H	57.4	1.1
51	17-10-10	NE1/4SE1/4		H	74.5	1.5
58	17-12-09	SE1/4SW1/4		H	63.7	1.3
62	17-12-17	NE1/4NE1/4		H	127.5	2.6
63	17-12-17	NE1/4NE1/4		H	12.2	0.2
66	17-12-17	NE1/4NW1/4		H	30.9	0.6
68	17-12-18	NE1/4NE1/4		H	33.8	0.7
69	17-12-18	NE1/4NE1/4		H	31.7	0.6
70	17-12-18	SW1/4NE1/4		H	133.2	2.7
71	17-12-18	SE1/4NW1/4		H	15.8	0.3
72	17-12-17	SE1/4NW1/4		H	27.6	0.6
73	16-12-13			H	21.3	0.4
74	16-12-13	SW1/4NE1/4		H	76.4	1.5
90	17-12-10	SWE1/4NW1/4	Hugh Bowman Ditch	B	587.4	11.7
96	17-12-12	NW1/4NW1/4		B	60.9	1.2
97	17-12-12	NW1/4NW1/4		B	26	0.5
99	17-12-12	NW1/4NWE1/4		B	31.7	0.6
104	18-12-05	NW1/4SW1/4		B	5.7	0.1
110	18-12-04	NE1/4SE1/4		B	44.5	0.9
115		Spring Creek Water		B		
116	18-12-02			B	8.8	0.2
117	18-12-01	SE1/4NW1/4		B	105.6	2.1

* A = Ahtanum Creek, A NF = NF Ahtanum, B =Bachelor Creek, H = Hatton Creek

Floodplain Modifications

Lower Ahtanum Creek is heavily diverted, diked, and straightened (WDFW 1998). Stream channels on lower Ahtanum Creek have been altered to accommodate agricultural development and associated irrigation delivery (Tri-County 2000). Extensive areas along lower Ahtanum Creek have been diked. Several reaches are confined by agricultural fills, and several reaches have lost floodplain connectivity. Housing and recreational facilities within the channel migration zone occur in the lower segments of NF and MF Ahtanum creeks, confining channels and resulting in the failure of channels to naturally respond to recovery from channel disturbances (Dominguez 1997).

Most of the moderate and steep gradient mainstem channels are confined or moderately confined, a configuration that does not provide adequate floodplain, side-channel, and low-gradient habitat (YSS 2001 DRAFT). Many of the channels in the upper Ahtanum have been impacted by significant debris torrents (Dominguez 1997). In the last 30 years, there have been 16 debris torrents in upper NF Ahtanum, 4 in lower NF Ahtanum, 1 in upper MF Ahtanum, and 1 in lower Foundation Creek. Naturally–occurring dam-break flood effects have been exacerbated by increased fine and coarse sediment input provided from roads constructed within the floodplain.

Floodplain reaches that appear to be crucial to the long-term survival and recovery of salmon in the Yakima watershed have been evaluated and ranked based on natural habitat heterogeneity, productivity, current and historic use by anadromous salmonids, and restoration potential (Snyder and Stanford 2000 DRAFT). The middle portion of Ahtanum Creek, from the confluence of the NF and MF to ~10 km downstream, was identified for conservation actions (ranked 8th in the overall Yakima watershed prioritization). This floodplain reach has channel features that suggest extensive alluviation and a variety of springbrooks are present in the lower portion. However, riparian condition is poor, and further inspection is needed before it can be considered a key restoration site.

Channel Condition

The Ahtanum Watershed Analysis (Chesney 1997) identified the following channel concerns in the Ahtanum Creek watershed: 1) extensive bank erosion (often severe and continuous) throughout the assessment area, continuing to mobilize and transport a variety of coarse and fine sediments, 2) a reduction and fragmentation of mature conifer overstories in riparian vegetation, 2) a corresponding decrease in canopy, 3) an increase in floodplain residential development (particularly on NF Ahtanum from the MF Ahtanum to Nasty Creek), 4) an increase in logging of forested riverine wetlands and changes in plant composition, 5) relative stability of channel position on the floodplain (some sinuosity increase in NF Ahtanum), and 6) use of the stream channels as logging skid trails along steep tightly confined channels in 1949 photos.

LWD is lacking throughout the mainstem channel segments in the Ahtanum (Chesney 1997, Dominguez 1997). The lack of LWD that forms pools, sculpts the bed, stabilizes bars, retains and sorts sediments, roughens the bed, resists flows, and creates hydraulic complexity is contributing to a dominance of plane-bed morphologies. LWD abundance has been decreased by selective removal of large trees from riparian areas and removal by flood or by humans. Reduced complexity, resulting from deficiency in LWD presence, increases the risk of debris torrents that scour the channel, removing gravel from spawning areas. Debris flows and dam break floods have occurred in the Ahtanum and have most often been associated with extreme runoff events .

Substrate Condition

Substrate condition is highly variable throughout due to chronic sources of sediment from roads and logging in the upper watershed, and grazing and residential development in the lower watershed. In addition, there is a large amount of bedload movement. The gradient in the lower 8-9 miles is slight to moderate, and bank sloughing from overgrazing has caused the deposition of a large amount of sand and mud (CBSP 1990).

The upper forested areas of Ahtanum Creek experience chronic sedimentation from road runoff and road encroachment on stream channels, which accelerates erosion rates during peak flow events (Chesney 1997). Pool margins and streambed gravels are negatively affected by presence of fine sediments. The movement of coarse and fine sediment has increased over time, as sediment-mobilizing flows are more common as channels evolve to plane-beds. The channel bed surface has become more susceptible to scour and fill events. After three of the century's highest flow events (1/15/74, 12/2/77, and 2/8/96), coupled with decreasing channel roughness, rates of fluvial sediment transport (washload, suspended load, bedload) is likely exceeding rates of storage. The fragmentation and loss of dense, mature conifer overstories has increased the erosiveness of unconsolidated materials forming banks and floodplains, and channel abandonment and migration. Spawning gravel quantity was rated as infrequent or absent through every surveyed segment surveyed in the Ahtanum Watershed Analysis (Dominguez 1997). Observations of the channel banks, floodplains, and headwater tributaries indicate an abundant supply of spawning-sized gravel (<3" diameter) within the system. However, these particle classes have very short residence times through transport reaches due to the lack of LWD. The magnitude and frequency of peak flow events is likely increased by road runoff and timber harvest in the upper watershed. Roads, road crossings, and grazing are sources of fine sediment delivery to forested streams in NF Ahtanum and MF Ahtanum. Culverts in this area have failed due to large volumes of road fill that were washed into the channel downstream. Livestock impacts include overgrazing of meadows, stream bank instability, and in-stream damage to spawning areas. Chronic fine sediment and excessive sedimentation have negatively affected spawning areas. Lower reaches experience bank sloughing that is aggravated by increased peak flows (Tri-County 2000). NF Ahtanum Road near Shellneck Creek is immediately adjacent to lower Shellneck Creek and contributes fine sediment and loss of riparian function (USFWS 2001 DRAFT). Shellneck Creek Road delivers fine sediment to Shellneck Creek from the road approaches and water running down/across the road crossing. Upper SF Ahtanum Road culverts are inadequately sized to pass peak flows (future loss of road fill) and fine sediment is delivered from the road approaches.

Moderate to high levels (15-25%) of fines (<0.85mm) were found in some sample reaches of the upper NF and SF, with the highest stream average of 25% fines (n=9) in SF Ahtanum (Bambrick and Matthews 1990, as cited in Dominguez 1997). McNeil gravel samples taken in 1991 in the MF and SF Ahtanum found that fines ranged between 20-25%, a concern for salmonid habitat (Matthews Unpublished Data, as cited in YSS 2001 DRAFT). Although peak flows, such as the February 1996 flood, may be considered to be "gravel-cleansing" events, continued chronic sediment input from surface erosion and accelerated bank erosion due to road proximity may have minimized or negated and positive gains from gravel cleansing (Dominguez 1997). Dominguez concluded that poor instream habitat heterogeneity and excessive input of road-related sediment are indicative of a general fine sediment input problem in the Ahtanum.

Riparian Condition

Historically, riparian areas below 3000 feet were dominated with conifers with some large hardwoods along the streams (Hall 1997). Along the banks, if sufficient open canopy existed, shrubby species such as Red Dogwood (*Cornus*) were found along the streams. Periodically, beaver ponds widened the riparian area, allowing for an abundance of hardwood growth. These areas are now primarily hardwood/large/sparse where conifers were removed and a few hardwoods have survived to large size, showing adverse effects of extremely heavy livestock use. Riparian areas between 3000 and 4500 feet elevation were historically conifer, with some hardwoods adjacent to the streams. Conifers have been removed from these areas, resulting in an increase in hardwoods. Primary impacts in this zone are from past grazing and from timber harvest in the riparian zone. Several of the creeks were previously designated as Type 4, and the riparian zones were heavily logged. As a result of the Ahtanum Watershed Analysis, approximately 10 miles of stream previously typed as Type 4 or Type 5 was upgraded to Type 3 (fish bearing), warranting riparian protection on future timber harvests (Dominguez 1997). There was little change in riparian condition on streams above 4500 feet elevation (Hall 1997). Due to the sparse condition of many riparian zones, 43% and 70% of the upper Ahtanum (Darland Mtn.) and Foundation Creek, respectively, were designated as having a high LWD recruitment hazard potential. In general, the lower mainstem channel segments in the upper Ahtanum and Foundation Creek also were identified as having a high Shade hazard rating.

Riparian condition in the lower 8-9 miles (downstream of Tampico) is generally poor with some remnant patches of functional riparian vegetation; riparian condition in this area is severely impacted by grazing and residential encroachment, particularly in the lower end (NYCD). Riparian condition downstream of the WIP diversion is further impaired by the lack of instream flow, which does not provide support for riparian vegetation growth during the hot, dry summer months. There is significant residential/non-commercial hobby farm development upstream of Tampico on NF Ahtanum (to DNR ownership) and on SF Ahtanum (~ 5 miles to the YN reservation boundary). Riparian condition in this area is generally fair/poor, with impacts from residential encroachment and grazing to the edge of the stream. Further upstream on both NF and SF Ahtanum, riparian condition improves, but is impaired by reduced riparian vegetative cover from past cattle grazing, logging, and associated road networks in close proximity to riparian areas (WDFW 1998). Instream cattle presence has been observed on bull trout spawning riffles in the NF (WDFW 1998). Grazing extent has declined in the NF, with only one grazing operation currently remaining (NYCD). Excessive off-road vehicle use within riparian corridors is also a problem in some areas on the NF (WDFW 1998). In the vicinity of Tampico Park, riparian vegetation on NF Ahtanum has been largely denuded, and there was significant channelization following the 1996 flood (Perry Harvester, as cited in YSS 2001 DRAFT).

Water Quality

Ahtanum Creek is designated as Class A (excellent) waters (WAC 173.201(a)), which determines which water quality parameters need to be met. Water quality is fair downstream of Tampico, and good upstream (including the NF) (WDFW 1998). Cuffney et al. (1996), documented moderately high presence of pesticide residues and other water quality standards deficiencies in water, bottom sediments, and fish tissue. USGS water quality sampling for pesticide presence in August 1999 detected the presence of 2 pesticide compounds (*p,p'*-DDE, Chlorpyrifos) in Ahtanum Creek at Union Gap (Ebbert and Embrey 2001). Prolonged high water temperatures occur in the lower floodplain areas where shade canopy is reduced (DNR 1997). Water

temperatures in the upper headwaters reaches of Ahtanum Creek are kept cool by inflow of cool spring water sources (DNR 1997).

The condition of invertebrate communities in Ahtanum Creek was ranked as unimpaired, and as one of the highest quality sites in the watershed for benthic invertebrates (Cuffney et al. 1997). Values for disturbance and pesticides (except pesticides in fish tissue) for Ahtanum Creek are also among the lowest in the agriculturally affected portions of the Yakima watershed. These observations are somewhat surprising, as the intensity of agriculture (mostly hay and pasture (NYCD)) in Ahtanum Creek is at least 6 times that in other high ranking sites (Umtanum and Satus downstream of Dry Creek) in the lower Yakima watershed, and is slightly less than other sites that were rated as of moderate concern (Cherry, Satus at gage, Wide Hollow). For unknown reasons, the invertebrate community in Ahtanum Creek appears to be highly resilient. However, because of its proximity to the cities of Yakima and Union Gap, the entire Ahtanum valley floor is experiencing high suburban/rural development pressures (NYCD). Ahtanum Creek invertebrate community conditions could be at risk if agricultural intensity, urbanization, or pesticide contamination were to increase further, even by relatively small amounts.

Water Quantity

In the Yakima River Basin, the first recorded irrigation diversion is generally credited to Kamiakin, who diverted water from Ahtanum Creek to irrigate his garden (Lyman 1919, as cited by Tuck 1993).

Adjudication reports are not yet available from the Yakima River Water Rights Adjudication for Ahtanum Creek (Tri-County 2000). Water diversions from Ahtanum Creek are mainly associated with irrigation uses. Diversions from the south side of the creek provide irrigation waters for agricultural lands within the Yakama Reservation.

A 1936 Court Decree gave the Wapato Irrigation District the right to the entire flow of Ahtanum Creek after July 10 of every year (Tri-County 2000). The Upper Wapato Irrigation Project facility at RM 19.6 diverts all or most of the stream flow from July 10 through mid-October, drying up the natural streambed downstream for 7-8 miles (to approximately RM 12) after the first week of August (WDFW 1998, CBSP 1990). Discharge is substantial downstream of the WIP diversions from mid-October through July (outside the irrigation season)(CBSP 1990). At RM 12, groundwater and irrigation returns recharge the stream, even during the worst period of dewatering. The resulting flow of 5-10 cfs persists to the mouth (CBSP 1990). Instream flows upstream of Tampico and in the NF are rated as good (WDFW 1998).

Ahtanum Creek flows have been gaged by USGS at three locations (SF Ahtanum near Tampico, Ahtanum Creek at Tampico, and at Union Gap)(Tri-County 2000). Records are not continuous for any of these locations. The flow record at Union Gap (Table 30) includes periodic measurements from the early 1900s, a short record in the 1950s, and a continuous record from 1961 to present.

Table 30: Average Monthly Flows (cfs) in Ahtanum Creek at Union Gap (from Tri-County 2000, based on USGS monthly discharge statistics 1904-1979)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
21.7	32.9	60.3	87.6	114.0	128.0	137.2	176.5	147.3	37.8	16.9	20.3

Instream flow recommendations were developed in the mid-1980s (see Instream Flow section at beginning of this chapter), but the TAG does not support implementation of those recommendations at this time. Instream flows recommended by USFWS (Simmons affidavit) generally represent the entire flow of the creek, with numerous years where the natural flow was much less (Perala). Rather, the TAG supports development and implementation of a normative flow regime that combines "the goal of sustaining ecological integrity of the watershed, while also maximizing use of water resources by humans" (SOAC 1999).

There is a proposal to build an off-stream storage reservoir in Pine Hollow (YSS 2001 DRAFT). Water would be diverted at the John Cox diversion on NF Ahtanum. Potential uses would include irrigation supplementation from mid-summer through the fall when flows are low, and improvement of instream flow for fish and habitat. A major component of the proposal would be to use a portion of the diverted water for instream flows, when needed, to benefit fish. Study efforts are underway to determine if the reservoir proposal can provide benefits for fish and wildlife.

An Ahtanum Creek Watershed Assessment was inaugurated in 1999 (YSS 2001 DRAFT). Analysis of the data will determine how water use and riparian management in lower Ahtanum Creek may be limiting production of anadromous salmonids in the watershed, as well as determining the most effective means for fish restoration.

Lakes

There are no lakes in this watershed.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Ahtanum Creek:

- **Prioritize and correct identified fish passage barriers and install fish screens on unscreened water diversions**
- **Restore instream flows downstream of the upper WIP Diversion dam (RM 19.6)**
- **Develop and implement stable flow regimes for channels downstream of irrigation diversions; reestablish adult and juvenile fish access**
- **Assess protection/restoration potential of alluviated floodplain reach from confluence of NF and SF downstream for ~10 km**
- **Ensure that channel effects and pesticide contamination from agriculture (primarily non-commercial) and residential development are not increased within the watershed**
- **Restore riparian function throughout watershed**
- **Implement a comprehensive grazing program to protect riparian vegetation and streambank stability (particular areas of concern include downstream of Tampico and in forested riparian areas)**
- **Develop and implement road management plans for the upper watershed that reduces fine sediment delivery and accelerated water delivery during storm events**
- **Develop and implement a short-term LWD strategy for the MF and NF, to provide LWD presence and habitat diversity until riparian function is restored**

Wide Hollow Creek 37.1400

General

Wide Hollow Creek is a right bank tributary to the lower Yakima River, entering at RM 107.4. The watershed is approximately 22 miles in length (CBSP 1990). The stream flows along the southern edge of Union Gap and Yakima. Wide Hollow Creek suffers many of the problems associated with urban streams, including stormwater runoff, leaking septics, and agricultural practices (mostly hay and pasture) (WDFW 1998). Wide Hollow Creek supports spring and fall chinook rearing, coho, and summer steelhead, as well as other resident salmonids and non-salmonids. Coho spawning has been observed (Eric Anderson, as cited in WDFW 1998), and chinook use the lower portion of the creek for rearing.

Cottonwood Creek (the major tributary to Wide Hollow Creek) has intermittent flow, with numerous springs and some Yakima-Tieton Irrigation District return flow during the irrigation season (NYCD). However, the lower portion of the creek is dry most of the year. There are two creeks named Spring Creek that are tributary to Wide Hollow Creek.

Fish Access

The old mill dam at RM 0.6 blocked upstream migration since 1869 (CBSP 1990). Adult passage has been provided at the dam with installation of an Alaska steep-pass fishway, but juvenile salmon are not able to migrate upstream through the fishway. In addition, small-scale adult and juvenile passage facilities would be required at two diversions at RM 1.3 and 2.1; these diversions are rock/plastic berms that are pushed up annually, and which are not screened (NYCD). Adult passage has been corrected at one of these berms, and correction is planned for the other (NYCD). Correction of these fish passage problems would restore anadromous salmonid access to 14-15 miles of stream (CBSP 1990). A number of debris jams were identified in a 1988 habitat survey in areas of heavy residential development with dense foliage on the tops of steep banks, one of which (RM 3.5) would have constituted a total upstream passage barrier (CBSP 1990); these debris jams are transient and likely no longer exist, as most downed wood is actively removed from the channel (NYCD).

Floodplain Modifications

Wide Hollow Creek flows through a developed/developing urban area, and the stream tends to be incised (CBSP 1990). Wide Hollow Creek has been dredged through part of the cities of Yakima and Union Gap (NYCD).

The channel upstream of the old mill dam barrier has been channelized and diked; habitat complexity is lacking (YSS 2001 DRAFT). There is sporadic beaver activity, with beaver dams providing some localized habitat complexity, although the beaver dams may also inhibit upstream fish passage. The opportunity exists to reroute the Wide Hollow Creek channel, from Bay Street to the mouth, to the pathway that it occupied prior to human encroachment, entering the Yakima River just upstream of the Ahtanum Creek confluence (Visser). The affected landowners and local government are supportive of the project, but the project has yet to be finalized, funded, and an implementation schedule set. Designation of the old mill as a historic landmark may also affect the ability to reroute the channel.

Channel Condition

Overgrazing has caused severe bank sloughing in several small reaches from RM 0.2-0.6. The reach from RM 1.3-2.5 also had significant impacts from past grazing, but land use through this reach has recently been converted to a business park. Pools and runs are fairly deep (>2 feet), and are more frequent than riffles. LWD is generally lacking; although there is some LWD contribution from mature willows adjacent to the stream, the LWD is typically removed to minimize potential for bank erosion and channel rerouting in the tightly confined stream corridor.

Substrate Condition

Sedimentation and substrate are rated as fair (CBSP 1990). Good coho and steelhead rearing conditions exist in most reaches, but gravel is in short supply.

Riparian Condition

Riparian condition is generally poor, with riparian vegetation consisting of narrow buffer with clumps of mature willow that provide shaded areas interspersed with sunny areas. Riparian vegetation is non-existent from RM 0.2-0.6 and from RM 1.3-2.5, where there are impacts from overgrazing. Land use in the reach from RM 1-3-2.5 has recently been converted to a business park, and riparian restoration is occurring as a component of the mitigation associated with the business park development (Visser). Riparian restoration should attempt to restore historic multi-age cottonwood stand conditions. Within areas of heavy residential development, the stream tends to be incised and very deeply shaded by dense foliage on the tops of steep banks (CBSP 1990).

Water Quality

Water quality is rated as poor/fair, with impacts from leaking septics, stormwater runoff, and elevated pesticide concentrations from agricultural runoff (CBSP 1990), and from urban runoff (NYCD). August 1988 stream temperatures were in the mid-60°s F. Current water quality concerns are primarily associated with hobby farms and grazing near the creek.

Wide Hollow Creek is on the CWA Section 303(d) impaired water quality list for 4,4'-DDD, 4,4'-DDE, DDT, Dieldrin, dissolved oxygen, Endosulfan, fecal coliform, and water temperature. Some of these listings are associated with measured exceedance in water samples and others involve exceedances in edible fish tissue. USGS water quality sampling for pesticide presence in August 1999 detected the presence of 6 pesticide compounds in Wide Hollow Creek at Union Gap (Ebbert and Embrey 2001).

Dense growths of filamentous green algae (*Cladophora*) were observed in Wide Hollow Creek by Cuffney et al. (1995), but abundance was probably underestimated by the sampling method used in the study. *Cladophora* and related filamentous green algae are important indicators of phosphorous and nitrogen enrichment, and are typically viewed as an aesthetic nuisance and indication of water quality degradation. Because the sampling procedures underestimated this group, the influence of agricultural sources of nutrients on algal communities also may have been underestimated.

Wide Hollow Creek was characterized as having very low EPT richness (<6 taxa) with no stonefly taxa (Cuffney et al. 1997). Low EPT benthic invertebrate richness is indicative of the effects of intensive agriculture [and urbanization] as indicated by the NPAI and pesticide indices.

The USGS documented turbidity significantly exceeding state water quality standards at the mouth of Wide Hollow Creek (USGS 1999, as cited in Tri-County 2000).

Water Quantity

Instream flows during a 1988 habitat survey were considered excellent, ranging from 20-30 cfs in the lower 4 miles, to 3-4 cfs near RM 14 (CBSP 1990). The USGS summarized flow related data for the period 1974-1981, as part of a statistical analysis of historic water quality for Wide Hollow Creek and other locations (USGS 1994, as cited in Tri-County 2000). Based on analysis of 74 measurements of Wide Hollow Creek flows, the median flow was estimated to be 25.0 cfs near the mouth. Monthly flow variations are presumed to be similar to those in Ahtanum Creek, although Wide Hollow Creek flows are affected to a greater degree during the irrigation season by inflow from Yakima-Tieton Irrigation District operations.

Water from Wide Hollow Creek is used for irrigation, domestic water supply, and stock water. Historic non-consumptive power-related use was associated with a flourmill, originally established near the mouth in 1869 (Report of Referee 1991, as cited in Tri-County 2000).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Wide Hollow Creek:

- **Prioritize and install fish screens on unscreened water diversions**
- **Prioritize and correct fish passage barriers**
- **Preserve integrity of reaches with remaining functional floodplain**
- **Restore lower Wide Hollow Creek (from Bay Street to the mouth)to its pre-diversion location and channel characteristics (sinuosity, gradient, riparian vegetation, relationship to floodplain)**
- **Diversify riparian vegetation and restore riparian function throughout the watershed**
- **Implement upland agricultural and residential BMPs to reduce nutrient loading and erosion of fine sediment to the stream**
- **Implement a comprehensive grazing program to protect riparian vegetation and streambank stability (particular area of concern is from RM 0.2-0.6, where there is unrestricted livestock access)**

Naches River Mainstem 38.0003

General

The Naches River mainstem extends from the confluence with the Yakima River upstream to the mouth of the Little Naches River. The watershed is 86,136 acres is size, with 52.7% (45,394 acres) in the snow-dominated zone, 27.6% (23,778 acres) in the rain-on-snow zone, 17.1%

(14,752 acres) in the highland zone, and 2.6% (2,209 acres) in the rain-dominated zone (USFS 1995).

The Naches River supports spring chinook, fall chinook (presumed presence), coho, summer steelhead, and bulltrout, as well as a number of other salmonid and non-salmonid species (WDFW 1998). The lower extent of spring chinook spawning in the Naches River is generally considered to be Horseshoe Bend, located approximately 2 miles upstream of the Tieton River confluence (B. Watson). Spring chinook fry emerging from the American River move into the middle Naches by late summer; fry from the upper Naches move into the lower Naches or Yakima River (CBSP 1990). The Naches River and tributaries have been thought to produce a significant percentage of the overall steelhead production in the Yakima watershed. Steelhead production from the Naches has not been directly assessed and has been estimated by subtracting the sum of Satus, Toppenish, and upper Yakima steelhead counts from total counts at Prosser Dam. Expanded counts in the upper Toppenish Creek watershed since 1998 indicate a much higher production from that system than previously thought, which would result in a corresponding decrease in estimated steelhead production from the Naches watershed (YSS 2001 DRAFT).

The lower portion of the Naches watershed is mostly agriculture (cereal crops, irrigated pasture, and hay production), with forestry in the upper portion of the watershed. Historically, the tributary streams of the Naches were major producers of anadromous salmonids. Flows in the lower portion of the watershed are regulated in an unnatural way by storage and release of irrigation water from Rimrock Reservoir on the Tieton River.

Fish Access

The Naches-Cowiche Diversion Dam (RM 3.6) is a low head structure of approximately 6 feet (BOR 2000). Adult salmonids can effectively swim over the structure at median to high flows. A fish ladder was constructed in 1987, and is being further modified to enhance the exit of the ladder and supply additional auxiliary water at the entrance to the ladder.

Impeded upstream passage of adult salmonids by low flows downstream of Wapatox Diversion Dam (the largest diversion on the Naches River) was identified as a concern in the 1990 Subbasin Plan (CBSP 1990). Impaired passage may not be directly lethal, but it may delay and exhaust adult salmonids to such a degree that they are subject to increased pre-spawning mortality. The dam was rebuilt in 1978 with a new fishway (a modified pool and step-type passage facility)(BOR 2000). Possible spring chinook passage delays have been observed at the dam, particularly during low stream flows. A steelhead radio-telemetry study conducted by NMFS, did not indicate any passage problems at this site (Hockersmith et al. 1995, as cited in BOR 2000).

A large number of unscreened/poorly screened Phase II diversions were located on the middle and lower Naches, resulting in a disproportionate impact on American River spring chinook smolt survival rates (CBSP 1990). These were replaced with louvered screens in the early 1990s, which should improve survival (Perala). One of the larger diversions that remains unscreened is the City of Yakima Water Treatment Plant (WTP), just downstream of the outlet of the Wapatox powerplant. The water right for this diversion is ~39 cfs. The City of Yakima Municipal Water intake is located in the tailrace of the Wapatox powerplant, when it is operating. However, the powerplant has not been operating for ~60 days/year in recent years; during these shutdowns, water is diverted through an unscreened auxiliary water intake from the Naches River. The BOR is negotiating with involved parties to buy out the Wapatox Powerplant to benefit salmon and steelhead by increasing instream flows in the Naches River (YSS 2001 DRAFT). Retirement of

the Wapatox powerplant would result in unscreened water intake to the WTP year round. In addition, the WTP diversion is separated from the main flow of the Naches River only by a low concrete wall running down the left bank of the river. During spring runoff, flows may top this wall, entraining downstream migrants into the WTP. Returning adult spring chinook or summer steelhead may also access the WTP canal during high water, where they are blocked from returning to the Naches River (two adult summer steelhead were observed in the upper end of the water intake canal on May 14, 2000). Juvenile and adult salmonids, including ESA-listed species that enter the WTP canal, are likely entrained and lost to production.

Floodplain Modifications

Loss of Naches River floodplain during the 20th century is estimated at 57%, with 30% of the loss occurring between 1915 and 1965 (Table 31). The Naches River and its floodplain have been affected by the location of SR 410 and other development with the riparian area. Through the 15.8 mile long Naches River within the USFS (1995) analysis area, 2.0 miles of the left streambank consists of riprap associated with SR 410, and ~0.2 miles of the right streambank consists of riprap associated with private and USFS roads. There are a total of 20.6 miles of roads within 300 feet of the 15.8 mile length of the Naches River within the analysis area. Approximately 234 acres (20.4%) of the total area within 300 feet of each side of the Naches River has been disturbed by human development, including roads, structures, and campgrounds. This is a conservative estimate and additional area within the 100-year floodplain has most likely been impacted (USFS 1995).

Table 31: Extent of historic floodplain compared to current floodplain. Historic floodplain delineated as Holocene sediment deposits. Floodplain encroachment includes road and rail revetments and flood control levees (data from Eitemiller and Uebelacker, as presented in Snyder and Stanford 2001)

	Extent of active floodplain (hectares)				**Percent loss of active floodplain from pristine**		
Reach	**Pristine**	**1884-1915**	**1916-1965**	**1966-1999**	**1915**	**1965**	**1999**
Naches River	3342	2548	1530	1422	24	54	57

The USFS (1995) conducted a comparison of channel conditions using 1962 and 1992 aerial photos (USFS 1995) for the Naches River (Pinecliff Bridge to confluence of Bumping River), and generally found that bankfull channel width had decreased (up to 13 feet), channel length had decreased (2,500 feet), and that channel gradient increased in some reaches. There was also a decrease in size and number of mid-channel gravel bars. Similar general changes were noted for the Little Naches for the same period (Smith 1993, as cited in USFS 1995), and are thought to be associated with a decreased sediment load over time (Rosgen 1994, as cited in USFS 1995). It is likely that the sediment reductions in the Naches River are associated with reductions in sediment from the Little Naches (USFS 1995), which is recovering from past impacts from increased sediment load.

The reach from the mouth to Wapatox Dam is 60% braided with many good gravel bars (CBSP 1990). Side channels that would provide important rearing habitat are dried up from early July until flip-flop (mid-September). Passage up the Naches River is also impaired. Downstream passage for spring chinook juveniles is feasible only until July 4th; thereafter, migrants are lost due to impassable conditions and stranding (WDFW 1998).

One side-channel area that has been of particular interest is the South Naches Channel, where a headgate has been placed at the upper end of the historic side channel to regulate flow into the side channel for irrigation purposes for the Powell Irrigation District (NYCD). The Powell Irrigation District provides water for irrigation of 1,800 acres, of which approximately half is for culture of agricultural crops on the floodplain terrace, and the other half is marginal hay pasture. Until the early 1990s, flow through the headgate was shut off at the end of the irrigation season, precluding juvenile salmon access to the side channel from the upper end, and severely limiting use of the side channel as over wintering habitat. The South Naches Channel provides important spawning and rearing habitat, and flows are now being maintained year-round, per agreement with WDFW (Visser).

Floodplain reaches that appear to be crucial to the long-term survival and recovery of salmon in the Yakima watershed have been evaluated and ranked based on natural habitat heterogeneity, productivity, current and historic use by anadromous salmonids, and restoration potential (Snyder and Stanford 2000 DRAFT). Two reaches of the Naches River were identified (ranked 4th in the overall Yakima watershed prioritization) for conservation actions:

- Upper Naches - In the Nile Valley of the Naches River, extending 3 km upstream and downstream of the confluence of Rattlesnake Creek. This floodplain reach is reasonably intact, but is influenced by regulated flows from Bumping Reservoir [NOTE: Floodplain function on the Naches from Rattlesnake Creek to the Little Naches is impacted by a significant amount of development, including presence of SR 410, small farms, residential development, recreational access and use, and floodplain confinement by several dikes (Visser, Lindhorst), and accelerated aggradation of Rattlesnake Creek at its confluence with the Naches (Freudenthal).]
- Lower Naches – From the Naches Canal Diversion (RM 18.4) downstream to near the confluence with the Yakima. The lower Naches valley floodplain is large and extensively braided, with the lower 8 km being an extensive upwelling zone with several large springbrooks, substantial fish habitat, and minimal housing encroachment. [NOTE: It is not clear whether the Stanford and Snyder reference to the lower end of this reach refers to the Twin Bridges or to the mouth. There has been severe floodplain loss in the reach from the natural constriction at twin bridges to the confluence with the Yakima. In this lower reach only about 30% of the floodplain remains (mostly the river itself) while the rest has been cut off by SR 12 (Freudenthal).]

The Yakama Nation is actively conducting a public outreach effort to protect and restore floodplain in the lower Naches River (YSS 2001 DRAFT). A total of 15 landowners have indicated an interest in selling their floodplain property, and with continued emphasis managers hope to eventually protect a large number of parcels in this reach.

Channel Conditions

The reach from Wapatox upstream to Bumping River is one of the best spawning reaches in the Naches watershed, with abundant spawning beds interspaced with deep, clear resting pools, (CBSP 1990). CBSP (1990) and WDFW (1998) both indicate that riparian conditions in this reach were “near pristine”, but there is significant riparian disturbance throughout, including SR 410 running the full length, numerous residences immediately adjacent to the stream, some agriculture, and several campgrounds, which adversely affect channel conditions (Hoefer).

The Naches River receives the majority of LWD from upstream tributary reaches, as well as surrounding riparian conifer stands. A 1992 survey of LWD from Pinecliff Bridge to the

Bumping River confluence (USFS 1995) found all reaches to be well below the Wenatchee National Forest and USFS Region 6 LWD standards. Limited presence of LWD is associated with active removal of LWD from the Naches River from Cottonwood Campground to the Bumping River confluence following a flood in 1976/1977 (USFS 1995). Channel cleaning efforts were part of flood rehabilitation efforts, with use of heavy equipment in the channel and salvage or burning of the removed debris on gravel bars. There is also a lack of instream cover (particularly LWD) downstream of Cowiche dam (CBSP 1990, WDFW 1998).

The USFS (1995) identified two reaches of the Naches River mainstem as critical aquatic habitat areas (USFS 1995). These include the reach from Lost Creek to just downstream of Cliffdell, which has good adult chinook holding habitat with deep pools and large substrate; and from Boulder Cave Road bridge to Boulder Cave Campground, where ~23% of the reach is off-channel habitat. Identified habitat problem areas include the reach from Boulder Cave Campground to the Bumping River confluence, where recreational use was identified as a source of surface erosion, bank erosion, and loss of overhead vegetative fish cover.

Comparison of aerial photos taken in 1927 with current channel location indicates a loss of channel sinuosity in the reach between the Tieton River confluence and the South Naches bridge (Freudenthal). This reach has lost three large meanders, and now flows in a straight channel for a distance of almost five miles. This channel condition allows for very high flow velocities to develop in this reach, resulting in high levels of bedload transport through this reach. Downstream to the "twin bridges" the channel is constricted at several locations by SR 12, irrigation diversions, and bank armor (Freudenthal). At each constriction, large amounts of bedload have accumulated upstream; the channel is actively downcutting through and downstream of the constrictions, which in some cases has resulted in active bank cutting and channel widening. These areas can be expected to regrade completely during flood events.

Substrate Condition

From the Tieton River confluence to the mouth, the wetted channel substrate is composed primarily of large cannon ball-sized material embedded with sands and fines; it is unknown to what extent these substrate conditions are associated with flip-flop flows and interrupted sediment transport from the Tieton River (B. Watson). The floodway in this reach is broad, but flows during much of the year are confined to a narrow deep thalweg. There are some gravels present in side-channels and high on the floodplain, but these areas are generally watered only during peak flows and flip-flop. Steelhead have greater access to these spawning gravels during spring runoff flows, but there is a high amount of sand present even on the floodway fringe. Coho have been observed spawning in gavel pockets behind LWD and large boulders.

Bed composition from the Tieton confluence downstream to the S. Naches Channel diversion is primarily large cannon ball sized (basalt) material with occasional inclusions of basalt bedrock as channel controls (Freudenthal). This substrate is overlain in many places by gravel bars of very coarse material, which is a mixture of basalt and glacially-derived granites. Downstream of this point the gravel consistently decreases in size, and the composition of the substrate gravels changes to almost pure granite near the twin bridges. Much of this substrate appears to be unstable due to channel constriction, floodplain loss, loss of riparian zone function/accelerated bank erosion, and lack of LWD. The current substrate conditions are heavily influenced by the recent 1996 flood event and channel shift/migration that occurred during that event. Substrate quality in this reach appears to have degraded since the 1990 Subbasin Plan (CBSP 1990), which indicated that from the mouth to Wapatox Diversion Dam the channel was 60% braided with many good gravel bars. Substrate condition in this reach would currently be rated as poor.

Substrate condition may improve over time in the lower river due to increased cross-sectional area that resulted from the channel changes in 1996.

From the Tieton confluence upstream to the mouth of the Bumping River, there is increasing presence of gravels, although there are still fines present in the gravels (B. Watson). Although there are substantial amounts of gravels present in this reach, substrate condition would generally be rated as fair, due to the moderate presence of fines.

Riparian Condition

Riparian condition is impacted by dike encroachment and roads, from the mouth to the confluence of the Tieton River (Visser Lindhorst). CBSP (1990) and WDFW (1998) both indicate that riparian conditions in the reach from Wapatox to Bumping River as "near pristine", but there is significant riparian disturbance throughout, including SR 410 running the full length, numerous residences immediately adjacent to the stream, some agriculture, and several campgrounds, which cumulatively impair riparian function (Hoefer). From the Tieton River to Rattlesnake Creek, the valley form narrows; the channel is entrenched as a result of a combination of natural confinement exacerbated by development encroaching on the channel. Approximately 10-20% of riparian corridor function is impaired by development. From Rattlesnake Creek to the Bumping River, the riparian corridor is heavily developed, with <50% of the riparian corridor having any functional riparian vegetation.

Water Quality

Excursions from state water quality standards for water temperature have been documented on the Naches River, which is listed on the CWA Section 303(d) impaired water quality list for pH, silver (further sampling recommended, as not consistent with other water quality samples), and temperature. USGS water quality sampling for pesticide presence in August 1999 found no detections of pesticide compounds in the Naches River (Ebbert and Embrey 2001).

Monitoring indicates that water temperatures in the Naches River consistently average 65-70°F, with the maximum 7-day average of daily maximum temperature at the Chinook Pass Work Center (CPWC) being 71.1^{o}F in 1994. The single day maximum temperature for the Naches River at CPWC in 1994 was 72.5^{o}F. Average summer maximum water temperatures for major streams entering upstream of the Naches mainstem include the Little Naches (69.8^{o}F), Bumping River (69.1^{o}F), and the American River (61.5^{o}F). These inflow temperatures result in an average maximum temperature of 67.4^{o}F at the upstream end of the Naches River, with the average maximum temperature increasing to 69.6^{o}F at the CPWC, 8 miles downstream (USFS 1995). Water temperature in the reach from the mouth to Wapatox Dam, rarely exceeds 70°F (CBSP 1990). Temperatures in tributaries to the Naches River are generally meeting the state water quality standard of 61°F (USFS 1995).

Monitoring data for turbidity or suspended sediment is very limited. High sediment/turbidity levels in Milk Creek are known to occur, primarily from natural mass wasting areas, although riparian roads also contribute. A total of 54 miles of roads occur within 300 feet of streams on high sediment hazard soils within the mainstem Naches watershed. There are a total of 20.5 miles of roads along 15.8 miles of river length that are within 300 feet of each side of the Naches River (USFS 1995).

A sediment budget was developed for the lower Yakima River, because of the link between total suspended sediment (TSS) and pesticide residues (Joy and Patterson 1997, as cited in Snyder and Stanford 2000 DRAFT). Results indicated that in 1995, inputs from tributaries and irrigation returns contributed a significant quantity of the sediment load of the Yakima River. The observed turbidity is primarily from irrigation return flows. The lower Yakima (downstream of the mouth of the Naches River) generated 67 and 92% of the total TSS load carried from March to October and from July to October, respectively (Snyder and Stanford 2000 DRAFT), indicating that >90% of the TSS load from July-October is from sources within this reach. The analysis by Joy and Patterson (1997) also indicated a high flux of TSS load (tons/day) early in the irrigation season, as compared to the period from July to October. The mean TSS load from March to October was 2.4 times greater than the mean load from July-October in the reach from Naches to Parker. Similar trends were observed in the reach from Parker to Kiona. The early season TSS load is thought to mainly be a function of high TSS load carried by the Naches River during spring runoff, although increased TSS load from Yakama Reservation tributaries and drains contribute as well. The high TSS load in the Naches is likely due to logging activities and sediment releases from the reservoirs; however, further studies are necessary to distinguish the contribution from these sources vs. others (Snyder and Stanford 2000 DRAFT). Outside the spring runoff period, there is little turbidity delivered from the Naches River.

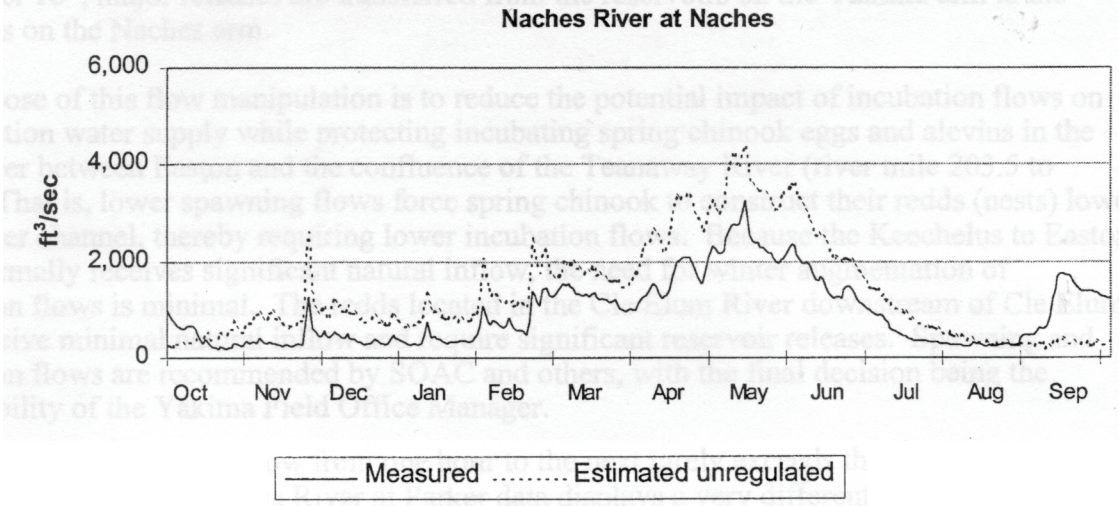
Water Quantity

Approximately one-fourth of the Yakima Project water storage capacity is situated in the Naches River watershed; Rimrock Lake (198,000 acre-feet) on the Tieton River and Bumping Lake (33,700 acre-feet) on the Bumping River (WDFW 1998). Other major tributaries, such as Cowiche Creek (RM 2.7), Rattlesnake Creek (RM 27.8), Little Naches River (RM 44.6), and the American River (RM 3.5 on the Bumping River) are unregulated and add significant flows, particularly during spring runoff, when inflow to the reservoirs is being stored (WDFW 1998).

Precipitation in the mainstem Naches watershed ranges from 20 inches at the eastern USFS boundary to over 70 inches at the higher elevations of Milk Creek, with the majority of precipitation falling as snow in the November-March period (USFS 1995). The Bumping River contributes ~40% of the total flow to the Naches River, the Little Naches contributes ~21%, the American River contributes 20%, Rattlesnake Creek contributes ~12%, and other minor tributaries contribute ~7% (USFS 1995). The average annual water yield for the Naches River at Oak Flat is 850,000 acre-feet for the period of record (USFS 1995). Average monthly flows vary from a low of 340 cfs in October to a high of 3,025 cfs during normal peak snowmelt in May. The 100-year flood flow for the Naches River at Oak Flat is ~15,500 cfs. The trend in average annual streamflow shows a slight increase over the period from 1939 to 1990, although probably not at a significant level. Changes in streamflow quantities and timing may be related to forest management activities, but in a watershed as big as the Naches River, it is unlikely that a significant change can be detected from the gage records (USFS 1995).

Low flows during the winter and early spring, and prolonged high and fluctuating flows in the summer are the major factors affecting anadromous salmonid production in the mainstem Naches River. Poor instream flows in the winter in the lower Naches River significantly impact natural reproduction of spring chinook, steelhead, and coho (WDFW 1997a). A comparison of 1986-1995 flows with the unregulated flow regime is presented in Figure 45. Of particular note is the rapid and significant increase in flow that occurs in September as a result of flip-flop water releases from Rimrock Lake. The existing hydrograph of the Naches River, downstream of the mouth of the Tieton River, is without corollary in the natural riverine processes of western North America, unless it would be the sudden draining of a glacial or landslide-formed lake in late fall

Figure 45: Comparison of average daily flows for the period 1986-1995 with the estimated unregulated flow regime for the Naches River at Naches (from SOAC 1999)



(Uebelacker and Eitemiller, as cited in YSS 2001 DRAFT). However, this would have been a one-time event, and not repeated annually for a quarter of a century.

The lower Naches River is plagued by extremes in flows. Sudden increases in flow cause fish to vacate feeding territories and migrate to new areas, increasing competition and stress, reducing growth, and increasing the likelihood of mortality, either through predation or being displaced to unsuitable downriver habitat (CBSP 1990). Sudden decreases in flow result in the stranding or death of salmonids that are unable to relocate to nearby pools or runs. Irrigation diversions dry up side-channel habitat prior to mid-July, which is critical for rearing spring chinook (WDFW 1998). Water temperature and quality are excellent, but instream flows between the Wapatox diversion and outfall frequently are too low for optimal rearing and adult passage from mid-July to mid-September (CBSP 1990). Wapatox canal diverts 300-500 cfs from the Naches River, while four smaller diversions downstream take an additional 100 cfs. From mid-July through mid-September, these diversions leave about 150 cfs in the reach from the mouth to Wapatox, which had a mean unregulated discharge of 1,800 cfs (CBSP 1990). Flows upstream of Wapatox Diversion Dam are seldom too low to cause problems (WDFW 1998). During the 1970-1980s, juvenile salmonids which managed to survive by rearing in the main channel were abruptly flushed out of the reach by the high flows during flip-flop, with flows in and downstream of the Tieton going from 40 cfs to 2,500 cfs in a 24-hour period (CBSP 1990). Water release operations have changed significantly since the 1970s-1980s and current ramping rates no longer allow a flow change of that magnitude in such a short timeframe (Perala). The period of low flow preceding flip-flop coincides with much of the spring chinook spawning period, but precedes most fall chinook spawning and would follow all steelhead spawning (CBSP 1990).

The braided channels of the Naches River downstream of Wapatox Dam (RM 9.7-17.1) are substantially dewatered at flows of 125 cfs and below. Higher flows in the Wapatox reach are necessary to maintain the high-quality rearing habitat for steelhead and salmon and to support the food organisms that sustain those fish. Researchers have hypothesized that most or all of the 30% estimated loss of smolts between Wapatox Dam and Sunnyside Dam occurs between Wapatox Dam and the powerplant outfall, and that the proximate cause is stranding in braids of the lower

Naches, and especially predation exacerbated by low flows (CBSP 1990). Power subordination at Wapatox, and transfer of the savings to instream flow, would increase smolt capacity in the reach by an estimated 314,700 smolts, approximately three times the estimated benefit of restoring riparian condition throughout the entire Yakima River watershed (CBSP 1990). The BOR is negotiating with involved parties to buy out the Wapatox Power Plant to benefit salmon and steelhead by increasing instream flows in the Naches River (YSS 2001 DRAFT). The Wapatox Canal also currently provides irrigation delivery to the Wapatox Irrigation District (~50 cfs), and tailwaters from the Wapatox powerplant are routed downstream to the City of Yakima Water Supply intake (39 cfs). Although instream flows in the Naches River would be significantly improved if the Wapatox buyout occurred, the diversion dam may need to be retained to provide water delivery to these other entities.

Although spring chinook redds are saved in the upper Yakima as a result of flip-flop management, there has been little or no effort to understand or monitor the effects of this flow regime on either the upper Yakima or on the lower Naches (Snyder and Stanford 2000 DRAFT). In the upper Yakima, significant stranding of benthic invertebrates may occur and numerous side-channel habitats critical to the completion of many different species life histories, including juvenile salmon, are disconnected as a result of the extensive instream flow variation associated with flip-flop. In the Naches River, flows capable of transporting bedload likely result in rapid rates of cut and fill avulsion, as well as generating a spectacular annual disturbance event, the magnitude and duration of which is well beyond that occurring historically. In both the upper Yakima and the lower Naches, organisms specifically adapted to the natural and predictable disturbance regime would likely be unable to adapt to the anthropogenic regime and would suffer declines in density and productivity (Resh et al. 1988, as cited in Snyder and Stanford 2000 DRAFT). This applies to the post-reservoir flow regime and particularly to the alteration of that regime via flip-flop. Snyder and Stanford (2000 DRAFT) strongly recommend that the flip-flop regime be re-examined carefully, although recognizing this as difficult due to the lack of quantitative data on resource impacts.

Road construction increased significantly along with timber harvest levels from 1950 to 1970, with increasing road densities affecting runoff rates and timing. Ten of the 20 sub-basins analyzed have road densities >4.0 mi/mi^2. An analysis of increased channel network due to precipitation being intercepted and routed by road surfaces to streams identified six subbasins where the channel network increased by >20% due to road crossings (USFS 1995).

Instream flow recommendations were developed in the mid-1980s (see Instream Flow section at beginning of this chapter), but the TAG does not support implementation of those recommendations at this time. Rather, the TAG supports continued work to develop and implement a normative flow regime that combines "the goal of sustaining ecological integrity of the watershed, while also maximizing use of water resources by humans" (SOAC 1999).

Lakes

There are no lakes on the Naches River mainstem; storage reservoirs on the Tieton and Bumping rivers are discussed in following sections.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Naches River:

- **Protect/preserve ecological integrity of critical floodplain reaches**
- **Eliminate hydropower diversions whenever instream flows downstream of Wapatox dam cannot otherwise be maintained at 400 cfs (500 cfs in Sept.-Oct.)**
- **Acquire Wapatox Power Plant and diversion; restore water diverted for power to instream flow**
- **Screen City of Yakima water intake**
- **Where possible, remove/relocate roads currently in the floodplain to outside the floodplain**
- **Develop and implement a short-term LWD strategy to restore LWD presence and habitat diversity**
- **Ensure that floodplain hazard planning and strategies consider and adequately protect salmonid habitat**
- **Reduce forest road densities that increase runoff interception and alter natural hydrology**

Cowiche Creek 38.0005, NF Cowiche 38.0008, SF Cowiche 38.0031

General

Cowiche Creek is a right bank tributary to the Naches River, entering at RM 2.7. Cowiche Creek supports spring chinook (presumed presence), summer steelhead, and coho, as well as other resident salmonids and non-salmonids (WDFW 1998). A survey in July 1988 indicated that Cowiche Creek had many miles of good/excellent spawning and rearing habitat for steelhead and coho (CBSP 1990). Cowiche Creek could be a major producer of steelhead and coho (and perhaps a minor producer of spring chinook). Lower Cowiche Creek and a number of tributary channels are utilized as off-channel winter refuge for pre-smolt spring chinook and steelhead. Land uses include grazing, agriculture, and recreation. Overall, habitat conditions in the Cowiche watershed are in a disturbed state, although some stable, healthy channel segments or reaches can be found in upper SF Cowiche and headwater areas of Reynolds Creek (Dominguez 1997). The presence of these stable sections provides an indication of the recovery potential of the disturbed channels.

Surveys of the Cowiche watershed by USFWS in August 1936 documented moderate to steep channel gradients with siltation occurring in most spawning areas (USFWS 1950, as cited in Tri-County 2000). Flow in the creek was impaired due to unscreened irrigation diversions, and dry streambed reaches were reported. Cowiche Creek was impaired to the extent that it was considered of little value to anadromous salmonids, and that it was infeasible to improve or restock this creek. However, biologists now identify Cowiche Creek as having major steelhead and coho production potential, minor spring chinook production potential, and having high restoration potential if fish passage problems (barriers and screening) were corrected (YRBCAG 1998, as cited in Tri-County 2000).

Fish Access

The primary salmonid limiting factor in Cowiche Creek is fish passage barriers (CBSP 1990). There are 5-6 unscreened diversions with associated structures that may be passage barriers (Schille). A rubble check dam at the mouth of Cowiche Creek diverts flow into the Yakima City Canal. This structure, and a wooden plank diversion dam just below the confluence of the NF

and SF (RM 7.5) are probably passable at high flows (CBSP 1990), but with impaired adult passage at lower flows, and impaired juvenile passage at all flows. The Yakima City Canal is screened, but other diversions are unscreened (WFDW 1998).

There are three concrete diversion dams on SF Cowiche (RM 1.3, 3.9, and 4.4) that are complete fish passage barriers at all flows; all of these diversions are also unscreened (CBSP 1990, WDFW 1998). CBSP (1990) identified a debris jam at the railroad trestle at RM 5.8 on mainstem Cowiche as a barrier to migration, and potential for logjams at several other crossings to be barriers; there are no current debris jams in Cowiche Creek (Freudenthal). Beaver dams are fairly common on the SF, and one upstream of the Reynolds Creek confluence (RM 11.8) may be a migration barrier (CBSP 1990). Culverts at two locations (Reynolds Creek and a tributary) were identified as fish passage barriers, impeding the potential for mainstem resident salmonids to migrate into a smaller tributary for spawning (Dominguez 1997). In addition, temporary potential fish passage problems were identified in Cowiche and Reynolds creeks, where loss of channel complexity and bed scour has resulted in channel disconnectivity. It is unknown to what extent fish passage is currently affected.

There is an irrigation reregulation reservoir (French Canyon Reservoir) at ~RM 6.0on NF Cowiche, which facilitates water distribution within the Yakima-Tieton Irrigation District (YTID)(BOR 2000). The capacity of the reservoir is 640 Acre-feet. Water from the Tieton River is diverted to the reservoir by the YTID during the irrigation season each year to supply water to their pressurized delivery system (R. Dieker, YTID). The dam also captures inflow from upper NF Cowiche Creek. The NF upstream of the reservoir is an intermittent stream, which produces surface flows in the spring and early summer. In most years the surface flow disappears by mid-May to early-June. The YTID has a 20 cfs flood-water right out of the NF Cowiche Creek, which is used to help fill the reservoir and supply early irrigation season demand. Any flow exceeding the 20 cfs is bypassed into the NF channel below the dam by means of the operational spillway or low-level bypass. During some winter peak storm flows, water exceeding storage capacity is spilled into the NF Cowiche, as described above. Operational spills during the irrigation season are typically only 24-48 hours in duration, with many resulting in surface flow only as far downstream as the town of Tieton, where low flows tend to go subsurface. The operational spills from French Canyon Dam into the NF Cowiche vary according to irrigation demand but in most cases do not exceed 10 cfs. However, occasional higher or longer spills may result in surface flow downstream to the confluence with SF Cowiche (Harvester). During these occasional events, juvenile and possibly adult salmonids, if present, may be attracted into the lower portion of the NF, where they may become stranded as the spill or flood flow is terminated. Options to address this concern include eliminating operational spills, placing a barrier at the mouth of the NF to prevent upstream fish passage, or finding a source of persistent flow that would minimize the potential of stranding and associated mortality.

Floodplain Modifications/Channel Condition

Cowiche Creek has many miles of good to excellent spawning and rearing habitat for steelhead and coho (WDFW 1998). The lower ~2 miles of the watershed are primarily agricultural, with the channel routed against the side of the valley for agricultural convenience. Upstream for 2-3 miles, the channel is located in a naturally confined canyon, with few pools and LWD; fish use in this reach is primarily passage only. Upstream of the canyon, the mainstem extends through a low gradient agricultural area for ~2.0 miles to the forks. The stream in this area is confined and incised in the floodplain, and has lost floodplain function (Freudenthal).

Housing and recreational facilities within the channel migration zone occur in the lower segments of Cowiche and Reynolds creeks, confining channels and resulting in the failure of channels to naturally respond to recovery from channel disturbances (Dominguez 1997). A moderate gradient is associated with many pools, riffles, and glides. Beaver dams are common on SF Cowiche (WDFW 1998). LWD is abundant in the mainstem (WDFW 1998). Banks are generally stable, except for severe bank sloughing due to overgrazing from RM 10-12 on the SF, and along much of the lower 3 miles of the NF (CBSP 1990, WDFW 1998).

Substrate Condition

There are enough gravel bars for spawning to fully seed the available rearing habitat (CBSP 1990, WDFW 1998). CBSP (1990) reported siltation due to riparian overgrazing to be minor, except for in the NF, where low flows allowed fine sediment to settle on the substrate. However, through the summer of 2001, there was a consistent source of fine sediment out of the SF, with the substrate coated with a large amount of fines to the mouth (Freudenthal). The sediment appears to be originating from a beaver dam that spans the floodplain and ties into the Cowiche Mill Road high in the watershed. A portion of the stream flow is now routed directly down the active road. Erosion from the stream itself, and erosion due to people driving through this short section of road, which has flowing water on it, combine to create a significant fine sediment load over the summer, when traffic on the road is highest.

Riparian Condition

Riparian condition is generally good through the canyon (RM 2-5), but is generally poor through the agricultural areas on the mainstem upstream of Wiekel. There are numerous developed small parcels adjacent to the SF, from the mouth to Rock Creek, where riparian function is impaired.

Water Quality/Water Quantity

Numerous excursions from state water quality standards have been documented in the Cowiche watershed. Cowiche Creek is on the CWA Section 303(d) impaired water quality list for fecal coliform, instream flow (based on comparison of actual flow with USFWS recommended instream flows, impacts of irrigation diversions, and declining steelhead populations), and temperature; NF Cowiche is listed for fecal coliform and temperature; and SF Cowiche is listed for fecal coliform and temperature. Reynolds Creek, a tributary to SF Cowiche, is also on the 303(d) list for water temperature.

Instream flows in the mainstem and SF Cowiche are perennial and sufficient to support salmonid rearing, even despite substantial irrigation withdrawals (CBSP 1990). Water temperatures are suitable for salmonids (50s^{o}F in July). Spring-fed flows on NF Cowiche provide perennial flow except from the mouth to just above the town of Cowiche, where the streambed is dry (natural condition) except for during spring runoff and during the higher and longer duration operational spills from French Canyon dam.

Instream flow recommendations were developed in the mid-1980s (see Instream Flow section at beginning of this chapter), but the TAG does not support implementation of those recommendations at this time. Rather, the TAG supports continued work to develop and implement a normative flow regime that combines "the goal of sustaining ecological integrity of the watershed, while also maximizing use of water resources by humans" (SOAC 1999).

Lakes

No lakes are present in this watershed.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Cowiche Creek:

- **Prioritize and correct identified fish passage barriers at water diversions and install fish screens**
- **Consolidate diversions, where possible**
- **Correct sedimentation from streamflow running down Cowiche Mill Road**
- **Implement a comprehensive grazing program to protect riparian vegetation and streambank stability; restore riparian vegetation and function**
- **Restore floodplain function, where impaired**
- **Correct false attraction problems into lower NF Cowiche Creek during the irrigation season, by installing a fish passage barrier at the mouth or by providing persistent flow through the lower NF**

Tieton River 38.0166, NF Tieton 38.0291, SF Tieton 38.0374, Fish Creek

(Oak Creek addressed separately below)

General

The Tieton River is a right bank tributary to Naches River, entering at RM 17.5. The Tieton River, downstream of Tieton Dam, historically supported spring chinook, steelhead, and bulltrout, as well as a number of other salmonid and non-salmonid species (WDFW 1998). Historically, coho occurred in the Tieton River (USFS 1996). Vestigial runs of chinook and bull trout may remain in the Tieton; most likely, these stocks have been extirpated by high flows in the fall caused by flip-flop water releases (WDFW 1998). Although, when the flow downstream of the dam was shut off several years ago to address dam safety concerns, abundant chinook juveniles and *O. mykiss* (resident or steelhead) were observed in pools throughout the Tieton (Harvester). The SF Tieton River supports bull trout (status designated as healthy, as well as other resident salmonids and non-salmonids; Fish Creek and Spencer Creek are possibly used by kokanee (Lindhorst); Short and Dirty Creek, Grey Creek, Camp Creek, and Corral Creek, may provide juvenile bull trout rearing, although utilization is questionable due to presence of barrier culverts, etc. (Lindhorst). Bull trout spawn in the lower 100m of Spruce Creek (WDFW 1998) and in the lower 0.5 mile of Bear Creek (Lindhorst). The NF Tieton supports major kokanee spawning downstream of Clear Lake Dam; bull trout are present throughout the NF, but no spawning activity has been documented (WDFW 1998). Indian Creek has large spawning populations of bull trout and kokanee (Hoefer, Cummins).

Most of the land in the Tieton River watershed lies within the Wenatchee National Forest. Except for Oak Creek, tributaries to the Tieton downstream of Tieton Dam are small, flow through shrubbe-steppe, and sometimes go dry in the summer. The upper watershed is forested, with headwaters in the Goat Rocks Wilderness.

Most of the land in the Yakima-Tieton Irrigation District is in agricultural production, although conversion to suburban use has gradually been increasing (BOR 2000). Approximately 80% of the district is in apples and pears, 10% is urbanized, and the remaining 10% alfalfa and pasture (Perala).

Fish Access

There are two dams with similar names in the Tieton watershed. The Tieton Dam (RM 21.3) creates the Rimrock Lake storage reservoir, which stores water for downstream irrigation diversions. Downstream of Rimrock Lake, the Yakima-Tieton Diversion Dam (RM 14.2) diverts irrigation water into the Yakima Tieton Irrigation Canal.

The Tieton Dam precludes access to 1.5 miles of the Tieton River from the dam upstream to the former confluence of the NF and SF (now inundated by Rimrock Reservoir), approximately 22 miles of the NF Tieton, and 4 miles of the NF tributaries of Clear Creek and Indian Creek (YSS 2001 DRAFT), as well as 13.5 miles of SF Tieton. This area in the NF Tieton and tributaries is estimated to be capable of sustaining a spawning population of 350 spring chinook, with a productivity of 3.8 adult progeny per spawner (EDT simulation, YN). This lost productivity is roughly equivalent to the current spring chinook production from the American River. In addition, instream flows downstream of Tieton Dam vary widely throughout the year (BOR 2000). Flows during September-October can be as high as 2500 cfs due to flip-flop operations, dropping to 35-50 cfs downstream of the Tieton Diversion Dam in winter, after the irrigation season. Adult steelhead migration (also likely for coho) up the Tieton River has been affected by low instream flows during the migration period.

Another structural concern for Tieton Dam is that the outlet works are unscreened (USFWS 2001 DRAFT). Bull trout, and other salmonids, which enter the submerged outlet structure would be subjected to a rigorous and potentially fatal flush to the river downstream. While bull trout mortality as a result of this has not been documented, dead kokanee have been observed on occasion below Tieton Dam. These lacustrine fish had undoubtedly been entrained in the respective outlet works, giving good cause to conclude that bull trout and other salmonids might be as well.

The Yakima-Tieton Diversion Dam (RM 14.2) is a barrier to upstream migration at low flows (WDFW 1998). The dam was rebuilt in 1990 to improve fish passage and to allow river rafting over the dam (BOR 2000). It has proven difficult to manage the stop logs at the base of the ladder, and fish have been observed jumping at the dam. BOR is working with the Fish Passage Technical Workgroup to redesign and modify the structure to ensure unobstructed fish passage.

Clear Creek Dam, located on NF Tieton River several miles upstream of Rimrock reservoir, has a fish ladder to facilitate upstream passage. However, probably due to insufficient attraction flow, the ladder is not used by bull trout (YSS 2001 DRAFT) or kokanee (Lindhorst), and would likely be a barrier to other salmonids in this reach.

Adult bull trout from Rimrock Reservoir enter SF Tieton to spawn in summer, possibly as early as June. A falls, which is a barrier to upstream fish passage, forms at the mouth of the SF as Rimrock Reservoir is drawn down in late summer (WFDW 1998). This falls is man-created, resulting from rerouting and channelization of the SF Tieton associated with road construction (Hoefer); inundation by the reservoir may actually assist access into the SF when pool levels are high (B. Watson). A natural falls at RM 13.5 on SF Tieton is a barrier to upstream bull trout migration.

There is a natural falls on Indian Creek at RM 6.0 that is a barrier to fish passage (WDFW 1998). Bull trout spawning occurs throughout the reaches downstream of the falls, though redds are concentrated in the springbrook areas. Most of the kokanee spawning is in the lower reaches of the stream.

The culvert on Jumpoff Creek at the 1201-554 road crossing is plugged, backing up water upstream (USFS 1996); this barrier may have been repaired (Lindhorst). There are culverts on Short and Dirty, Grey, Camp, and Corral creeks that limit spawning and rearing utilization to only the lower reaches (Lindhorst).

There are cascades on Wildcat Creek that cause difficult fish passage conditions. In addition, there is an irrigation diversion at ~RM 0.5 that is a partial fish passage barrier; adult steelhead and bull trout could likely jump over the diversion, but no *O. mykiss* or bull trout have been documented upstream of the diversion (Lindhorst).

Floodplain Modifications

The Tieton River and its floodplain have been affected by the location of SR 12 and other development within the riparian zone. Of the 14.5 miles of the Tieton River within the USFS (1996) analysis area, it was determined that ~2.13 miles of the left streambank consists of riprap associated with SR 12. There are a total of 19.7 miles of roads within 300 feet of the 14.5 miles of river within the analysis area. Approximately 153 acres of riparian zone, or 14.5% of the total area within 300 feet of each side the Tieton River has been disturbed by human development, including roads, structures, and campgrounds. This is a conservative estimate, and additional area within the 100-year floodplain has most likely been impacted.

The natural floodplain function of the Tieton River has been eliminated from Tieton Dam through the upper end of Rimrock Reservoir, a distance of ~6.5 miles. This area, previously known as McCallister Meadow, was a highly productive salmonid area, with habitat conditions likely similar to those in the American River (B. Watson). McCallister Meadow was also the location of a historic Yakama fishery. Upstream salmonid access is precluded upstream of Tieton Dam and there is no remaining suitable stream channel habitat within the inundated area.

Channel Conditions

Surveys of the Tieton and selected tributaries by USFWS in July 1935 documented moderate channel gradients (50 feet/mile) and occasional good deep resting pools and numerous riffles, although with large rubble (USFWS 1950, as cited in Tri-County 2000). Fair spawning areas were found. The greatly reduced value of Tieton River for fish production was noted, due to control of streamflow at Tieton Dam. Kokanee stocked in Rimrock Lake were noted as often being killed in passage over or through Tieton Dam. There is also concern regarding bull trout mortality as a result of passage through Tieton Dam during flip-flop (Lindhorst). The BOR initiated a trapping project in 2000 to estimate the number of bull trout leaving the reservoir in this way. The study is continuing in 2001, as drought conditions will result in a greater reservoir drawdown than in normal water years. Wildcat Creek, a tributary downstream of Tieton Dam, was documented as having clean cold water with adequate flow, but had cascades that created fish passage difficulties.

LWD source material for the Tieton River downstream of Tieton Dam is primarily contributed from tributaries below the dam (USFS 1996). Prior to the construction of Tieton Dam and Clear Lake Dam, the Tieton River received LWD input from the extensive watershed area upstream of the dam. Construction of these dams eliminated recruitment of LWD from upstream areas to the lower Tieton River. Stream survey results from 1992 confirmed the resulting lack of LWD in the Tieton downstream of Tieton Dam, indicating only 3-4 pieces of LWD/mile (USFS 1996). In addition, LWD that does accumulate downstream of Tieton Dam is often actively removed by white water rafters (Lindhorst). Pine Creek, Milk Creek, Jumpoff Creek, and Fish Creek are lacking LWD. Pine Creek and Jumpoff Creek are likely at or near natural LWD levels due to the fact that the majority of these drainages are in the dry forest type, with little LWD contribution from wetter areas further upstream. Milk Creek is likely low due to its proximity to the 1200 road, and upstream timber harvest. Fish Creek LWD abundance may be low due to upstream timber harvest.

Upstream of Tieton Dam, LWD and pool frequency and quality are generally rated as good. Habitat in Bear Creek is excellent and pristine, annually supporting 40+ bull trout redds in the lower mile (Hoefer).

The upper reaches of the SF Tieton are pristine (WDFW 1998). The USFS conducted stream surveys in the lower 3.5 miles of Indian Creek in 1999 (Lindhorst). Most of the known spawning occurs in this reach. The surveys documented little overhead cover, and LWD (>12 inches diameter and >50 feet long) was estimated at 25 pieces per mile, well below the USFS standard of 100 pieces/mile. Conditions upstream of this reach do have better overhead cover and more LWD. The lower reach is subject to frequent channel changes; the middle reach, below the barrier falls, has three large springs that significantly contribute to instream flows.

Substrate Condition

Primary site characteristics in the Tieton watershed that contribute to high mass wasting hazards include steep terrain, deep soils, and moderate to high subsurface water storage capacity (USFS 1996). Due to these characteristics, the mass-wasting hazard is naturally high in a number of the landforms. Roads, and to a lesser extent timber harvest, are believed to be the dominant management activities which increase sediment source and delivery. Nearly all of the units in this watershed have moderately high road densities (>1.6mi/mi^2). Generally, more than 30% of the roads are within high erosion hazard landforms. In addition, the number of channel crossings is high in 6 of the 8 units, ranging from 20 to 58 crossings. Channel crossings are particularly sensitive to fillslope failures and sediment delivery due to erosion of road tread and cutslopes. The effects of increased susceptibility of the watershed to mass wasting and erosion are not manifested in the lower Tieton (downstream of Tieton Dam), as increased sediment supply in the upper watershed is mostly retained within Rimrock Lake.

Most substrate assessment techniques are designed to look at the presence and impact of fine sediment to spawning and rearing substrate. There is limited data available to assess the change in coarse substrate composition over time. Prior to the construction of Tieton and Clear Lake dams, sediments (coarse and fine) from the upper Tieton watershed were transported through the system to the lower Tieton River. With the construction of the dams, the transport of bedload (coarse sediment, gravels) and LWD (that assisted in the retention of gravels and fines) was essentially eliminated, impacting the substrate quality of the Tieton River. A lack of spawning gravel and in-channel LWD would be expected in this situation. Stream survey results confirm that current substrate is dominated by cobble and small boulders, with only 3-4 pieces of LWD/mile (USFS 1996). In addition to the lack of sediment recruitment from the upper

watershed, the increased incidence of bank-full flow events (see Water Quantity section below) has likely transported suitable spawning gravels out of the channel downstream of the dam, leaving an armored streambed that is less suitable for salmonid spawning and rearing. The reach downstream of Tieton Dam experiences bank erosion and resulting sedimentation (USFS 1996). There are few remaining bedload sediment sources for the area downstream of Tieton Dam. One source is Wildcat Creek, which is a left-bank tributary entering shortly downstream from Tieton Dam. Care should be taken to ensure that bedload gravel that is transported into the lower Tieton River is retained, and not rearranged out of the active channel, as occurred downstream of the mouth of Wildcat Creek after the 1977 flood (Perala).

There is no quantitative fine sediment data for the upper Tieton (USFWS 2001 DRAFT). A large natural slide (Blue Slide) contributes a large amount of sediment to the SF Tieton. The extent to which timber harvest contributes additional sediment is not known and is further masked by apparent increased sediment due to grazing and recreation use (MacDonald et al 1998, as cited in USFWS 2001 DRAFT). WDFW (1998) indicates that grazing and off-road vehicle use erodes streambanks on SF Tieton, increasing fine sediment to spawning areas; however, Hoefer indicates that while grazing still occurs, the cattle are removed from the bull trout spawning areas after August 31. Grazing impacts are apparent even in meadows where cattle have been excluded; the impacts appear to be the result of elk grazing in these areas (Lindhorst). Grazing allotment modifications and improvements have almost eliminated cattle entering and resting in SF Tieton riparian areas (Lindhorst). In addition, previous off-road vehicle fords in and upstream of known spawning habitat have been closed to access (Hoefer), and efforts are currently being implemented to restore riparian meadows and improve trail conditions (Lindhorst).

Riparian Condition

SR 12 is located in close proximity to the Tieton River for the full distance from Tieton Dam to the mouth, with many locations where the road is directly next to the river, with heavy armoring and total lack of riparian vegetation. In addition, there are numerous areas of dispersed and developed camping and recreational access, and some areas with residential development on the river bank (Hoefer). Cumulatively, these result in impaired riparian function through much of this reach.

USFS (1996) rated riparian condition on 21.3% of the 111 miles of perennial streams in the Tieton watershed. The ratings indicated that 47.2% were properly functioning, 49.4% were rated as functional at risk, and 3.4% were rated as non-functional. The rated areas were representative of riparian areas throughout the watershed, so the results are likely indicative of the watershed in its entirety.

Riparian conifer stands in the lower portions of the tributaries downstream of Tieton Dam (dry forest group) tend to be dense stands of small grand firs, making for poor LWD recruitment potential (USFS 1996). Few large trees are present, and those that are are predominantly grand fir, which decay more rapidly than other conifers once they fall into the stream channel.

The shift of bankfull discharge timing (see Water Quantity section below) from May or June (unregulated flow) to mid-September (flip-flop) has had unknown effects to riparian vegetation, but could be linked to the observed decline in cottonwood species along the lower Tieton River (USFS 1996). The absence of a normal spring flow regime has been shown to severely impair or eliminate cottonwood regeneration (Jeff Braatne). Similar flow regime impairments exist on the Tieton River. There is a fair density of late-seral stage ponderosa pine and cottonwood, but very limited regeneration (B. Watson). In addition, the incision of the channel as a result of flip flop

water releases has likely caused a lowering of the water table in the adjacent riparian areas, further inhibiting the ability for riparian regeneration. Unless the current conditions can be improved, further decline in riparian condition can be anticipated.

There are a total of 19.7 miles of roads within 300 feet of the 14.5 miles of the Tieton River within the USFS (1996) analysis area. Approximately 153 acres (14.5%) of the total area within 300 feet of each side of the Tieton River has been disturbed by human development, including roads, structures, and campgrounds. This is a conservative estimate, and additional area within the 100-year floodplain has most likely been impacted.

Cattle grazing and off-road vehicle use has destroyed riparian vegetation on SF Tieton, increasing fine sediment to spawning areas (WDFW 1998). However, grazing allotment modifications and improvements have almost eliminated cattle utilization of the SF Tieton riparian areas (Lindhorst). In addition, watershed restoration projects are being implemented at ORV use areas, eliminating fords, restoring riparian meadows, and improving trail conditions.

Water Quality

USGS, as part of the National Water Quality Assessment (NAWQA) program, documented dissolved oxygen levels below state standards at sampling sites in the Tieton River downstream of Tieton Dam (USFS 1996). The low dissolved oxygen levels were attributed to water releases from the deeper levels of Rimrock Reservoir. Streambed sediment samples from the Goat Rocks area were found to contain high concentrations of copper, cobalt, iron, titanium, vanadium, and zinc, all naturally occurring constituents in surrounding geology.

A considerable amount of data has been collected on water temperatures in the Tieton watershed. Water temperatures in tributaries generally meet the state water quality standard of 61°F for most of the summer months with occasional periods of exceedance at approximately 40% of the sites measured. Maximum temperatures in the Tieton and SF Tieton Rivers have generally averaged 59-69°F (USFS 1996). Excursions from state water quality standards for water temperature have been documented on SF Tieton River, which is listed on the CWA Section 303(d) impaired water quality list for temperature. The 61°F state water quality temperature standard was exceeded in the SF Tieton for 49 days in 1992, 11 days in 1993, and 0 days in 1995. The standard was exceeded in the lower Tieton River for 31 days in 1995. Water temperatures have exceeded the maximum the state water quality standard (61°F) and the Forest Plan standard (58°F 7-day average maximum) in Milk Creek, SF Tieton River, Soup Creek, Thunder Creek, Tieton River, and Wildcat Creek (USFS 1996). Monitoring has also been conducted at two sites on Short and Dirty Creek over the past 6 years. Loss of stream shading along approximately two miles of stream has resulted in an average water temperature increase of 6.8^{o}F, which exceeds state water quality standards for temperature effects from non-point source pollution.

Precipitation results in increased turbidity, due to large slide areas (WDFW 1998). Monitoring data for turbidity or suspended sediment is very limited. High sediment levels in Milk Creek, Spencer Creek, Fish Creek, Soup Creek, Thunder Creek, and some areas in SF Tieton are known to occur primarily from natural mass wasting areas, although surface erosion from riparian roads has resulted in increased sediment reaching surface waters (USFS 1996). Specific roads of concern include Corral Creek Road and Withrow Road.

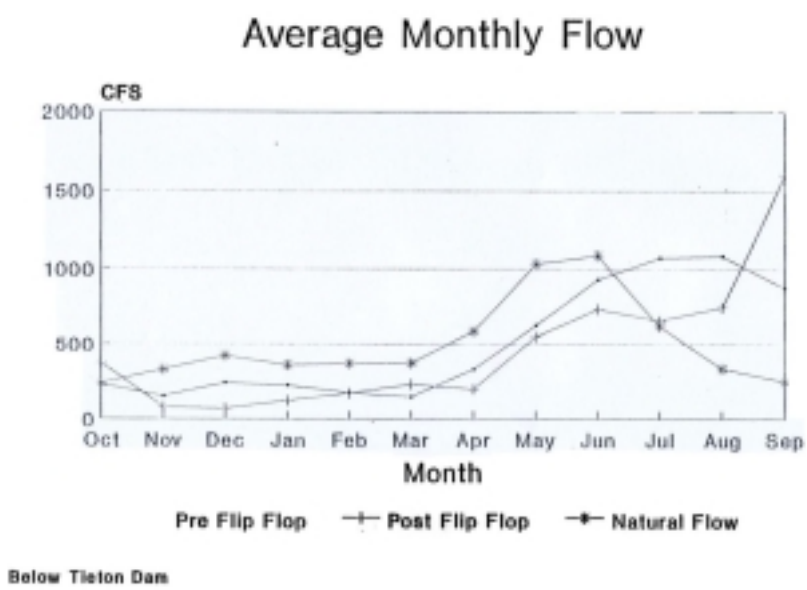
Water Quantity

Precipitation in the Tieton watershed ranges from 20 inches near the eastern USFS boundary up to 90-100 inches at higher elevations of the SF Tieton River. The majority of precipitation falls as snow during the November-March period. DNR rain-on-snow data indicates that 44.1% (50,414 acres) of the Tieton watershed is within the snow-dominated zone, 40.2% (45,944 acres) is within the highland zone, 15.0% (17,182 acres) is classified as within the rain-on-snow zone, and <0.7% (846 acres) is within the rain-dominated zone.

SF Tieton contributes 36% of the total flow of the Tieton River, and NF Tieton/Clear Creek/Indian Creek contribute 47% of the total flow (USFS 1996). The average annual water yield for the Tieton River downstream of Tieton Dam is ~358,400 acre-feet, or 494 cfs for the period of record.

Flows from the Tieton River were first diverted in approximately 1908, when the first diversion dam was built on the Tieton (Tri-County 2000). Construction of Tieton Dam was started during WW I, and completed in 1925. Rimrock Lake, created by the dam, has a storage capacity of 198,000 acre-feet. Clear Creek Dam, located approximately 0.5 mile west of Rimrock Lake, was constructed in 1914. The Clear Lake storage capacity of 5,300 acre-feet supplements the storage capacity of Rimrock Lake. Both of these dams are operated by the BOR as part of the Yakima Project. The combined storage volume of these reservoirs is 203,000 acre-feet, or 57% of the total average annual water yield from the area upstream of Tieton Dam. This represents ~19% of the total water storage in the Yakima River basin. Water use from the Tieton watershed is primarily for irrigation and domestic purposes. The major water diversion from the Tieton is by the Yakima-Tieton Irrigation District (YTID), which has a contract with the US Government to divert up to 114,000 acre-feet of water (recent water awarded by the court is less, and is currently under appeal), subject to prorating in years when water availability is short for irrigation use downstream (Tri-County 2000). Approximately 350 cfs are diverted to irrigate 27,271 acres in the Tieton and West Yakima areas. Additional water storage from Rimrock Reservoir is diverted downstream of the dam for irrigation in the lower Yakima valley. Because of water delivery efficiency improvements in the early 1980s, including conversion to a totally enclosed pressurized conduit, YTID abandoned all drainage facilities in the Tieton watershed (BOR 2000). In addition, there are 20 domestic water diversions and 26 spring developments for stock water, most all of which are for minor amounts <0.1

Figure 46: Unregulated and regulated average monthly flows for the Tieton River (from USFS 1996)



cfs, and many of which are unscreened.

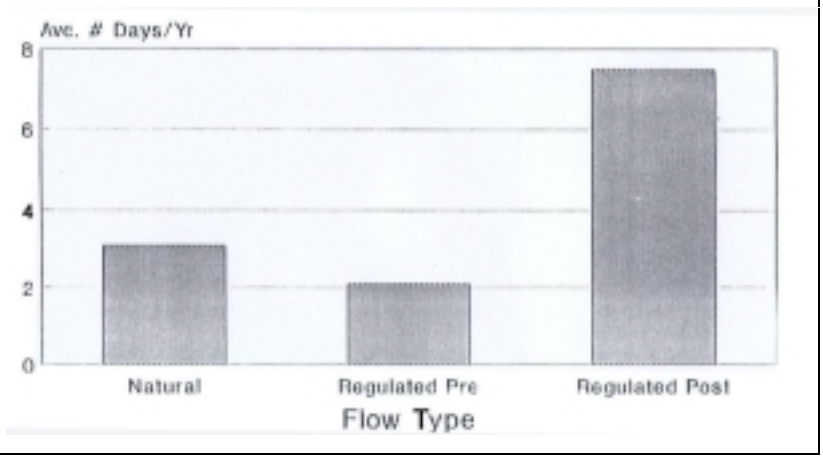
Flows in the Tieton downstream of Tieton Dam have been dramatically altered due to irrigation scheduling known as flip-flop (Figure 46). Streamflow gage records downstream of the YTID headworks (~5 miles downstream of Tieton Dam) are presented in Table 32. These flows are considered representative of the flows in the lower ten miles of the Tieton River, to the confluence with the Naches River (Tri-County 2000). Flows upstream of the diversion may be 200-300 cfs higher during the irrigation season, depending on diversions to the YTID.

Table 32: Gaged flows (cfs) in the Tieton River downstream of the Tieton Irrigation Canal headworks (from Tri-County 2000)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1994	453	23	30	38	33	64	43	68	40	99	310	1124
1995	484	48	63	51	194	267	609	742	596	422	497	1702
1996	330	149	1314	1045	1826	692	446	649	699	400	495	1610
1997	593	23	126	171	508	702	1480	1294	750	737	450	1223
1998	322	526	484	347	305	229	494	689	850	641	321	1632
1999	501	92	290	171	147	438	614	624	838	825	331	1719

Since 1981, irrigation storage in Rimrock reservoir has been held until late season (September) to mitigate disturbance to salmon redds in the upper Yakima River. Winter and spring flows are managed for flood control. Once the Yakima Project is on storage control, releases from Rimrock reservoir are limited to ensure as full a reservoir as possible at the end of the irrigation season to accomplish flip-flop operation. In winter, after the irrigation season, flows have been as low as 4 cfs at the gage downstream of the Tieton Diversion Dam. Recent winter flows have been in the range of 35-50 cfs; flows during flip-flop have been >2600 cfs in September. Rearing habitat in the Tieton is compromised by flows that are too low in the winter and too high during flip-flop operations. Low flows in the winter reduce the quality and quantity of rearing habitat, and high flows during flip-flop in late summer probably physically displace juveniles from the Tieton and lower Naches rivers downstream into the Yakima River. The frequency of bankfull discharge levels (Figure 47) has increased from the natural unregulated conditions of three days per year (typically May or June), or pre flip-flop average of only 2 days per year (normally in July or August), to a post flip-flop average of 8 days per year (typically in September) (USFS 1996). The impact of Tieton Dam water releases on salmonids is considered serious. The Northwest Power Planning Council (CBSP 1990) identified

Figure 47: Days exceeding bankfull flow (regulated and unregulated flows) for the Tieton River downstream of Tieton Dam (courtesy USFS 1996)

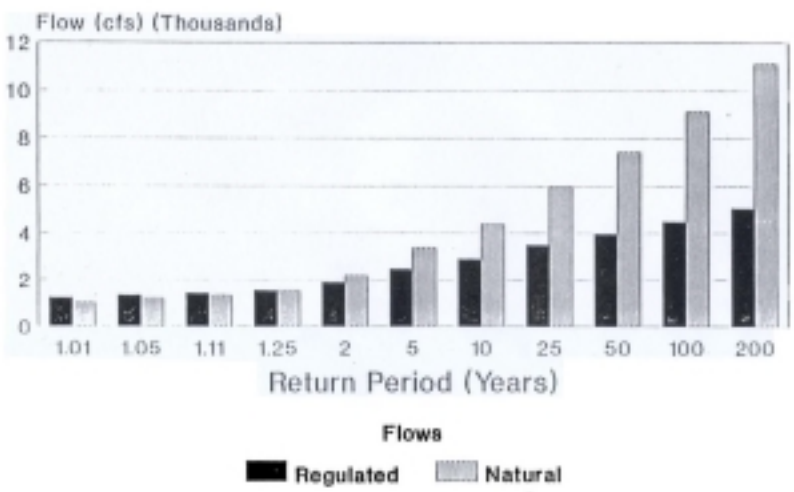


the following concerns:

> "Although the Tieton was historically a major producer of spring chinook, flip-flop storage control makes successful spawning in the Tieton extremely unlikely. When Rimrock reservoir is refilling in the winter, discharge is very low (100-200 cfs or less), whereas during flip-flop (mid-September to mid-October) discharge is quite high (800-1000 cfs or more). Whatever salmon redds may be constructed in the fall are probably dewatered in the winter. Flows for steelhead, which spawn in April and emerge in July and August, are much more favorable, at least for the period of early rearing. Subyearlings are, however, probably flushed from the system during flip-flop, and it is debatable whether the Tieton River has more potential for steelhead production than salmon."

In addition, fluctuations in flows associated with BOR Yakima Project operations do occur, and are often associated mainly with river operations (Tri-County 2000). Fluctuating flows have been identified as a concern relating to stranding rearing juveniles and impacts to the food web. USBR operations have established flow ramping rates of 2-inches of rise or drop in river water surface per hour at Tieton Dam (BOR 2000).

Figure 48: Comparison of magnitude of flood flows in the lower Tieton River for natural and regulated flows (courtesy USFS 1996)



Tieton Dam operations have significantly reduced the incidence and magnitude of floods in the lower Tieton River (USFS 1996). Figure 48 shows the difference in peak flows by flood frequency for regulated and natural flows. Flood magnitudes are nearly the same for the 1-2 year recurrence interval events, but are reduced by >50% for the 100-200 year recurrence intervals with flow regulation.

An important component of the river ecosystem is the flow regime (Vannote et al. 1980, as cited in SOAC 1999). An underlying assumption is that the natural, unaltered flow regime produced the ecosystem conditions necessary to sustain abundant anadromous salmonid populations, and that human alterations of this flow regime impact the ecosystem, resulting in reduction of these populations. The existing hydrograph of the Tieton and lower Naches River (downstream of the mouth of the Tieton River) is without a corollary in the natural riverine processes of western North America, unless it would be the sudden draining of a glacial or landslide-formed lake in late fall (Uebelacker and Eitemiller, as cited in YSS 2001 DRAFT). However, this would have been a one-time event, and not repeated annually for a quarter of a century, as is currently the case. In a river basin with extensive flow regulation, such as the Tieton, managing aspects of the flow regime to more closely resemble natural conditions may recover some ecosystem functions

and offers the potential to improve salmonid production. A shift of the flow regime towards a "normative condition" (Stanford 1996, 1997, as cited in SOAC 1999) is an important step in the recovery process. A normative flow regime would seek to mimic many of the characteristics of the historic hydrograph, although it is likely to reflect a scaled-down version of the historic hydrograph, as it is likely infeasible to duplicate historic flow volumes (SOAC 1999). Although spring chinook redds are saved in the upper Yakima as a result of flip-flop management, there has been little or no effort to understand or monitor the effects of this flow regime on either the upper Yakima or on the lower Naches (Snyder and Stanford 2000 DRAFT). In the upper Yakima, significant stranding of benthic invertebrates may occur and numerous side-channel habitats critical to the completion of many different species life histories, including juvenile salmon, are disconnected as a result of the extensive instream flow variation associated with flip-flop. In the Naches and Tieton rivers, flows capable of transporting bedload likely result in rapid rates of cut and fill avulsion, as well as generating a spectacular annual disturbance event, the magnitude and duration of which is well beyond that occurring historically. In both the upper Yakima and the lower Naches/Tieton, organisms specifically adapted to the natural and predictable disturbance regime would likely be unable to adapt to the anthropogenic regime and would suffer declines in density and productivity (Resh et al. 1988, as cited in Snyder and Stanford 2000 DRAFT). This applies to the post-reservoir flow regime and particularly to the alteration of that regime via flip-flop. Snyder and Stanford (2000 DRAFT) strongly recommend that the flip-flop regime be re-examined carefully, although recognizing this as difficult due to the lack of quantitative data on resource impacts.

Instream flow recommendations were developed in the mid-1980s (see Instream Flow section at beginning of this chapter), but the TAG does not support implementation of those recommendations at this time. Rather, the TAG supports continued work to develop and implement a normative flow regime that combines "the goal of sustaining ecological integrity of the watershed, while also maximizing use of water resources by humans" (SOAC 1999).

Lakes

Lake level fluctuation and drawdown of Rimrock Lake likely reduce production of phytoplankton, zooplankton, and aquatic insects (BOR 2000), which reduces the food web base for bull trout and kokanee residing in the reservoir. This is particularly applicable to Rimrock Lake, which has no dead storage and can be fully drained. Productivity in Rimrock Lake is likely limited by factors similar to those identified in Cle Elum Lake (loss of nutrients provided by anadromous fish passage, hypolimnetic discharge, and fluctuating lake levels). Please refer to the "Lakes" element in the Cle Elum River section of this chapter for a discussion of these factors. Washington Dept. of Wildlife (1992, as cited in BOR 2000) identified the following concerns regarding drawdown of Rimrock Lake: "We are confident that bull trout populations will not be significantly impacted if the pool is maintained at or above 30,000 acre-feet. Significant, but not catastrophic kokanee losses will occur if the pool is reduced to 10,000 acre-feet. Pool levels below 10,000 acre-feet will have significant impacts on kokanee and unknown, but perhaps major, impacts on bulltrout."

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Tieton River:

- **Review effects of flip-flop on Tieton River habitat and fish resources; restore "normative" flow regime (SOAC 1999) downstream of Tieton Dam**

- **Correct fish passage impairments at Yakima-Tieton Diversion Dam**
- **Assess feasibility and potential habitat benefits from supplementation of gravel recruitment in the Tieton below Rimrock Dam**
- **Restore riparian function where impaired, including removal/relocation of roads located within floodplain (where practicable)**
- **Restore adult and juvenile anadromous fish passage over Tieton Dam; install juvenile fish screening**
- **Develop and implement a short-term LWD strategy to provide LWD presence and retain available spawning gravels until riparian function is restored**

Oak Creek 38.0169

General

Oak Creek is a left bank tributary to the Tieton River, entering at RM 1.8. *O. mykiss* are present in Oak Creek, but no steelhead spawning has been observed in the entirety of the Tieton watershed in recent times (B. Watson). However, steelhead presence is presumed in Oak Creek from the mouth to the 1400-232 road crossing. Recent U.S. Forest Service's surveys have documented one bull trout in Oak Creek (USFWS 2001 DRAFT); it is assumed that they are present in the perennial streams of the watershed (USFS 1997).

Fish Access

There are several identified culvert barriers to upstream fish passage (USFS 1997), including:

- a culvert on Indian Creek at the 1400 Road
- a culvert on NF Oak Creek at the 1400 Road
- a culvert on an unidentified forest road in Section 7 on USFS segment 50

The impacts of these culvert barriers are primarily to resident salmonids. The potential of other culvert barriers in the watershed was also noted by USFS.

Floodplain Modifications

Oak Creek and SF Oak Creek are significantly impacted by roads located within their floodplains (USFS 1997). Prior to 1998, roads were located immediately adjacent to Oak Creek and SF Oak Creek for much of their length (Hoefer). After severe flood damage to these roads in the 1996 flood, these roads were obliterated, and the portion of the 1400 road that had been along Oak Creek was relocated upslope. NF Oak Creek has a road adjacent to it for 74% of its length, and several tributaries have roads in their valley bottom.

Channel Conditions/Substrate Condition

The six reaches of Oak Creek assessed by USFS (1997) meet the NMFS properly functioning criteria for LWD, although none of them meet the Forest Plan standard for LWD. In addition, there are several areas along Oak Creek where riparian condition is comprised of dense stands of small grand fir or clearcuts, which will not produce LWD >12" diameter for 20-50 years. None of the reaches of Oak Creek meet the pool frequency or pool quality standards of NMFS or the Forest Plan. Pool frequency may be low because of the coarse substrate and lack of water to scour significant pools. Lack of pools >1m in depth may by natural for a stream of this size.

Presence of off-channel habitat is rated as at-risk in the lower segments of Oak Creek due to downcutting of the stream, as properly functioning in the middle portion where beavers activity has created high-quality rearing habitat, and as not properly functioning in the upper segments where the 1400 road constricts the floodplain. Significant streambank erosion is occurring in the lower segments of Oak Creek, where the stream is downcutting, exposing raw streambanks.

Riparian Condition

Riparian canopy was assessed to determine the extent of altered stream shading. Forested areas of the watershed would be expected to have >70% canopy closure (USFS 1997). Eighteen percent or less of the stream lengths in Oak Creek, Indian Creek, and NF Oak Creek meet or exceed the expected 70% canopy closure level. NF Oak Creek has 52% of the stream length with <40% canopy closure.

Water Quality

Water temperatures in tributaries to Oak Creek meet the state water quality standard of 61°F for most of the summer months with occasional periods of exceedance at most of the sites measured. Maximum temperatures in mainstem Oak Creek near the USFS boundary exceeded the 61°F standard for most of the mid-July/August 1996 measurement period, when the maximum seven day average of daily maximum temperatures was 67.9^{o}F (USFS 1997). Water temperatures most likely are affected by removal of riparian shading due to timber harvest and road locations, and may also be somewhat elevated due to the percentage of non-forested area and relatively low elevations in the watershed (USFS 1997). No other water quality concerns have been identified for this watershed.

Water Quantity

Precipitation in the Oak Creek watershed ranges from 20 inches near the eastern USFS boundary to over 30 inches at the higher elevations. The majority of annual precipitation falls as snow in the November through March period. According to DNR rain-on-snow data, 52.1% (11,132 acres) of the watershed is within the snow-dominated zone, 24.3% (5,187 acres) are within the rain-on-snow zone, 15.6% (3,336 acres) are within the highland zone, and 8.0% (1,719 acres) are rain dominated. In addition, 55.2% of Bear Canyon is within the snow-dominated zone, and 43.6% is within the rain-on-snow zone ((USFS 1997). Oak Creek contributes 3% of the annual flow of the lower Naches River (USFS 1997). The estimated 100-year flood flow for Oak Creek is 480 cfs; the estimated 100-year flood flow for Bear Canyon is 93 cfs (USFS 1997). WDFW operates the only known surface water diversion from Oak Creek (just upstream of the SR 12 crossing) for irrigation use at the Oak Creek Feeding Station.

The Oak Creek watershed has relatively low canopy closure and a high percentage of area in low elevations, which results in a high risk of rain-on-snow flood events. Timber harvest has reduced canopy closure over a large percentage of the watershed (~83% of the forested area has had some type of past timber harvest), and has probably increased melt rates and contributed to increased rates of surface runoff (USFS 1997). In addition, the Oak Creek subbasin has a 25% increase in channel network due to forest road crossings, increasing the quantity and rate of flow to the stream channel.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Oak Creek:

- **Correct identified fish passage barriers**
- **Remove/relocate remaining roads that are located within the floodplain, where practicable**
- **Restore riparian function; encourage reestablishment of large conifers in riparian zone**
- **Develop and implement a short-term LWD strategy to provide LWD presence and habitat diversity until riparian function is restored**
- **Restore and maintain hydrologic mature condition in forested portion of watershed**

Wildcat Creek 38.0270

General

Wildcat Creek is a left bank tributary to the Tieton, entering at RM 20.7. The creek supports spring chinook and steelhead, as well as other resident salmonids (WDFW 1998), although no spawning has been observed in the entirety of the Tieton watershed in recent times. Wildcat Creek is not affected by flip-flop flows to the extent that the Tieton River is impacted. The lower portion of Wildcat Creek may provide critical off-channel refuge rearing habitat during flip-flop. In addition, Wildcat Creek is one of the main remaining sources of spawning gravels to the Tieton downstream of the dam, and care should be taken to ensure sediment transport to the Tieton River is retained.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Wildcat Creek:

- **Ensure that sediment transport through Wildcat Creek to the Tieton River is retained**

Rattlesnake Creek 38.0518, NF Rattlesnake Creek, Little Rattlesnake Creek 38.0519, Hindoo Creek 38.0618, Little Wildcat 38.0661

General

Rattlesnake Creek is a right bank tributary to the Naches River, entering at RM 27.8. The watershed supports spring chinook, steelhead, coho (historic), and bulltrout, as well as other resident salmonids and non-salmonids (WDFW 1998). Chinook redds usually are found from the mouth of Rattlesnake Creek to the forks; bull trout redds are usually found in the mainstem upstream of the confluence of NF Rattlesnake (WDFW 1998). Bull trout spawn as far upstream in Rattlesnake Creek as McNeil Creek (Hoefer), and inhabit Rattlesnake, Dog, Hindoo, Little Wildcat and NF Rattlesnake creeks (USFWS 2001 DRAFT).

The Rattlesnake Creek watershed has been influenced by uplifted faults, basalt flows, and periods of glaciation, that have left U-shaped valleys and an abundance of coarse sediment. Stream channel gradients near the headwaters are steep (4-10%) and have a high capacity for sediment transport. Riffles and rapids are abundant with scour pools. Floodplain extent is limited by narrow valleys, except in downstream areas. Downstream reaches have more moderate slopes (2%) and a riffle/pool character, providing excellent fish habitat, although these channel habitats are very sensitive to disturbance (USFS 1997, as cited in Tri-County 2000). Approximately 56% of the Rattlesnake watershed is within the William O. Douglas Wilderness Area of the Wenatchee National Forest (USFS 1997).

Fish Access

The 1990 Subbasin Plan (CBSP 1990) indicated that the upper half of the Rattlesnake watershed was probably not useable to salmonids – this is erroneous (B. Watson). Chinook salmon spawning in Rattlesnake Creek in August and September is limited by low instream flows; good instream flows in April and May favor steelhead spawning.

The USFS (1997) has identified two culvert barriers on Three Creeks, which are barriers to upstream fish migration. These are in USFS reaches +053 and +056 at the 1500 road crossings. There are several natural waterfall barriers in the Rattlesnake watershed, including:

- Nelson Creek at RM 0.37
- Dog Creek – three barrier falls
- Hindoo Creek at RM 0.33
- Little Hindoo Creek at RM 2.0

In addition, the lower 300 feet of McNeil Creek is dry at low flow, creating a migration barrier.

The Tri-County (2000) watershed assessment report indicates presence of a cascade falls on Rattlesnake Creek at RM 16.5 (as cited from USFWS 1950) that prevents upstream anadromous salmon migration at low flows. However, bull trout are documented to spawn from RM 14.2-RM 19.5, with no cascade or falls noted in the vicinity of RM 16.5 (Cummins). There is a falls at approximately RM 0.75 on NF Rattlesnake that blocks upstream anadromous access (Cummins).

Floodplain Modifications

The Naches River floodplain reach from Nile Creek to Rattlesnake Creek is thought to have historically been a braided anastomosing “bead” on the Naches River (Snyder and Stanford 2000 DRAFT). The lower 0.5-1.0 mile of Rattlesnake Creek was likely historically covered by a network of braided channels. The area immediately downstream of the canyon reach on the Rattlesnake was an area where sediment from Rattlesnake Creek was deposited as it exited the canyon. This delta area has been highly modified by channelization and residential development, which keeps the channel constrained (Snyder and Stanford 2000 DRAFT), and limits the area available for sediment deposition in the floodplain, resulting in chronic aggradation at the confluence with the Naches (Freudenthal). Residential development on the alluvial fan, in the lower mile of Rattlesnake Creek, precludes potential for channel migration (Tri-County 2000). If the development were removed from the alluvial fan (including the road prism/dike on the southern side of the delta), restoration of natural channel function in Rattlesnake Creek and the adjacent portions of the Naches River would likely naturally follow within a short period of time (B. Watson, Perala).

The lower 2.5 miles of Little Rattlesnake Creek is disconnected from its floodplain in places due to the presence of the 1501 road (USFS 1994). The road is located in the channel migration zone, and confines the stream channel, reducing channel and riparian function (USFWS 2001 DRAFT). The 1501 road was rebuilt following the 1996 flood, although it was rebuilt in the same location (Lindhorst). Floodplain connectivity is also impaired in this reach due to channel downcutting, likely associated with headcutting up into the Little Rattlesnake, following the in-channel bulldozer channelization work that was done in lower Rattlesnake Creek following the 1996 flood.

Evaluation of off-channel habitat conditions in lower Rattlesnake (within USFS ownership), Little Rattlesnake, NF Rattlesnake, and upper Rattlesnake rated all surveyed reaches, with the exception of lower Little Rattlesnake, as properly functioning (USFS 1997). Off-channel habitats that provide excellent rearing habitat and that are of particular importance include USFS reaches +019, *192, and *195 of Rattlesnake Creek, and reaches +054 and +056 of Three Creeks.

Channel Condition

Channel conditions in the channelized section downstream of the Little Rattlesnake are generally poor, with lack of LWD, pools, and habitat diversity. All riparian vegetation in this reach was removed after the 1996 flood, and any LWD that was present was transported to the mouth of the creek (B. Watson).

Evaluations of LWD presence by USFS (1997) found virtually all reaches in lower Rattlesnake (within USFS ownership), Little Rattlesnake, NF Rattlesnake, and upper Rattlesnake met or exceeded the NMFS standard of 20 pieces of LWD >12" diameter per mile, although a number of the reaches did not meet the Forest Plan LWD standards. Generally, LWD condition is rated as properly functioning.

USFWS documented numerous resting pools in 1935-1936, but noted they were not well protected (USFWS 1950, as cited in Tri-County 2000). Evaluations of pool frequency in Little Rattlesnake, NF Rattlesnake, and upper Rattlesnake (USFS 1997) found that neither NMFS nor Forest Plan standards for pool frequency were met in any of the reaches evaluated. This may in part be an artifact of not including all pools in the count. The majority of pools in upper Rattlesnake and NF Rattlesnake were greater than 1 m in depth, providing high quality pool habitat. Pool quality in tributaries is thought to be naturally <1m in depth, due to the small size of these streams. Streambank erosion in USFS reaches +019, +020, and +021 of Rattlesnake Creek are rated at-risk due to lack of ground cover and presence of cut banks.

Substrate Condition

Rattlesnake Creek is generally recognized as having a high natural level of bedload instability (B. Watson). The instability is mostly thought to be associated with the flashy runoff pattern in Rattlesnake Creek, although it has likely been exacerbated by channelization in the lower watershed and past timber harvest in the upper watershed. Little Rattlesnake bedload is much more stable, and is an example of excellent summer steelhead habitat.

USFWS (1950, as cited in Tri-County 2000) documented good spawning riffles in the lower 3 miles and in a reach 15-16 miles upstream. Substrate conditions were evaluated by USFS (1997) throughout the USFS ownership portion of the watershed. Naturally high levels of fine sediment were noted in a few reaches. Substrate conditions in all reaches, with the exception of Three

Creeks and reach +018 of Rattlesnake Creek, were considered to be reflective of natural conditions. Three Creeks was noted as having eroding streambanks, sand-dominated substrate, and embedded spawning gravels. The Three Creeks watershed contains relatively deep fine soils, so presence of fine sediments in the channel is likely natural, although erosion may have increased associated with timber harvests in the 1980s (Lindhorst). The jeep crossing (ford) on Forest Road 620 contributes fine sediment and damages the banks and channel (USFWS 2001 DRAFT). The Forest Service has indicated this problem is to be corrected. Reach +018 of Rattlesnake Creek had presence of many cut banks, which were identified as significant fine sediment sources.

A 4-wheel drive trail developed over time on USFS ownership in the upper 2 miles of Little Rattlesnake Creek (Lindhorst). The trail went right up the stream channel, resulting in excessive erosion and bank damage. The USFS has recently closed access to this trail.

Riparian Condition

Riparian condition is good upstream of the confluence of the Little Rattlesnake (RM 1.)(CBSP 1990). Riparian canopy was assessed by USFS (1997) to determine the extent of altered stream shading levels in the watershed. Although a significant percentage of the channels in the Rattlesnake watershed were found to have <70% canopy closure, the majority of the lowered canopy closure was due to sparse vegetation in the area. Water temperature is thought to have been only minimally affected by removal of riparian shading due to timber harvest and road locations. Riparian reserves in Three Creeks are rated as not properly functioning, because there are several past timber sale units that left inadequate riparian buffers.

Water Quality

Water quality is excellent (CBSP 1990). Excursions from state water quality standards for water temperature have been documented on both Rattlesnake and Little Rattlesnake creeks, which are both listed on the CWA Section 303(d) impaired water quality list for water temperature. Based on water temperature monitoring in the 1990s, temperatures in mainstem Rattlesnake Creek near the USFS boundary typically exceeded the 61°F state water quality standard for over two weeks during the mid-June-September period (USFS 1997). The Wenatchee National Forest (WNF) standard of 58°F was exceeded in lower Rattlesnake Creek for most of the summer measurement period. Water temperatures in tributaries to Rattlesnake Creek generally meet the state water quality standard of 61°F for most of the summer months with occasional periods of exceedance at most of the sites measured. The WNF Plan standard of 58°F was exceeded in lower Rattlesnake Creek for most of the summer measurement period. Water temperatures in upper Rattlesnake Creek and Little Rattlesnake Creek are thought to be generally reflective of natural conditions, and have not been significantly impacted by land use actions (Lindhorst). Current water temperatures in this watershed are similar to water temperatures sampled in 1935.

Anomalous levels of several minor elements (lead, copper, zinc, arsenic, and selenium) were found in fine-grained streambed sediments, which was attributed to high levels of these elements in the volcanic geologic materials in the area (Fuhrer et al. 1994, as cited in USFS 1997).

The USFS (1997) noted presence of springs adjacent to tributaries in the upper portion of Rattlesnake Creek. These springs are particularly important as they provide cool water temperatures, which are important for bulltrout. Springs were found in Dog Creek (for ~1 mile

above the mouth of Lookout Creek), lower Lookout Creek, the lower two miles of Hindoo Creek, and lower Elkhorn Creek.

Water Quantity

The 1990 Subbasin Plan (CBSP 1990) indicated that the upper half of the Rattlesnake watershed was probably not useable to salmonids – this is erroneous (B. Watson). Rattlesnake Creek drains very steep topography, and as a result has a very flashy runoff pattern, with widely varying flows. The hydrology of Little Rattlesnake is much more stable, due to lower elevation and less steep topography. Chinook salmon spawning in Rattlesnake Creek in August and September is limited by low instream flows; good instream flows in April and May favor steelhead spawning. Precipitation ranges from 20 inches near the mouth to over 70 inches near Pear Butte. The majority of precipitation falls as snow during the November-March period. DNR rain-on-snow data indicates that 47.3% of Rattlesnake Creek is within the highland zone, 43.2% (36,982 acres) is within the snow-dominated zone, 9.2% (7,866 acres) is classified as within the rain-on-snow zone, and <1% (233 acres) is within the rain-dominated zone. Average monthly flow in Rattlesnake Creek ranges from a low of ~20 cfs in September to a high of ~285 cfs in May. The estimated 100-year flood flow for Rattlesnake Creek near its mouth is 9,430 cfs (USFS 1997).

The relatively low canopy closure and high percentage of low elevation area in the Rattlesnake watershed results in a high risk of rain-on-snow flood events (USFS 1997). Timber harvest, which has reduced canopy closure and increased soil compaction over a large percentage of the non-wilderness portion of the watershed (~75% of the forested non-wilderness portion of the watershed has had some type of past timber harvest), has probably increased melt rates and contributed to increased rates of surface runoff. In addition, the road network in lower Rattlesnake, Little Rattlesnake, and Three Creeks has increased the channel network due to road crossings, resulting in a rating of at-risk or not properly functioning for these subbasins. As early as 1935-1936, logging operations in the lower watershed were reported to cause increased flow peaking and bank erosion (USFWS 1950, as cited in Tri-County 2000).

The Report of Referee for the Upper Naches Subbasin (1991, as cited in Tri-County 2000) identifies seven small irrigation diversions from Rattlesnake Creek near the mouth for irrigation of 85 acres and one domestic water supply. Final determination on these diversions is unknown. Some of these small diversions may not be screened (Tri-County 2000).

Instream flow recommendations were developed in the mid-1980s (see Instream Flow section at beginning of this chapter), but the TAG does not support implementation of those recommendations at this time. Rather, the TAG supports continued work to develop and implement a normative flow regime that combines "the goal of sustaining ecological integrity of the watershed, while also maximizing use of water resources by humans" (SOAC 1999).

Biological Processes

Interspecific interaction between bull trout and non-native brook trout is a concern relating to the health of bull trout populations. Brook trout and bull trout compete for resources, but the primary concern is that they can spawn together resulting in hybrid offspring, resulting in damage to the native bull trout gene pool (WDFW 1992, as cited in USFS 1997).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Rattlesnake Creek:

- **Protect good quality habitat in Rattlesnake Creek upstream of the mouth of the NF, and in Little Rattlesnake Creek**
- **Restore floodplain function from the mouth to the confluence of Little Rattlesnake; revise land-use policy to ensure that any future flood response work is protective of salmonid habitat**
- **Abandon/relocate Forest Road 1501, in the lower 2.5 miles of Little Rattlesnake Creek, in a manner that reestablishes floodplain function and connectivity to disconnected off-channel habitat**

Nile Creek 38.0692

General

Nile Creek is a right bank tributary to the Naches River, entering at RM 29.4. Nile Creek supports spring chinook, summer steelhead, and coho (historic). Nile Creek is fairly long (13 miles), and carries adequate flows for steelhead (and perhaps coho) rearing through most of its length (CBSP 1990). Nile Creek is inaccessible to salmon in the fall due to low flows (CBSP 1990).

Fish Access

There are a few water diversions on Nile Creek. These diversions need to be assessed for fish passage and screening status, and to determine if they are legal.

Floodplain Modifications

The Naches River floodplain reach from Nile Creek to Rattlesnake Creek is thought to have historically been a braided anastomosing "bead" on the Naches River (Snyder and Stanford 2001). From the mouth to Nile Loop Road (RM 0.75), it is likely that Nile Creek was historically covered by a network of braided channels. However, floodplain function is severely impaired in this reach by residential development encroachment, and possible channelization (B. Watson).

Channel Conditions/Substrate Condition/Riparian Condition

Habitat conditions in Nile Creek are generally good, with good riparian, substrate, and water quality (CBSP 1990, WDFW 1998). Pool:riffle ratios, pool frequency and depth, and LWD presence are rated as good; substrate condition is fair, with more fines than desired (B. Watson).

The Nile Creek watershed has a high sediment delivery hazard (USFS 1995). Nile Creek, within and downstream of the USFS boundary, has abundant LWD, meeting or exceeding the WNF and USFS Region 6 standards. A portion of NF Nile Creek was rated poor for LWD presence, likely due to the locations of the 1611-1615 and 1600 forest roads adjacent to the stream channel. The portion of Nile Creek for ~0.5 mile on each side of the USFS boundary is low gradient with extensive beaver activity, resulting in high quality rearing habitat. Bank and surface erosion, and

lack of overhead vegetative fish cover were identified as problems in Lower Nile Creek and the lower 0.75 mile of NF Nile Creek.

Recreational gatherings and rendezvous adjacent to the creek have increased fine sediment erosion to the creek (B. Watson). Restoration of soils and vegetation in these encampment areas would be beneficial to reducing fine sediment input.

Water Quality/Water Quantity

Excursions from state water quality standards for water temperature have been documented on NF Nile Creek, which is listed on the CWA Section 303(d) impaired water quality list for temperature.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Nile Creek:

- **Assess legal, fish passage, and screening status of water diversions; prioritize and correct identified problems**
- **Remove/relocate forest roads 1611-1615 and 1600 to restore floodplain and riparian function**
- **Restore soils and vegetation in recreational rendezvous encampment areas**

Rock Creek 38.0754

General

Rock Creek is a left bank tributary to the Naches River, entering at RM 33.5. The creek supports spring chinook rearing (presumed), steelhead, and coho (historic). Spring chinook and *O. mykiss* rearing is only known to currently occur in the lower couple hundred yards of Rock Creek (B. Watson).

Downstream of SR 410, Rock Creek is subject to channel changes during high water, because a large portion exists within the floodplain of the Naches River (USFS 1995). LWD presence in RF Rock Creek meets the WNF and USFS Region 6 standards; lower Rock Creek and LF Rock Creek were not surveyed (USFS 1995).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Rock Creek:

- **Assess habitat conditions for anadromous salmonids, restore impaired salmonid habitat**

Gold Creek

General

Gold Creek is a left bank tributary to the Naches River, entering at RM 38.5. The creek supports spring chinook (presumed), summer steelhead, and coho (historic) in the lower reaches. There are two fish passage barriers that block anadromous salmonid access into the Gold Creek watershed. The SR 410 crossing, just upstream of the mouth of Gold Creek, eliminates access to approximately 6.6 miles of habitat within mainstem Gold Creek and approximately 2.5 miles of habitat within NF Gold Creek, plus other possible habitat at the mouths of other tributaries. Another barrier, at the 1703 road on NF Gold Creek, blocks access to approximately 2.3 miles of habitat within NF Gold Creek (the habitat potential is primarily for resident westslope cutthroat, but there is some potential steelhead or coho habitat in the lower segments of Gold Creek)(USFS 1995).

Water temperature excursions are documented on Gold Creek (tributary to upper Naches River), where monitoring documented an average increase of 6°F downstream of two clearcuts that removed a total of ~1,500 feet of riparian shading (USFS 1995), resulting in listing on the 303(d) list.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Gold Creek:

- **Correct identified fish passage barriers**
- **Assess habitat conditions for anadromous salmonids, restore impaired salmonid habitat**

Lost Creek 38.0790

General

Lost Creek is a right bank tributary to the Naches River, entering at RM 38.2. The creek supports spring chinook (presumed), summer steelhead, and coho (historic). Lost Creek has been recently stocked with coho juveniles (Hoefer).

No information was located on salmonid habitat conditions in Lost Creek.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Lost Creek:

- **Assess habitat conditions for anadromous salmonids, restore impaired salmonid habitat**

Swamp Creek 38.0812

General

Swamp Creek is a right bank tributary to the Naches River, entering at Cliffdell (~RM 41). The creek primarily supports resident salmonids, but may have rearing potential for anadromous salmonids in the lower reaches. Two culvert fish passage barriers were identified on Swamp Creek, although both are in resident cutthroat only habitat (Lindhorst). The first is the 1761 forest road crossing of a tributary to Swamp Creek (blocks access to ~1.0 miles of habitat), and the second is a road crossing over Swamp Creek just downstream of the 1762 forest road crossing (blocks access to ~4.5 miles of habitat within mainstem Swamp Creek) (USFS 1995). Barrier correction would benefit resident cutthroat.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Swamp Creek:

- **Correct identified fish passage barriers** (benefits to resident salmonids only)

Milk Creek 38.0828

General

Milk Creek is a left bank tributary to the Naches River, entering at RM 44.0. Milk Creek supports spring chinook and bulltrout, as well as other resident salmonids and non-salmonids (WDFW 1998).

Juvenile spring chinook and bull trout have been observed downstream of the culvert at ~RM 0.15 (Lindhorst). Weirs were placed and monitored at this culvert in the mid-1990s, and did not confirm any upstream passage, including marked fish that were placed immediately downstream of the culvert. Rainbow and cutthroat have been observed upstream of the culvert. The culvert at the outlet to Milk Pond (~RM 2.5) is perched, and would be a total barrier to upstream fish passage. It is unknown whether anadromous salmonids used Milk Creek upstream of the culvert at ~RM 0.15 prior to construction of road crossings.

Reaches of Milk Creek surveyed by USFS (1996) have a high accumulation (up to 12 inches) of fine sediment on top of substrate gravels. This is considered to be natural, the result of deep very fine soils and settling of the fines in beaver ponds (Lindhorst).. There is some question as to the extent of movement of this material out of Milk Creek, and whether it transports out as suspended sediment or bedload (B. Watson).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Milk Creek:

- **Correct fish passage barrier culvert at ~RM 0.15; monitor upstream salmonid utilization and correct fish passage barrier culvert at ~RM 2.5, if warranted**

Bumping River 38.0998

General

The Bumping River supports spring chinook, summer steelhead, kokanee, coho (historic), and bulltrout, as well as other salmonid and non-salmonid species (WDFW 1998). The spring chinook stock in the Bumping River is genetically distinct from the stock in the American River. The kokanee population in Bumping Lake is naturally reproducing, with no supplementation; it is uncertain where the kokanee are spawning, but likely that they are spawning in lower Deep Creek and the lower portion of the Bumping River upstream of Bumping Lake (Cummins). However, more recently, kokanee have not been encountered in Deep Creek during WDFW bull trout spawning surveys, indicating that kokanee may not be spawning in Deep Creek. The spawning locations for Bumping Lake kokanee remain unknown.

Fish Access

Bumping Dam, constructed in 1910 at RM 15.7 of the Bumping River, is ~37 feet high, and is operated by the Bureau of Reclamation. It is a barrier to upstream anadromous access when water is stored behind the dam, precluding upstream fish access to Bumping Lake, 1 mile of the Bumping River upstream of the lake, and approximately 5 miles of lower Deep Creek (YSS 2001 DRAFT). Outlet flow is generally drawn from the bottom of the dam, although there are also periodic spills over the spillway for irrigation or springtime flood control (Perala). Through the spring and summer, much of the flow is passed through the reservoir to support instream flows, and meet downstream irrigation demands; additional reservoir drawdown typically occurs in September to augment flip-flop operations. At full reservoir drawdown, flow is released through the low-gradient outlet channel of the lake, and may be passable to adult salmonids (B. Watson, Perala). This opportunity typically only occurs from approximately mid-September to late-November/early-December, making coho the only species returning at a time when they could possibly pass through the outlet channel.

The lower one-half mile of Deep Creek goes subsurface during low water years, likely impairing spawning migration of adult bull trout, although some bull trout have been observed upstream during these years (USFS 1998).

The best opportunity to restore sockeye presence in the Yakima watershed may be in the Bumping River/Bumping Lake watershed (B. Watson). Restoring adult and juvenile sockeye passage over Bumping Dam may be more feasible than at the other historic sockeye producing reservoirs, mainly due to the low height of the dam.

Floodplain Modifications

Bumping Road is located immediately adjacent to the Bumping River or within the floodplain for approximately 80% of the lower 12 miles of the river (USFS 1998). Despite this encroachment, all seven reaches of the lower Bumping River were rated as properly functioning, because 3.6-19% of the available habitat consists of side channels.

Channel Conditions

USFS (1998) indicates that reach 082 of the lower Bumping River had high streambank erosion, with occasional cutbanks noted in other reaches.

In surveys conducted from 1992 to 1996, LWD presence exceeded the NMFS threshold criteria of 20 pieces/mile for all reaches of the Bumping River, with many of the reaches approaching or meeting the WNF standard of 100 pieces/mile (USFS 1998). Similar surveys found that pool frequency did not meet either the NMFS or WNF standards for pool frequency based on channel width, although this may be due in part to not all pools having been counted.

Substrate Condition

A substantial amount of spring chinook spawning occurs in the Bumping River (CBSP 1990). Channel gradient downstream of Bumping Dam is 1-2%; much of the substrate upstream of the American River confluence is boulders, with patches of spawning gravels (B. Watson). These patches are used for spawning by spring chinook and steelhead. From the American River confluence to the confluence with the Naches River, substrate quality is much better than upstream of the American, being lower gradient and having greater abundance of spawning gravels (B. Watson). Of the seven reaches of the lower Bumping River evaluated by USFS (1998), only one was rated as properly functioning for substrate, with the remainder having dominant/subdominant cobble, which is embedded.

The USFS (1998) rated sediment delivery hazard throughout the Bumping and American River watersheds, using soil survey erosion potential and proximity to stream channels. Only two (Granite Creek and Morse creek) of the 50 subbasins evaluated have >25% of their basin area in the severe erosion hazard category, and 11 of the subbasins have >25% of their stream length flowing through severe erosion hazard soils.

Riparian Condition

The riparian corridor on the Bumping River is generally excellent, except in increasing numbers of areas where there are clusters of summer homes, with associated removal of riparian vegetation and riprap armoring of the streambanks (WDFW 1998). The Bumping River downstream of the dam is generally in a confined ravine with periodic wide flat floodplain areas; these flat areas have been developed into campgrounds and residential areas (B. Watson). A riparian disturbance analysis (300' riparian width) conducted by USFS (1998) found that ~15% of the riparian area on the Bumping River (mouth to the dam) was disturbed [NOTE: these estimates are thought to be conservative].

USFS conducted an assessment of riparian canopy condition, which indicated that the largest percentage of channels in the Bumping and American rivers have >40% crown closure (USFS 1998). The majority of areas with lowered canopy closures were indicated as due to the sparse vegetation in the higher elevations of these watersheds. Water temperatures are indicated as only minimally affected by removal of riparian shading due to road locations, except possibly downstream of Bumping Dam, which has the most loss of shading due to road locations along riparian areas, and where water temperatures have exceeded 68°F.

Water Quality

The Bumping River is designated as Class AA (extraordinary) waters (WAC 173.201(a)), which determines which water quality parameters need to be met. The highest designated beneficial use is salmonid spawning and rearing. A very limited amount of water quality data has been collected in the Bumping River watershed. The Bumping River is listed on the CWA 303(d) impaired water quality list for water temperature. There were numerous excursions from the temperature standards documented on the Bumping River at the American Forks campground from 1991-1994. Recent monitoring efforts have concentrated on assessing the validity of this designation and determining the natural temperature regimes in this relatively pristine basin (USFS 1998).

Water temperature monitoring by USFS from 1991 through 1997 indicated that the mainstem Bumping River, downstream of Bumping Dam, typically exceeded the 61°F state water quality standard for over two weeks during the mid-June-September monitoring period, and exceeded the 58°F standard of the Wenatchee Forest Plan for most of the summer measurement period (USFS 1998). Monitoring in 1996-1997 found water temperature at Bumping Crossing (below the dam) to average 10 degrees warmer than the Bumping River upstream of the reservoir. Stream temperatures in Deep Creek averaged 18-20°F cooler than at Bumping Crossing. Bumping Lake, with a surface area of 1,310 acres and a storage volume of 33,700 acre-feet, has the largest surface area to volume ratio of all of the major reservoirs in the Yakima watershed, resulting in a significant amount of thermal heating due to the relatively shallow water depths (USFS 1998). Water temperatures downstream of Bumping Dam are also impacted by loss of riparian shading due to road construction along riparian areas in lower Bumping River (USFS 1998). Temperatures in tributary streams to the Bumping Rivers are believed to be meeting the state water quality standard of 61°F for most of the summer months, with occasional periods of exceedance in some of the streams (USFS 1998).

Monitoring and review of existing data, accomplished by USGS as part of the National Water Quality Assessment (NAWQA) program, identified anomalous levels of lead, copper, zinc, arsenic, and selenium in the fine-grained streambed sediments, which were attributed to the high levels of these elements in the volcanic geologic materials in the area (Fuhrer et al. 1994, as cited in USFS 1998).

Water Quantity

Precipitation in the Bumping River watershed ranges from 35 inches near the confluence of the American and Bumping Rivers to nearly 100 inches near the Cascade crest on the western boundary of the watershed (USFS 1998). The majority of annual precipitation falls as snow in the November-March period. 57.6% (42,300 acres) of the Bumping River watershed is located in the highland zone, 37.9% (27,868 acres) is in the snow-dominated zone, 4.5% (3,311 acres) is in the rain-on-snow zone, and none of the watershed is classified in the rain-dominated zone (USFS 1998). Local knowledge indicates that occasionally the rain-on-snow zone extends to higher elevations into the snow-dominated zone.

The Bumping and American river watersheds have relatively high canopy closures and a high percentage of area in upper elevations, which results in a relatively low risk of rain-on-snow events. They also have a high percentage area in wilderness, and only minor amounts of timber harvest or related road construction have occurred. Timber harvest has not reduced canopy closure significantly in these watersheds, and thus snowmelt regimes have not been changed from

natural conditions (USFS 1998). Only two (Lower Bumping River and Fifes Creek) of the 50 subbasins analyzed in the Bumping/American watershed have road densities of >3.0 mi/mi^2 (USFS 1998).

The average annual water yield from the Bumping River basin contributes ~40% of the annual flow in the lower Naches (USFS 1998). Flows in the Bumping River are regulated by Bumping Dam, which stores 33,700 acre-feet with a surface area of 1,310 areas. This storage represents only 10% of the average annual flow in the Bumping watershed and 3.15% of the total storage in the Yakima basin (USFA 1998). Reservoir releases from Bumping Dam alter the hydrograph in the Bumping River, particularly during flip-flop operations, but the impacts are relatively small compared to other regulated rivers in the watershed (Tri-County 2000). Compared to the natural flow regime in the American River, the Bumping River has slightly lowered flows in April and May, while the reservoir is being filled, and then slightly elevated flows in July-September, when water is released from the reservoir (USFS 1998). The Yakima Project manages the Bumping River for a minimum target flow of 50 cfs for spring chinook incubation throughout the winter and early spring (BOR 2000). By March, Bumping Reservoir is being managed for flood storage, and the water entering the reservoir is allowed to pass through (Perala and B. Watson indicate that flow through occurs as early as mid-September) The Bumping River probably plays an important role in the recharge of groundwater aquifers, some of which probably reenter and augment surface waters in the lower Naches River (USFS 1998).

Instream flow recommendations were developed in the mid-1980s (see Instream Flow section at beginning of this chapter), but the TAG does not support implementation of those recommendations at this time. Rather, the TAG supports continued work to develop and implement a normative flow regime that combines "the goal of sustaining ecological integrity of the watershed, while also maximizing use of water resources by humans" (SOAC 1999).

Lakes

Bumping Lake is a relatively small (33,700 acre-feet) irrigation storage reservoir. There is concern that release of warm surface waters from Bumping reservoir may excessively warm the upper Naches River in years of low flow (Crase 1985, as cited in CBSP 1990).

Lake level fluctuation and drawdown of Bumping Lake likely reduces production of phytoplankton, zooplankton, and aquatic insects (BOR 2000), which reduces the food web base for bull trout and kokanee residing in the reservoir. Productivity in Bumping Lake is likely limited by factors similar to those identified in Cle Elum Lake (loss of nutrients provided by anadromous fish passage, hypolimnetic discharge, and fluctuating lake levels). Please refer to the “Lakes” element in the Cle Elum River section of this chapter for a discussion of these factors.

Bumping Lake was treated with rotenone in 1950 to remove northern pikeminnow and suckers; bull trout rearing upstream of the lake apparently repopulated the lake (BOR 2000).

Biological Processes

The health of bull trout populations in this watershed may be at risk because of interspecific interaction (competition and cross-breeding) between bull trout and non-native brook trout. An additional concern is the interaction between native westslope cutthroat and hatchery rainbow (USFS 1998).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Bumping River:

- **Protect high quality salmonid habitat throughout the Bumping River watershed**
- **Improve riparian function, where impaired, along lower 12 miles of Bumping River**
- **Restore adult and juvenile upstream/downstream passage over Bumping Dam; assess feasibility of restoring anadromous sockeye presence upstream of Bumping Dam**

American River 38.1000

General

The American River supports spring chinook, coho (historic), and bull trout, as well as other salmonid and non-salmonid species. *O. mykiss* are present in the very lower sections of the American River, but all appear to be resident rainbow trout; summer steelhead spawning is rare in the American River (B. Watson). Fluvial bull trout redd index count areas are located in the American River watershed in and around Union Creek (RM 11.5) and upstream of Lodgepole Campground RM 15.5)(WDFW 1998). Bull trout inhabit the American River and Kettle, Timber and Union creeks (USFWS 2001 DRAFT). The spring chinook stock in the American River is genetically distinct from the stock in the Bumping River. The American River is the most productive spring chinook spawning reach in the Naches watershed, and also has the highest density of fluvial bull trout redds in all of the Yakima watershed, particularly around and upstream of Union Creek (WDFW 1998).

Fish Access

There are no fish passage barriers in the lower portions of the American River. The American River enters a narrow gorge upstream of Union Creek (RM 14), where it drops 100 feet in 400 yards in a series of cascades. The cascade is likely a barrier to upstream salmonid migration at low flows (CBSP 1990, WDFW 1998), but is considered passable at normal water levels (USFWS 1936, as cited in Tri-County 2000), and appears to be regularly passable to bull trout (Hoefer). Pinus and Wash creeks are seasonally dry, but have salmonid presence when flowing (WDFW 1998).

Floodplain Modifications

All reaches of the American River were rated as having properly functioning off-channel habitat, except reach 097, where SR 410 adds to the natural confinement (USFS 1998).

Channel Conditions

The mean stream gradient on the American River is 1%, although in the lower five miles the gradient is approximately 2% (CBSP 1990). The steeper lower 5-mile section of the American River is filled with large boulders and abundant LWD, and is the only section not affording excellent spring chinook spawning (CBSP 1990). Upstream of RM 5, presence of deep, well protected resting pools averages six per mile (CBSP 1990, WDFW 1998).

In surveys conducted from 1992 to 1996, LWD presence exceeded the NMFS threshold criteria of 20 pieces/mile for all reaches of the American River, with many of the reaches approaching or meeting the WNF standard of 100 pieces/ mile (USFS 1998). Similar surveys found that pool frequency did not meet either the NMFS or WNF standards for pool frequency based on channel width, although this may be due in part to not all pools having been counted. Pool frequency surveys, conducted between 1990-1992, indicated a reduction in pool frequency in the American River of 27% (3.3 to 2.4 pools/km) since 1934 (McIntosh et al. 1994). Pool depth in the mainstem typically met or exceeded the depth threshold of one meter.

Substrate Condition

Some of the best spring chinook spawning and steelhead spawning and rearing habitat in the Yakima River watershed is found in the American River watershed, from the confluence of the Bumping and Naches rivers upstream to the American River headwaters (WDFW 1998). The steeper lower 5-mile section of the American River is filled with large boulders and abundant LWD, and is the only section of the American River not affording excellent spring chinook spawning (CBSP 1990). Upstream of this lower section of the American River, the stream is lower gradient, with numerous side channels and abundant spawning gravel. Substrate condition in all reaches of the American River was evaluated by the USFS (1998) as properly functioning.

The USFS (1998) rated sediment delivery hazard throughout the Bumping and American River watersheds, using soil survey erosion potential and proximity to stream channels. Only two (Granite Creek and Morse creek) of the 50 subbasins evaluated have >25% of their basin area in the severe erosion hazard category, and 11 of the subbasins have >25% of their stream length flowing through severe erosion hazard soils. McNeil core sampling conducted in 1996 at three sites on the American River ranged from 10.3 to 11.2% fine sediment (<1.0mm).

Riparian Condition

Riparian condition on the American River is excellent (CBSP 1990). A riparian disturbance analysis (300' riparian width) conducted by USFS (1998) found that ~15% (estimate is likely conservative) of the riparian area on the American River (mouth to Morse Creek) was disturbed. Riparian vegetation is trampled through the Pleasant Valley Campground, resulting in excess bank erosion (B. Watson).

USFS conducted an assessment of riparian canopy condition, which indicated that the largest percentage of channels in the Bumping and American rivers have >40% crown closure. The majority of areas with lowered canopy closures were indicated as due to the sparse vegetation in the higher elevations of these watersheds. Water temperatures in the American River are indicated as only minimally affected by removal of riparian shading due to road locations (USFS 1998).

Water Quality

Water temperatures in the American River are generally colder than in the Bumping River (B. Watson). The American River is designated as Class AA (extraordinary) waters (WAC 173.201(a)), which determines which water quality parameters need to be met. The highest designated beneficial use is salmonid spawning and rearing. A very limited amount of water quality data has been collected in the American River watershed, but water quality is generally

considered to be excellent (TAG). The American River is listed on the CWA 303(d) impaired water quality list for water temperature. There were 23 excursions documented in the American River at RM 0.5 between 1992 and 1994. Recent monitoring efforts have concentrated on assessing the validity of these designations and determining the natural temperature regimes in this relatively pristine basin (USFS 1998).

Temperatures in tributary streams to the American River are believed to be meeting the state water quality standard of 61°F for most of the summer months, with occasional periods of exceedance in some of the streams (USFS 1998).

Monitoring and review of existing data, accomplished by USGS as part of the National Water Quality Assessment (NAWQA) program, identified anomalous levels of lead, copper, zinc, arsenic, and selenium in the fine-grained streambed sediments, which were attributed to the high levels of these elements in the volcanic geologic materials in the area (Fuhrer et al. 1994, as cited in USFS 1998).

Water Quantity

Precipitation in the American River watershed ranges from 35 inches near the confluence of the American and Bumping Rivers to nearly 100 inches near the Cascade crest on the western boundary of the watershed (USFS 1998). The majority of annual precipitation falls as snow in the November-March period. 76.2% (38,745 acres) of the American River watershed is located in the highland zone, 22.2% (11,297 acres) is in the snow-dominated zone, 1.6% (836 acres) is in the rain-on-snow zone, and none of the watershed is classified in the rain-dominated zone (USFS 1998). Local knowledge indicates that occasionally the rain-on-snow zone extends to higher elevations into the snow-dominated zone.

The American River watershed has relatively high canopy closures and a high percentage of area in upper elevations, which results in a relatively low risk of rain-on-snow events. They also have a high percentage area in wilderness, and only minor amounts of timber harvest or related road construction have occurred. Timber harvest has not reduced canopy closure significantly in this watershed, and thus snowmelt regimes have not been changed from natural conditions (USFS 1998).

The average annual water yield from the American River contributes ~20% of the annual flow in the lower Naches River (USFS 1998). The natural hydrology in the American River has been retained. Salmonid production in the American River is probably limited by natural low flows in the summer and fall, which typically range from 50-300 cfs (CBSP 1990). The American River probably plays an important role in the recharge of groundwater aquifers, some of which probably reenters and augments surface waters in the lower Naches River (USFS 1998).

Instream flow recommendations were developed in the mid-1980s (see Instream Flow section at beginning of this chapter), but the TAG does not support implementation of those recommendations at this time. Rather, the TAG supports continued work to develop and implement a normative flow regime that combines "the goal of sustaining ecological integrity of the watershed, while also maximizing use of water resources by humans" (SOAC 1999).

Lakes

There are no lakes within the anadromous zone of the American River.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the American River:

- **Protect integrity of high quality salmonid habitat throughout the American River watershed**
- **Improve riparian vegetation density and function where impaired by roads or dispersed recreation**

Little Naches River 38.0852, NF Little Naches, SF Little Naches, MF Little Naches, and Crow, Quartz, Matthew, Bear, and Blowout creeks

General

The Little Naches River enters the Naches River from the west at RM 44.6; the mouth of the Little Naches marks the upstream end of the Naches River and the downstream end of the Bumping River (CBSP 1990). The Little Naches River supports spring chinook, summer steelhead, coho (historic) and bulltrout, as well as other salmonid and non-salmonid species (WDFW 1998). Bull trout inhabit the Little Naches River and Crow, Quartz and Pileup creeks (USFWS 2001 DRAFT). Until recently, the Little Naches represented no more than a minor spring chinook producer, with moderate amounts of spawning in the lower 4.4 miles (downstream of Salmon Falls)(CBSP 1990).

The upper Little Naches watershed has a long history of natural and human disturbance (Plum Creek 1996). Historically, Native Americans and later trappers, miners, and the first settlers in the middle to late 1800s used trails through Naches Pass and Green Pass at the headwaters of the Little Naches River as major routes between the western and eastern portions of the central cascades. An attempt was made to develop easier access across the Naches Pass trail in the 1850s, but a crude road used by wagon trains was the most development that occurred in the area (USFS 1995, as cited in Plum Creek 1996). Intense grazing of sheep and cattle occurred from the late 1880s to the early 1900s, with steady, although substantially less use up through the 1950s. Grazing in the lower watershed had decreased by 1930; the upper watershed was grazed heavily until the early-1940s (Wissmar et al. 1994). The majority of the upper watershed came under federal jurisdiction in 1893 as part of the Pacific Forest Reserve, with designation of the Norse Peak Wilderness Area. Substantive timber harvest on private and federal lands did not begin in the upper Little Naches until the mid-1970s, with partial cutting at lower elevations and more intense clearcutting in the 1980s-1990s at higher elevations.

The first road in the basin was Forest Road 1900, which was paved in 1934 and ran for 9.7 km upstream from the mouth of the Little Naches. Road densities in the basin have increased significantly in the last 40 years. Until 1962 there were 32-48 km of primary and secondary roads in the basin. Between 1962 and 1990 483 km of new roads were constructed, primarily to accommodate timber harvesting. Most of the private timber lands in the river valleys were completely logged by 1944. Selective timber harvests extended throughout the Little Naches valley through the 1970's. Between 1963-1975, 17% of harvestable acres in the basin had been harvested. Commercial thinning was initiated in 1975 (Wissmar et al. 1994).

A large fire or series of fires in the mid-1800s burned portions of Blowout Creek, Bear Creek, Matthew Creek, and extended through the South Fork and Little Naches River valley. Smaller fires were also noted at the turn of the century in the headwaters of the NF around Pyramid Creek and in the central portion of the Pyramid Creek drainage (Plummer 1902. as cited in Plum Creek 1996). Forest fires have been actively suppressed in the area since at least the 1930s.

The major habitat concerns in the Little Naches are excessive amounts of fine sediments in spawning gravels associated with timber harvest and roads, lack of deep pools and habitat complexity associated with lack of LWD, increased frequency and magnitude of peak streamflows associated with timber harvest, and high water temperatures (Plum Creek 1996). The low frequency of pools and LWD, shallow water, and cobble embeddedness in the Little Naches are the most likely primary factors limiting the production of chinook, if adult escapement was adequate to seed the available habitat. The presence of cobble substrate that is embedded with sand is most likely the primary factor limiting steelhead production, if adult escapement was adequate to seed the available habitat. The relative effects of all habitat impacts on juvenile rearing mortality are probably greater for steelhead than for chinook. However, adult spawner escapements are currently below carrying capacity, the poor quality of spawning habitat may be more important than the quality of rearing habitat conditions. The similarity of chinook escapement trends among the subbasins of the Naches River suggests that stream habitat conditions are currently less likely to be limiting chinook production than factors outside the Naches watershed.

Fish Access

Installation of fish passage facilities at Salmon Falls (RM 4.4) in 1988 allowed anadromous access to approximately 18 miles (252,853 yd^2) of upstream habitat (WDFW 1998, CBSP 1990).

There are no passage barriers to migrating fish at any of the forks of the Little Naches or the mouths of most tributaries, and a significant amount of suitable habitat is available if anadromous salmon populations increase (Plum Creek 1996). However, access to the upper NF Little Naches by spring chinook may be inhibited by a dewatered reach within the NF Little Naches; the increased sediment load from streamside landslides and debris flows has likely caused the stream to flow subsurface in late summer in two reaches, which reduces available habitat and prevents upstream migration of adult chinook.

Floodplain Modifications

The Little Naches and NF Little Naches River have a low gradient (<2%) to within a few kilometers of the Cascade Crest (Plum Creek 1996). The low gradient and broad valley allow large amounts of sediment to be deposited and creates predominantly fine-grained (coarse gravel and smaller) bed material. The mainstem Little Naches and lower NF Little Naches are prone to natural stream migration across the channel migration zone (CMZ).

The lower Little Naches River, downstream of Salmon Falls, was severely degraded by a series of floods in the late-1970s, and by an emergency floodplain reclamation project that removed deposited bedload material, widened the river channel, and destroyed the riparian corridor (CBSP 1990). An extensive instream restoration project was completed at the same time as the Salmon Falls passage in 1988. The project included placement of log weirs, individual boulders, turning rocks, and logs placed or anchored perpendicular to the channel, to catch spawning gravels and LWD, to narrow and deepen the channel for adult passage, and to increase habitat diversity

(Hoefer). The Little Naches River has been channelized in its lower reaches; dike berms are still visible upstream and downstream of the mouth of Crow Creek (Tri-County 2000). Recreational development since the 1950's has contributed to channelization by placement of riprap to protect campgrounds from erosion (Wissmar et al. 1994).

Lack of off-channel rearing habitat is considered a critical limiting factor for spring chinook in the Little Naches River, where streambank cover is deficient (USFS 1994). Loss of off-channel habitat is particularly evident from the mouth to Salmon Falls (~4 miles), which is a much less confined reach than upstream (B. Watson). This reach historically had much greater side-channel habitat; the stream was channelized in the 1980s and is currently comprised of homogenous "ditch-like" habitat.

The majority of observed rearing chinook in the Little Naches were downstream of Sand Cr., likely because most of the spawning occurs in this area (USFS 1994). This area contains 47.7% of the total rearing area available in the watershed, providing rearing habitat for only 16% of the estimated chinook that emerged in 1994. The remainder of emerging chinook would be displaced to other areas for rearing, likely with decreased juvenile survival.

Channel Conditions

The USFS (1994) identified the reach from the mouth of the Little Naches upstream to Sand Creek as the primary area of degraded habitat in the watershed. Survey data from 1990 indicates an LWD rating of poor throughout this area, ranging from 4 pieces/mile at the downstream end to 20 pieces/mile at the upstream end. Upstream of Sand Cr., LWD condition is rated as fair/good. Limited presence of LWD is likely influenced by active removal of LWD from the lower 10.3 miles of the Little Naches following a flood in 1976, and clearing of 149.3 acres of stream channel on the Little Naches and 0.7 acres of the lower 0.5 miles of stream channel of Crow Creek in 1979 following a flood (USFS 1994). Both channel cleaning efforts were part of flood rehabilitation efforts, with use of heavy equipment in the channel and salvage or burning of the removed debris on gravel bars.

Plum Creek (1996) identified the mainstem Little Naches up through the NF as the primary area lacking LWD. In segments surveyed by the USFS (1994), only 0.14 pieces/channel width were found in the mainstem (only pieces >50cm diameter were considered functional, due to size of channel and need for larger key piece LWD), and an average of 0.18 pieces/channel width were found in the NF Little Naches; both well below the indicated westside target of 2 pieces/channel width. The lower portions of Matthew, Bear, and Blowout creeks were indicated as having low counts of LWD (pieces >15 cm diameter were considered as functional LWD) and low recruitment potential. Lower Fawn Creek was indicated as also having low LWD recruitment potential. They identified that natural stream migration and flooding may lead to naturally low levels of shade and LWD in these areas, but also noted that the stream cleanout activities in the 1970s (see above) significantly reduced the presence of LWD. Other stream reaches in the upper Little Naches watershed with reduced LWD recruitment potential due to timber harvest include Pyramid Creek, Fawn Creek, Blowout Creek, Matthew Creek, and Bear Creek.

The frequency of large pools increased in the Little Naches from 1.7 pools/km in 1935 to 4.6 pools/km in 1990 (Wissmar et al. 1994)., with the majority of the increase in the unconstrained reaches (Smith 1993). The increase in pool frequency is likely due to a number of factors, with the most likely being recovery from the period of intense grazing and large wildfires in the watershed from 1880 to 1930, and the designation of large tracts of wilderness in the upper watershed. However, pool frequency remains below the standards identified in the Forest Plan.

Pool numbers were significantly different between constrained and unconstrained reaches in 1935, but not in 1990. The difference in pools between constrained and unconstrained reaches in 1935 implies that pool habitat was more heterogeneous and complex in 1935 than in 1990. Unconstrained reaches typically have the potential for higher number of pools because of pool development at meander bends, which recruit and retain large structural elements that facilitate pool formation (Lisle 1986, as cited in Smith 1993). The lack of a significant difference in pools between constrained and unconstrained reaches in 1990 indicates that these reaches display less complexity because of bank erosion and downcutting through the streambed.

Percent pools and percent primary pools are rated as poor/fair downstream of Sand Cr. and fair/good further upstream (USFS 1994). USFS surveys indicated that pools compose a small proportion of the fish habitat, ranging from 1.7 to 39.5% in nearly all stream reaches (Plum Creek 1996). The mean residual depth of pools in all but three of the surveyed tributary reaches is less than or equal to 2 feet deep, and pools in the mainstem channel are <3 feet deep. Although these shallow pools may be suitable for rearing salmonid fry, they are poor for yearling and older salmonids, and are not suitable for spring chinook adult holding during summer and early fall. Upstream of Salmon Falls, habitat is considered pristine, with abundant spawning gravel, excellent riparian condition, adequate summer flows, and plentiful LWD and instream cover (CBSP 1990).

Substrate Condition

The low gradient and opportunity for sediment storage on floodplains of the NF and mainstem Little Naches indicate a residence time for sediment in the watershed that is likely on the order of hundreds, if not thousands of years (Plum Creek 1996). The lower portion of the Little Naches has probably been downcutting through stream deposits since the early 1900s, indicating that sediment is being exported faster than it is being delivered. Removal of instream LWD for flood control may have also contributed to downcutting in the last few decades.

For the most part, the major tributaries to the mainstem Little Naches (upstream of the confluence of Pileup Creek) and NF Little Naches are transport channels, with gradients ranging from 2-8% (USFS 1994). The mainstem Little Naches consists solely of response segments (except for one mile upstream of Sand Cr.), which are not saturated with excess sediment. Large inactive landslides (several km^2 in area) are common throughout the lava flow, ejected volcanistic rock, and thin sedimentary rock dominated terrain on the south side of MF Little Naches River (Plum Creek 1996).

Deposition of fine sediments has increased since the initiation of large-scale clearcutting in the upper watershed (CBSP 1990, WDFW 1998). General consensus among local fisheries biologists is that fine sediment in spawning gravels is one of the major problems relative to fish habitat in the Little Naches watershed (USFS 1994, Plum Creek 1996). Sampling by the YN since 1985 in the Little Naches and NF Little Naches documented increases in presence of percent fines (<0.85mm), increasing from 10% to 20% for the Little Naches, and from 8% to 19% for the NF Little Naches (Matthews 1994, as cited in USFS 1994). In 1993, fine sediment in all reaches in the Little Naches ranged from 18% to 24.1%. Significant increases in mud/sand presence in the substrate from 1935 to 1990 were also documented by Smith (1993, as cited in USFS 1994).

While the watershed can be expected to be naturally prone to fine sediment delivery, timber harvest, roads and dispersed recreation are felt to be contributing. In 1992, 215 miles of road were surveyed in the watershed, 55% were determined to have potential for sediment delivery to streams with 20% showing evidence of actively delivering fine sediment. Since then road

improvements (improved drainage, surfacing, stabilizing cut slopes) and road obliteration have been completed on approximately one-half the problem road segments. In the past 3-4 years fine sediment in spawning gravels has been on a downward trend (Dawson 1999, as cited in USFWS 2001 DRAFT).

Between 1935 and 1990, greater confinement of 80% of the main channel of the Little Naches River by roads and riprap forced the channel to scour down through the bed, displacing both small and large sized substrates (Smith 1993). In the downstream reaches, repeated scouring of the channel bed exposed bedrock, creating coarse streambeds and more frequent and larger pools (Wissmar et al. 1994). The presence of large rubble increased significantly, comprising about 47% of the total surface area. Medium rubble changed little, remaining at about 28% of the substrate. In addition, streambed embeddedness has increased significantly, with >50% of the surface substrate >30% embedded with fine sediments, affecting the quality of the substrate for spawning and rearing. Excessive sediment supplies from gravel roads and compacted areas along with peak flow events act together to increase the total channel area while decreasing spawning area. The retention of larger sized particles and loss of small gravels, and the observed embeddedness of the larger sized substrate, could increase the effectiveness of moderate discharge levels to transport gravels, and therefore reduce presence of suitable spawning substrate.

The amount of gravel available for spawning by chinook, steelhead, and resident trout is generally not a concern in the upper Little Naches watershed, except possibly in the lower NF (Plum Creek 1996). Gravel is the dominant bed material in the mainstem, and is either dominant or subdominant in all potential anadromous spawning areas in the tributaries, except for the lower NF, where cobble and sand are the dominant and subdominant substrate.

USFS surveys observed cobble embeddedness >35% of the cobble depth at stream reaches in Matthew, MF, Pyramid, and NF creeks (Plum Creek 1996). Over winter survival of juvenile steelhead can be significantly reduced by cobble embeddedness, because of the reduction of interstitial space available for refuge habitat.

The potential for sediment delivery to streams is relatively high, with 36.3% of the watershed rated as high sediment hazard, and 35% rated as moderate hazard (USFS 1994). The highest incidence of debris flows and streamside landslides in the upper Naches watershed is in the NF Little Naches (Plum Creek 1996). Timber harvest in riparian areas, as well as the 1988 Falls Creek fire, likely increased the incidence of streamside landslides. Other drainages with a high probability of debris flow initiation include Blowout Creek, Bear Creek, and Matthew Creek. Within the NF Little Naches, the increased sediment load from streamside landslides and debris flows has likely caused the stream to flow subsurface in late summer in two reaches, which reduces available habitat and prevents upstream migration of adult chinook. In the remainder of the upper Little Naches watershed, deep-seated landslide toes probably have the greatest effect on channel location and sediment input. Where deep-seated landslides impinge upon stream channels, sediment is consistently being eroded into the water, locally increasing levels of fine sediment in the streambed.

The average road density in the upper Little Naches watershed (upstream of Pileup Creek) is 2.6 mi/mi^2, but the amount of road length delivering sediment to streams is relatively small (Plum Creek 1996). The Pyramid Creek drainage had the highest relative sediment production, exceeding natural background inputs by ~44%; other drainages typically averaged increased inputs of <20%. Even though sediment production from roads in the upper Little Naches was considered relatively low, management prescriptions were developed to minimize sediment

delivery from roads. High fine sediment levels may also be associated with wildfires that have occurred in portions of the upper Little Naches, the largest of which occurred in the late 1800s. Hillslope erosion from forest management activities was not considered to be a widespread problem, but compaction on fine-grained stream-deposited soils, broadcast burning on steep slopes, and skid trails from cable yarding on steep slopes were identified as sources of fine sediment delivery to streams. Bank erosion and road erosion were estimated to have contributed half the amount of fine sediment, as compared to a combination of erosion from the Falls Creek fire, landslides in the NF, and natural downslope soil creep. It is unlikely that reductions in sediment production from forest practices can significantly reduce fine sediment levels in the short-term (decades), although reductions in sediment supply may show local or long-term improvements in substrate quality.

There is also an indication of potential for redd disturbance from gravel scour and fill in the mainstem and NF Little Naches (Plum Creek 1996). Burial of five modified Whitlock-Vibert boxes at each of nine spawning gravel monitoring riffles during the winter of 1992-93 found that after 10 months in the streambed, all but one of the riffles had been disturbed by scour or fill. All of the boxes were buried at one riffle, all were lost at two riffles, and many were shifted or rolled at five riffles. No information is available to indicate the extent to which observed gravel instability may compare to natural rates. Gravel instability may be exacerbated by low LWD presence and increased peak flows, both of which are identified as concerns in the Little Naches watershed. If redd scour and fill are problems, chinook have a higher risk of being impacted than do steelhead or resident trout. Because chinook spawn in the fall, redds are typically located closer to the stream thalweg, and are subject to fall/winter rain-on-snow events.

Riparian Condition

Riparian condition is excellent upstream of Salmon Falls (CBSP 1990, WDFW 1998), but is severely degraded from the mouth to Salmon Falls (B. Watson). There are areas upstream of Salmon Falls where riparian condition is impaired, including along the 1900 Road, through the Crow Creek campgrounds, and through dispersed camping sites located along the streams (Hoefer). The 1900 road is immediately adjacent to the river channel and confines the river channel (USFWS 2001 DRAFT). Much of the riparian vegetation on left bank in the lower 5 miles of the river has been permanently removed coincident with the highway construction.

Riparian canopy was assessed to determine if removal of stream shading has impacted stream temperatures. The subwatershed with maximum riparian removal was Pyramid Creek, with 26% of the perennial stream miles with riparian removal; even with this removal, water temperatures averaged 56°F. Water temperatures on tributaries to the Little Naches most likely have been affected by removal of riparian shading, but because of the high elevation and topographic shading, the temperature increases are not significant (USFS 1994). However, there are numerous areas along the Little Naches where riparian canopy has been removed. The lack of riparian shading along the Little Naches appears to be the major influence causing high summer maximum temperatures (USFS 1994). The Little Naches has very little quality edge habitat for rearing due to the lack of riparian vegetation and LWD (USFS 1994).

Smith (1993, as cited in Snyder and Stanford 2000 DRAFT) documented changes in the riparian community in the lower Little Naches River using aerial photographs from 1949, 1962, and 1985. Conifer stands decreased from 66% to 12% on the left bank, vegetated areas decreased from 72% to 47% on the left bank, and canopy opening increased from 36 to 67 m on the right and left banks. These changes were attributed to a combination of anthropogenic and natural disturbance events, including selective harvest in the 1960s, major flood events in 1964 and 1977, highway

and revetment construction, and increased recreational use. Similar change in percent conifers was observed in the upper Little Naches, where riparian width actually decreased (attributed to delayed timber harvest until 1975 vs. 1960s). These changes indicate a decrease in shade and potential supply of LWD, as well as a potential for increased bank erosion and sediment input. Potential long-term impacts of timber harvesting in riparian areas along the Little Naches River have been identified as chronically eroded areas in aerial photographs (Wissmar et al. 1994). Since the rise in recreational use for the Little Naches basin, the increasing amount of vehicle traffic and off road equipment has reduced understory vegetation and decreased the rooting strength of the soil, effectively increasing erosion rates near stream banks and road crossings (Wissmar et al. 1994).

The Little Naches and NF Little Naches have low shade levels due to channel migration and it will be difficult to meet shade target levels (Plum Creek 1996). Natural meadows along Fawn Creek, Middle Creek, Blowout Creek, and Bear Creek also limit potential shade levels. Timber harvest was noted as reducing shade levels in the upper NF, and shorter portions of Fawn Creek, MF Little Naches, Pyramid Creek, Blowout Creek, Bear Creek, and Matthew Creek.

Water Quality

General water quality in the Little Naches is excellent (WDFW 1998). Excursions from state water quality standards for water temperature have been documented on several tributaries to the Little Naches River. Bear, Blowout, Mathew, and Crow creeks are listed on the CWA Section 303(d) impaired water quality list for temperature. Similar summer exceedances were also noted in Fawn Creek and NF Little Naches (Plum Creek Timber 1996, as cited in Tri-County 2000). Impaired water quality from these creeks may affect habitat suitability at the confluence of these creeks with the little Naches River, although spring chinook and summer steelhead are known to use the lower portions of these creeks, and bull trout have been observed in the lower portions of Crow, Quartz, and Pileup creeks (Hoefer). Recording thermograph measurements over a period of at least four years indicate that in general, temperatures in tributaries are meeting the state water quality standard of 61°F. Temperatures in the Little Naches have consistently averaged in the 65-70°F range (USFS 1994).

Water Quantity

Precipitation ranges from 35 inches/year near the mouth to >100 inches at the Cascade Crest, with ~60% of the watershed receiving >60 inches/year (USFS 1994). The majority of the watershed is within the highland (45, 316 acres) or snow-dominated (42, 813 acres) zones. In addition, 7,214 acres are within the rain-on-snow zone. The average annual water yield is 246,700 acre-feet for the period of record. Average monthly flows vary from a low of 47 cfs in September to a high of 719 cfs during normal peak snowmelt in May, with peak flows in the 5,000-10,000 cfs range (25-50 year recurrence interval). Most peak flows on the Little Naches are generated from spring snowmelt, although winter rain-on-snow floods are common and account for the largest floods of record (Plum Creek 1996).

There are no permanent surface water diversions within the Little Naches watershed (USFS 1994).

There is much concern that clearcutting and fires in the upper drainage may increase peak flows, possibly to damaging levels, as well as decreasing already marginal summer low flows; however, there is no conclusive evidence of a change in the hydrograph (CBSP 1990, WDFW 1998).

Average flows in the Little Naches River have been compared to those in the nearby American River (USFWS 2001 DRAFT). Prior to the period of intensive timber harvest and road construction (1966-1975), flows in the Little Naches were comparable to those in the American River. However flows in the Little Naches (1981-1994) after intensive timber harvest and road construction are higher than those in the American for the same period.

Observed changes in streamflow quantities (reductions in average flows over the last 30 years) and timing (shifts in peak flows to March-May from the pre-1975 May-June period) may be related to forest management activities since the late 1970s, but it is unlikely that any significant change can be detected from the gage records (USFS 1994). However, an analysis of increased channel network due to road interception of runoff for each subwatershed indicated increases as high as 33% for the Pyramid Creek subwatershed, with 47% of the watershed in stands <35 years old and a road density of 3.7 mi/mi^2. The watershed assessment team concluded, based primarily on studies in the scientific literature, that the potential existed for significant changes in streamflow due to the amount of hydrologically immature vegetation in the upper Little Naches watershed, with the highest proportion of immature vegetation and the greatest potential increases in peak flows in the Pyramid Creek, Blowout Creek, and NF Little Naches drainages (Plum Creek 1996). They estimated that spring snowmelt peak flows may have increased 10-40% and timing advanced 1-2 weeks by timber harvest in the Little Naches watershed, although the need for further study was identified to determine the magnitude of change or potential impact to fish habitat.

Instream flow recommendations were developed in the mid-1980s (see Instream Flow section at beginning of this chapter), but the TAG does not support implementation of those recommendations at this time. Rather, the TAG supports continued work to develop and implement a normative flow regime that combines "the goal of sustaining ecological integrity of the watershed, while also maximizing use of water resources by humans" (SOAC 1999). Instream flows recommendations made by USFWS (Simmons) exceed natural unregulated flows in the Little Naches River (Perala).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Little Naches watershed:

- **Restore natural floodplain function and riparian condition from the mouth upstream to Salmon Falls; protect the integrity of functional channel migration zones elsewhere in the watershed**
- **Assess potential to consolidate forest ownership, increasing protection for streams in the watershed**
- **Develop and implement a road management plan for the Little Naches watershed, as road construction and use are a common causal mechanism for many of the identified habitat problems (USFS 1994)**
- **Restore and maintain hydrologic maturity in the watershed**
- **Develop and implement a short-term LWD strategy downstream of Salmon Falls and in the NF, to provide LWD presence and habitat diversity until full riparian function is restored**

Wenas Creek 39.0032

General

Wenas Creek is a right bank tributary to the lower Yakima River, entering at RM 122.4. The Wenas watershed is 192 mi^2 in size (NYCD), with 72% in the snow-dominated zone, and 28% in the highland zone (USFS 1995). Historically, it was probably a small productive coho stream also utilized by steelhead (YSS 2001 DRAFT) [historic utilization by anadromous salmonids is unknown and speculative (Perala); review of early settlers documents (the valley was first settled in 1865 and almost completely settled by 1877) does not indicate salmonid presence in any portion of Wenas Creek (Gene Jenkins)]; currently Wenas Creek supports summer steelhead rearing from the mouth upstream to Cottonwood Creek. The lower reaches are also presumed to have historically supported spring chinook rearing and potential spawning. Coho probably spawned primarily in side-channels of the mainstem, and steelhead primarily in the tributaries, although spatial overlap probably occurred. The mainstem of Wenas Creek ascends a broad, alluvial valley for 22 miles before branching into the NF and SF. Downstream of the forks, the creek is unconfined, of moderate slope (1-2%), anastomosing, with a cobble/gravel substrate; the forks and tributaries flowing off the slopes of Manastash Ridge and Cleman Mountain are steeper (3-4%) pocket-water type streams with patch gravel.

Except for the uppermost portion of the mainstem and its forks, the Wenas Creek of today bears little resemblance to historic Wenas Creek (YSS 2001 DRAFT). This creek is severely impacted by heavy irrigation diversion and severe riparian damage. Salmonids are not known to currently use Wenas Creek downstream of RM 14, except for summer steelhead rearing downstream of RM 1.4 (mouth of Cottonwood Creek).

Fish Access

A storage reservoir with an impassable dam was built at RM 14.7 in 1911 (Gene Jenkins), blocking access to the upper drainage (YSS 2001 DRAFT). The Wenas Irrigation District, formed in 1925, purchased and enlarged the dam in 1925; the dam was further enlarged in 1983 to the present size (Gene Jenkins). A control structure at RM 12 diverts the stream into two channels to facilitate irrigation withdrawals (YSS 2001 DRAFT). These channels reconnect six miles downstream. Summertime irrigation withdrawals from the creek and the channels remove all surface water from RM 9-14. Flows downstream of RM 9 are intermittent, and only minimal where present. Substantial irrigation with well water in the lower valley likely also contributes to low flow in the creek. These low-flow conditions persist into the winter as Wenas Reservoir is refilled.

Floodplain Modifications/Channel Condition

Floodplain function downstream of the dam (RM 14.7) has been altered by channel incision, caused by combined effects of channelization, gravel scalping from bars in the channel, and unrestricted livestock access to the channel. In addition, some historic floodplain side channels have been filled and graded, and converted to agriculture.

Substrate Condition

Bank sloughing is common in the heavily grazed area downstream of RM 9, and the streambed consists of mud and silt (YSS 2001 DRAFT).

Riparian Condition

Historic riparian vegetation near the mouth consisted of cottonwood and willows, changing to alder/aspen/cottonwood/Ponderosa pine nearer the forks, with Douglas fir in the headwaters (YSS 2001 DRAFT). Currently, downstream of RM 9 the creek flows through areas heavily used for grazing, and riparian vegetation is virtually nonexistent. Riparian condition appears to improve from RM 9 to the dam, but condition rating is unknown. Upstream of Wenas Lake, riparian condition is fair/good (NYCD). There is good potential for riparian restoration in lower Wenas Creek, as ownership is by a limited number of landowners, who have indicated an interest and willingness to attempt riparian restoration.

Water Quality

Water temperatures in those portions of Wenas Creek that retain surface flows during the irrigation season may exceed 80°F (CBSP 1990). These water temperatures are the result of severe riparian damage (CBSP 1990, WDFW 1998) and impoundment of a small lake upstream of Wenas Lake Dam (RM 14.7), which likely increases water temperature (WDFW 1998). Water passed downstream of the lake during the irrigation season is drawn from the bottom of the lake (NYCD). The North Yakima Conservation District is collecting water temperature data for Wenas Creek, but the data have not yet been analyzed. The Upper Yakima suspended sediment and pesticides TMDL technical committee is setting goals for sediment reduction in the upper Yakima River watershed (Creech).

Water Quantity

Wenas Creek is included on the CWA 303(d) impaired water quality list for impaired instream flow. The Wenas Creek watershed has limited potential for additional storage to augment instream flows. The stream is over-appropriated for irrigation, and without additional instream flow, has virtually no potential for production of anadromous salmonids (CBSP 1990). Historic unregulated maximum and minimum mean monthly flows at the mouth were estimated at 140 cfs in May, and 15 cfs in September (HKM 1990, as cited in YSS 2001 DRAFT). However, flow modeling by NRCS in 1997 estimated bankfull flow (~2 year recurrence interval) at 270 cfs, which differs substantially from the HKM estimates (NYCD). The BOR was interested in pursuing acquisition of the dam and associated water rights to restore instream flows in lower Wenas Creek, but there are no longer any discussions between BOR and the Wenas Irrigation District on this proposal (Gene Jenkins).

Instream flow recommendations were developed in the mid-1980s (see Instream Flow section at beginning of this chapter)(the total flow indicated in these recommendations exceeds the naturally occurring flows in Wenas Creek (Gene Jenkins)), but the TAG does not support implementation of those recommendations at this time. Rather, the TAG supports continued work to develop and implement a normative flow regime that combines "the goal of sustaining ecological integrity of the watershed, while also maximizing use of water resources by humans" (SOAC 1999).

Lakes

Wenas Lake, at RM 14.7, was constructed in the early 1930s as an irrigation storage reservoir, and the reservoir also provides recreational fishing opportunities. The dam at the outlet of the lake does not have fish passage. Water retention in the lake also results in increased water temperatures that would likely be lethal to salmonids. Water released downstream of the dam is drawn from the bottom of the reservoir.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Wenas Creek:

- **Implement a comprehensive grazing program to protect riparian vegetation and streambank stability**
- **Restore instream flow downstream of Wenas Lake dam, particularly in early fall**
- **Develop and implement a short-term LWD strategy to provide LWD presence and habitat diversity until riparian function is restored**
- **Restore floodplain function throughout, including reestablishment of side-channel habitats**
- **Restore riparian function throughout watershed, particularly in the lower reaches**
- **Restore anadromous fish passage upstream of Wenas Lake**

Lmmuma (Squaw) Creek

General

Lmmuma Creek is a left bank tributary to the Yakima River, entering the Yakima Canyon just upstream of Roza Dam. The Lmmuma Creek watershed drains an area of 112 mi^2 (KCCD 1999). Approximately 72% of the watershed lies within the Yakima Training Center. Uplands are dominated by range vegetation, and precipitation averages ~8 inches annually (mostly snow).

Although located in an arid sagebrush canyon, Lmmuma Creek has perennial surface flow and likely provides rearing habitat for spring chinook, steelhead, and possibly coho in the lower reaches, and may provide spawning habitat for steelhead during the spring snowmelt runoff (Renfrow, Pearson). Resident salmonids are known to occur to upstream of I-82 (Renfrow).

The riparian zone has been damaged by many years of intense grazing by livestock and by military maneuvers with both wheeled and heavy tracked vehicles (Renfrow). Many areas of stream are deeply incised, the water table has been reduced and woody riparian vegetation, particularly large trees, are lacking. There is little LWD or LWD-related pools.

WDFW staff indicate there were historically cottonwood stands along lower Lmmuma Creek (KCCD 1999). Riparian condition has been impaired in the watershed by grazing in the lower watershed and by roads on the Yakima Training Center. Yakima Indian Nation staff have recommended reintroduction of beaver in lower Lmmuma Creek. The lower 7-8 miles of Lmmuma Creek are owned by a single landowner, which may provide unique opportunities to pursue restoration through conservation easement, CREP, or acquisition.

USGS water quality sampling in lower Lmmuma Creek near Wymer, in August 1986, reported a flow of 1.8 cfs and water temperature of 19°C (KCCD 1999). Water quality sampling in 1983-1984 near the mouth indicated flows of 2-9 cfs, with summer flows from 2-3 cfs. Water temperatures exceeded 18°C on four occasions, with a peak temperature of 23.2^{o}C in June 1983. Turbidity during runoff events may be elevated (suspended sediment of 15.3 mg/l in March 1989), pH levels range from 7.7-9.0 (1983-1984, water quality standard threshold is 8.5) and nutrient levels were relatively high (1983-1984). The Upper Yakima suspended sediment and pesticides TMDL technical committee is setting goals for sediment reduction in the upper Yakima River watershed (Creech).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Lmmuma Creek:

- **Reestablish historic cottonwood riparian areas in the lower reaches with perennial surface flow**
- **Reintroduce beaver into the lower watershed**
- **Restore natural riparian function throughout watershed**
- **Maintain riparian roads on Yakima Training Center to reduce erosion of fine sediments to stream**

Roza Creek 39.0371

General

Roza Creek is a right bank tributary to the lower Yakima River, entering at RM 127.9. Roza Creek is not known to support anadromous salmonids (WDFW 1998). The lower portion of Roza Creek has a number of large beaver ponds, which could provide salmonid rearing and possibly spawning habitat, but there is no open surface water connection with the Yakima River except during higher river flows (Renfrow, Pearson). A primitive dirt road (currently closed to access) is located immediately adjacent to the lower 3 miles of Roza Creek (left bank). Presence of this road limits riparian and possibly floodplain function, and is a potential source of fine sediment; road abandonment should be pursued. The Upper Yakima suspended sediment and pesticides TMDL technical committee is setting goals for sediment reduction in the upper Yakima River watershed (Creech).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Roza Creek:

- **Retain beaver activity in lower reaches**
- **Evaluate riparian condition in lower reaches; restore riparian function, as warranted**
- **Evaluate surface water connection with Yakima River; restore connection if impaired by human-caused actions**
- **Abandon dirt road adjacent to lower 3 miles of creek**
- **Evaluate spawning potential in stream**

Umtanum Creek 39.0553

General

Umtanum Creek is a right bank tributary to the lower Yakima River, entering at RM 139.8, approximately in the middle of the Yakima Canyon (YSS 2001 DRAFT). The watershed lies between Umptanum and Manastash ridges, and has very few roads and no development in the anadromous zone downstream of the falls at RM 7.8. However, habitat function is significantly impaired by presence of roads, residential development, and grazing upstream of the falls. The creek drains approximately 64 mi^2 (KCCD 1999) of arid and rugged terrain, and is approximately 16 miles in length (CBSP 1990). Umtanum Creek supports spring chinook (rearing) and steelhead, as well as other resident salmonids and non-salmonids (WDFW 1998). A good run of coho is reported to have used this stream prior to the construction of Pomona Dam in the late 19th century (Bryant and Parkhurst, as cited in YSS 2001 DRAFT).

Fish Access

Anadromous salmon access may be currently limited to downstream of RM 4.8 (Old Durr Rd.), where a large gabion structure, intended to protect a pipeline crossing, is a fish passage barrier (YSS 2001 DRAFT), particularly at low flows. If this barrier were corrected, access would extend to an impassable falls at RM 7.8 (CBSP 1990, WDFW 1998, YSS 2001 DRAFT). In addition, fish access and passage is impaired during the summer by low instream flows in the lower and middle part of the anadromous reaches (CBSP 1990).

Floodplain Modifications

There is little development in the accessible anadromous area in the lower 7.8 miles, and adjacent rangeland is currently only lightly used. Historically, grazing pressure was much greater, adversely affecting riparian function (Renfrow). As a result, the stream is now entrenched in many locations and flood flows do not access the floodplain. Natural floodplain function upstream of the falls (RM 7.8) has been severely degraded by overgrazing.

Channel Condition

Within the anadromous reach, the channel is sinuous but somewhat entrenched (Renfrow). Eroding streambanks are common on the outside of meanders. Since approximately 1977 (when grazing practices changed), beaver activity has locally increased the water table and encouraged recovery of the channel and floodplain. However, the channel is not yet able to withstand flood events without substantial bank erosion.

Substrate Condition

Soils in the watershed include shallow, stony, and cobbly loams in higher areas with deeper clay loams and loams in the drier rangelands to the east (NRCS Soil Survey as cited in KCCD 1999). Erosion risk is generally moderate, except in steeper draws, where erosion risk is rated as very high. Sedimentation and substrate are good downstream of the falls, with spawning gravel present in all areas, and abundant gravel in some areas (CBSP 1990, YSS 2001 DRAFT).

Riparian Condition

The deciduous and brushy riparian habitat downstream of the falls is considered to be nearly pristine (CBSP 1990, KCCD 1999, YSS 2001 DRAFT). Riparian condition was impaired in this area, but has naturally recovered since 1977 (Renfrow). Riparian condition upstream of the falls is overgrazed and badly degraded, and would benefit from cattle exclusion fencing to restore riparian function and additional summer flows.

Water Quality

Umtanum Creek is designated as Class A (excellent) waters (WAC 173.201(a)), which determines which water quality parameters need to be met. Water quality is rated as fair downstream of the falls, likely impaired by unrestricted cattle access upstream of the falls and associated loss of instream flow (CBSP 1990). USGS water quality sampling in 1989-1990 measured flows of 1.0-3.6 cfs and water temperature of 16.5^{o}C in late June 1989; nutrient levels were low, and dissolved oxygen, turbidity, and pH levels were acceptable (KCCD 1999). USGS water quality sampling for pesticide presence in August 1999 detected the presence of 1 pesticide compound (EPTC) in Umtanum Creek at Umtanum (Ebbert and Embrey 2001). The Upper Yakima suspended sediment and pesticides TMDL technical committee is setting goals for sediment reduction in the upper Yakima River watershed (Creech).

The condition of invertebrate communities in Umtanum Creek was ranked as unimpaired, and as one of the highest quality sites in the Yakima watershed for benthic invertebrates (Cuffney et al. 1997).

Water Quantity

The waters of Umtanum Creek are used for livestock watering in the forest and range areas (KCCD 1999). There are no known irrigation diversions. The riparian zone is overgrazed above the falls and the streambed dries up seasonally (KCCD 1999). Whether and to what extent overgrazing impacts affect instream flow during low flow periods is unknown. In August 1988, flows of barely 1 cfs were estimated in the lower and middle part of the accessible anadromous reaches (CBSP 1990). Flows are sometimes intermittent at RM 10, due to a long history of overgrazing and subsequent channel downcutting (YSS 2001 DRAFT). In dry years, the creek also becomes intermittent from RM 0.5 to 0.8. Overall, instream flows are rated poor/fair (CBSP 1990, WDFW 1998). Yakama Nation staff has recommended reintroduction of additional beaver colonies into the watershed upstream of the falls (KCCD 1999). There are already beaver upstream of the falls, but presence is limited to a short reach (Renfrow). The road is located immediately adjacent to the stream through much of this reach, and the Yakima County Public Works Dept. has battled beaver dam impacts to the road for years. It is likely that trapping/removal to address their concerns has limited the expansion of the colonies. Increased presence of beaver dams would capture sediment, increase floodplain water storage (and potentially enhance summer base flows), and restore riparian function. Limited presence of woody riparian vegetation in the upper watershed may limit support capability for additional beaver colonies (Chain).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Umtanum Creek:

- **Evaluate fish passage status at varying flows at gabion structure at RM 4.8 (Old Durr Rd.); correct problems as warranted**
- **Protect high quality riparian condition from the mouth to the falls**
- **Implement a comprehensive grazing program upstream of the falls to protect riparian vegetation and bank stability, and to reduce fine sediment and nutrient input to Umtanum Creek**
- **Restore beaver colonies upstream of the falls to increase floodplain water storage and associated summer low flows**

Manastash Creek 39.0988

General

Manastash Creek is a right bank tributary to the lower Yakima River, entering at RM 154.5. The creek branches upstream of RM 8.5 into the 12-mile long NF and the 20-mile long SF (CBSP 1990). Manastash Creek currently supports spring chinook (rearing juveniles) upstream to the seasonal irrigation diversion dam at Barnes Road (spring chinook spawning could potentially occur in this reach in years when sufficient flow is available (Renfrow)). Spring chinook spawning is typically currently limited to the confluence with the Yakima River, due to lack of sufficient surface flows across the delta fan for upstream adult migration during early fall. Summer steelhead are potentially present upstream into both forks. However, there are six active irrigation diversion dams that are passage barriers at various flow conditions. Manastash Creek historically supported these species and coho into the upper reaches of both forks. The creek contains excellent spawning and rearing habitat for anadromous salmonids, but instream flows are severely impacted by irrigation diversions during the irrigation season.

The lower 5 miles of the mainstem flow through fields and pastures. The lower portion of the Manastash Creek watershed has been experiencing significant suburban growth, with numerous short plats created since the mid 1990s (KCCD 1999).

Manastash Creek rainbow trout productivity was near the average of ten upper Yakima tributaries that were evaluated (Pearsons et al. 1994, as cited in KCCD 1999). The three main factors that limit salmonid production in Manastash Creek are barriers to upstream fish passage, unscreened water diversions that entrain juvenile salmonids, and low streamflows (CBSP 1990).

Fish Access

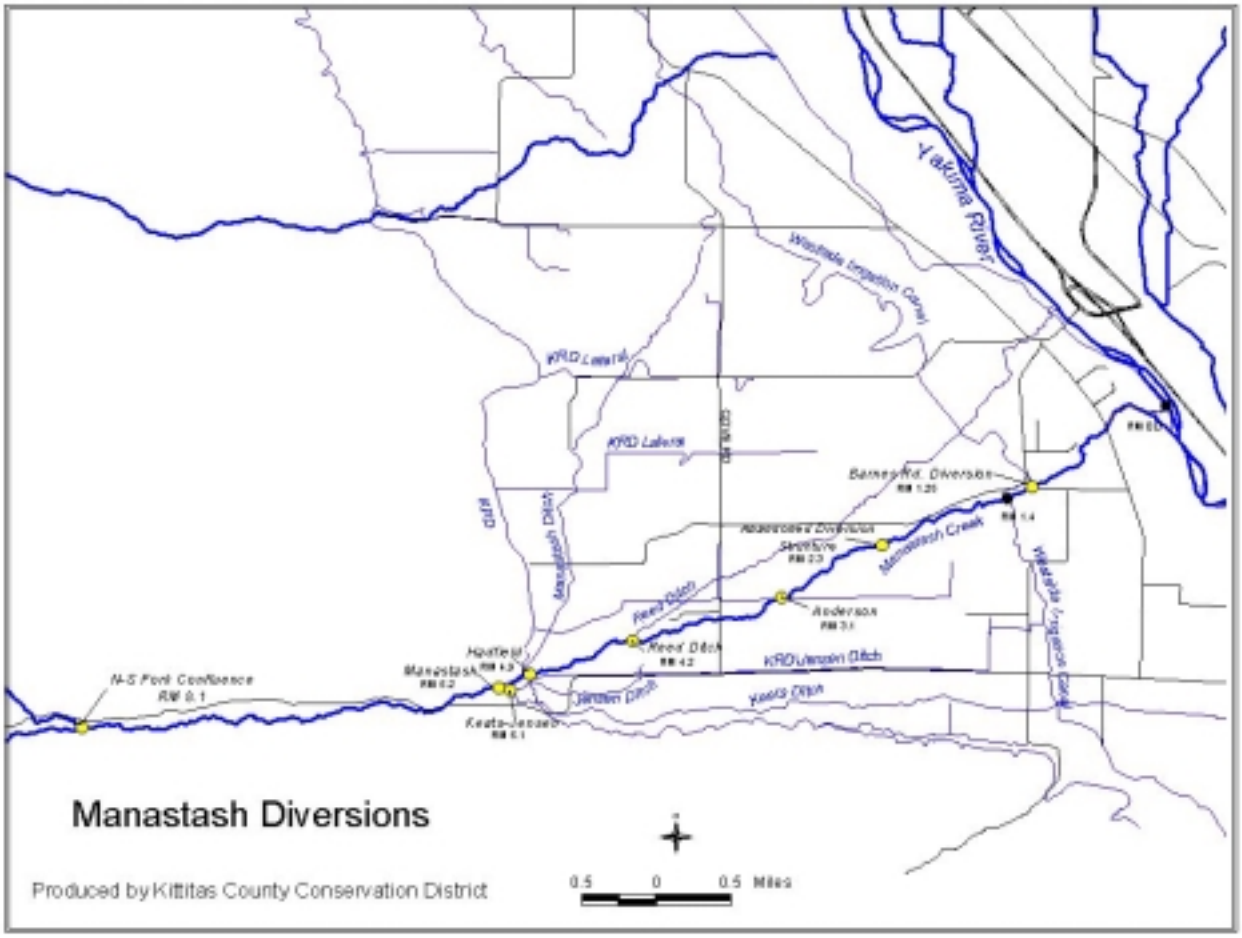
Natural runoff in Manastash Creek is fully appropriated for irrigation. Typically, there is no surface flow from mid-July through October from just below the diversion at RM 4.2 downstream to just upstream of the Westside Ditch Crossing (~RM 1.5). The lack of flow is due in part to irrigation diversions, although remaining flows go subsurface just downstream of the diversion at RM 4.2(KCCD), precluding fall-spawning adult salmonid access to high quality spawning habitat upstream (WDFW 1998, CBSP 1990, YSS 2001 DRAFT). Flow in the lowermost 1.4 miles is comprised primarily of groundwater return seepage (YSS 2001 DRAFT) and operational spill from the Westside Canal (some of which is diverted at the Barnes Road diversion (KCCD)), amounting to 4-5 cfs at the mouth (YSS 2001 DRAFT). Lack of concentrated surface flows across the delta fan during low flow periods impairs upstream fish passage. Although lack of instream flow is exacerbated by irrigation withdrawals, flow is also affected by the rocky porous

substrate, particularly in the reach just downstream of the diversion at RM 4.2 to Serenity Lane (KCCD).

Many miles of spawning and rearing habitat remain relatively undisturbed upstream of the diversions, but are presently inaccessible because of both upstream and downstream passage problems at the diversions. Six active gravity diversions divert water from Manastash Creek between RM 1.25 and 5.2 (KCCD, YSS 2001 DRAFT); all are partial or total barriers to all life stages, and none of them are screened.

An assessment of water diversions on Manastash Creek, conducted by Yakama Nation biologists in 2000, identified 5 irrigation pumps and 7 gravity irrigation diversion structures (2 of these were not in use)(Hank Fraser, YN). These diversions are shown in Figure 49 (KCCD). Only one of the pump intakes was screened (although probably not to NMFS criteria), and none of the gravity diversions are screened. The Barnes Road diversion (RM 1.25) is a seasonal barrier to adult migration at low flows and a barrier to juveniles at all flows; adult coho and steelhead can probably pass this diversion at higher flows that typically occur during their spawning migrations (Nicolai, Monk). The diversion at RM 2.3 is an abandoned concrete structure with a head of 8 feet that may be a fish passage barrier; the creek has scoured under the concrete structure, fish passage may be possible at low flows, but high velocities likely impair fish passage at high flows.

Figure 49: Map showing water diversions on Manastash Creek (courtesy of KCCD)



The new diversion (right bank at RM 3.1) that replaced the diversion at RM 2.3 is a spanning pole structure with hay bales upstream; no instream flow was present in June-July, so no evaluation of fish passage during higher flow conditions could be made. The diversion at RM 4.2 is formed by a broad concrete sill, with approximately 5 feet of head. This structure may be passable at high flows, especially by steelhead, but requires a fishway or other passage structure to allow passage by all salmon and steelhead adults and juveniles; lack of instream flows downstream of the diversion may preclude migration at certain times of the year. The diversion at RM 4.9 includes an instream berm that feeds a pre-cast vault located in a small side channel. The diversion appeared to be non-functional on June 13, with the berm breached and instream flow passing freely. Athletic adult steelhead and coho can probably negotiate the diversion at RM 5.1 and the diversion at RM 5.2 at higher flows that typically occur during their spawning migrations, but both structures are barriers to juvenile salmonids and many adults. Instream flows upstream of the diversion at RM 5.2 were 75 cfs at the canyon mouth on June 13 and 16.4 cfs on July 24 2000. YN biologists are collecting irrigation diversion information and working with landowners to develop appropriate restoration solutions for passage, screening, water quality, and instream flows (YSS 2001 DRAFT). Also, the diverters approached the Kittitas County Conservation District in May 2000 and formally requested technical and/or financial assistance to screen their diversions and correct fish passage issues; they have been actively working with the Conservation District staff and engineer over the last year (KCCD).

Floodplain Modifications/Channel Condition

From the mouth to Barnes Road (RM 1.25), the channel is naturally incised; lack of surface flows across the delta fan during low flow periods impairs fish passage. From Barnes Road upstream to the diversion at RM 4.2, the channel is channelized and incised, with no LWD or pools. The natural role of LWD downstream of RM 4.2 and on the delta fan should be assessed to determine whether LWD restoration in this reach is warranted (Nicolai). Upstream of the diversion at RM 4.2, presence of LWD and pools are less than historic condition, but are better than downstream areas (Renfrow). Habitat complexity and LWD abundance increase dramatically in the upper reaches, particularly upstream of Buck Meadows (~RM 10) on SF Manastash Creek. However, the Quartz Mountain Watershed Analysis (Plum Creek 1994, as cited in KCCD 1999) indicates lack of LWD as a habitat concern in the 5-7 miles of SF Manastash Creek west of the Forest Service boundary. Lack of LWD is likely associated, at least in part, with past logging of the entire watershed.

Timber harvest and other development has led to 20% of the watershed above the National Forest boundary being in a hydrologically immature condition; 30% of the land below the USFS boundary is in a hydrologically immature condition (USDA 1995, as cited in USFWS 2001 DRAFT; figures are for Manastash and Taneum watersheds combined). Road density in the Manastash watershed is 2.82 mi/mi^2. Past logging and associated road construction are felt to be contributing to loss of in-channel woody debris, loss of off-channel habitat, and some bank instability (Mayo 1999, as cited in USFWS 2001 DRAFT).

The NF is now somewhat entrenched through the meadows located in T18N, R16E, Section 19, presumably as a result of past grazing practices (Renfrow). This entrenchment has lowered the water table, limited the ability of flood flows to access the floodplain, and is causing erosion of the soft earthen banks. Beaver have established colonies in the reaches downstream of the meadows.

Substrate Condition

Soils in the watershed are generally stony or very cobbly loams, with deeper loams and silt loams in the agricultural areas near the Yakima River (NRCS Soil Survey, as cited in KCCD 1999). Higher reaches include sandy and gravelly loams. Manastash Creek has extensive areas of very high erosion risk along the NF and on the southern slopes of the SF and mainstem. The broad alluvial fan that characterizes lower Manastash Creek, downstream of the canyon, has a low erosion risk. Steeper irrigated lands on finer textured silt or clay loams near the western edges of the agricultural area are considered highly erodible, although sediment delivery from fields to streams is probably limited, as return flows generally do not go back to the creek (Chain).

Spawning habitat ranges from reaches with adequate "patch gravel" to reaches in which gravel bars are common (CBSP 1990). Manastash Creek habitat evaluations rated 7 of 35 stream segments as poor for spawning, 17 segments rated poor for winter rearing and 31 rated poor for summer rearing. Evaluations of stream gravels at riffle sites (1990-1992) showed all 15 of the sampled riffle sites exceeding 15% fines, with several exceeding an average of 25% fines (Arango et al., as cited in KCCD 1999). Sources of sediment within SF Manastash Creek showed bank cutting, slope erosion, and bank disturbances as the most frequently encountered sources, with recreation considered to be the most significant cause (Plum Creek 1994). Three SF Manastash tributaries were also evaluated; recreation was cited as the primary cause of sediment erosion in two of the tributaries and logging was considered the main source in the third tributary. No information was found on sediment potential from the NF.

Riparian Condition

Vegetation and streambank cover are favorable to salmonid production in nearly all areas of the mainstem (CBSP 1990), with shade present in most areas (Renfrow). Except for a 1-mile reach of overgrazed riparian habitat between RM 2 and 3, agricultural activity along the mainstem (mainly crop production) has had little effect on riparian vegetation. Trees and brush are dense in the lower 1.5 miles, often forming a "jungle-like" canopy over the stream. The riparian corridor remains in generally good condition even along reaches that are seasonally dewatered. LWD presence is uncommon, presumably because landowners periodically remove most naturally recruited LWD (Renfrow).

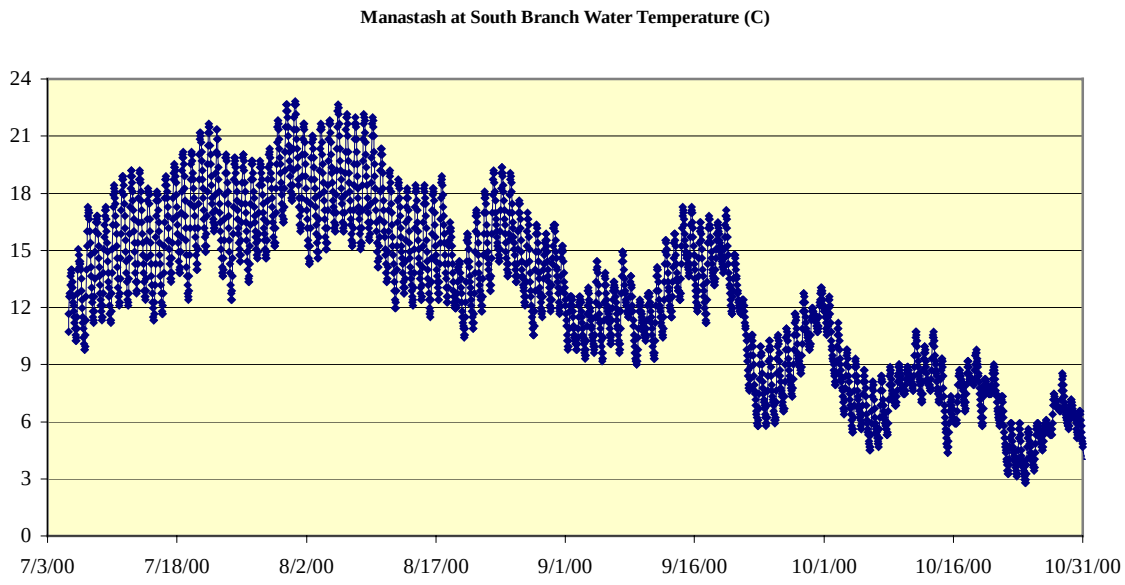
Riparian condition in forested reaches of the watershed have been impacted by past commercial forestry, recreation, etc, but are improving since the heavy logging that occurred in the 1970s and 1980s. Improved Forest Practice Rules should assist in the recovery of forest riparian areas. Loss of shade canopy in riparian areas was identified as one of the key habitat concerns in the Manastash Creek Watershed Analysis (Plum Creek 1994). Poor riparian condition was also identified in SF Manastash Creek for 5-7 miles downstream of the Forest Service boundary.

Water Quality

Manastash Creek from the mouth to the confluence of the NF and SF, in the NF to the headwaters, and the SF to the Forest Service boundary are designated as Class A (excellent) waters (WAC 173.201(a)), which determines which water quality parameters need to be met. The SF from the forest service boundary to the headwaters is classified as Class AA (extraordinary) waters. SF Manastash Creek is on the CWA 303(d) impaired water quality list for water temperature; mainstem Manastash Creek is listed for non-compliance with instream flow requirements.

Maximum summertime water temperatures in the lower sections of Manastash Creek can occasionally approach 70°F (Johnston 1989, as cited in YSS 2001 DRAFT), but these episodes are brief, diurnal fluctuations are large, and excessive temperature is not believed to be a serious problem (YSS 2001 DRAFT). Water temperature was 21°C in August 1985 near the mouth (USGS 1985, as cited in KCCD 1999); water temperatures in Manastash Creek in 1994 near the mouth and in the canyon reached 20-21°C (KCCD sampling). The KRD/Kittitas County Water Purveyors collected water quality data in Manastash Creek in 2000 at two sites, KRD South Branch Canal and Brown Road. Temperature data loggers at these sites showed that stream temperatures exceeded the standard (18°C) daily from early-July to mid-August (Figure 50). Dissolved oxygen levels, pH, and nutrient levels have generally been acceptable; turbidity was measured at 16 NTU in spring runoff in 1994 (KCCD 1999). Data collected by the KRD/KCWP over 16 sampling excursions from March to November 2000 showed low nutrient and sediment levels. Median turbidity values at the two sample sites were 2 and 5 NTUs. (KRD/KCWP). Manastash Creek is estimated to deliver 2700 tons of fine sediment to the Yakima River annually (KCCD 1999). The Upper Yakima suspended sediment and pesticides TMDL technical committee is setting goals for sediment reduction in the upper Yakima River watershed (Creech).

Figure 50: Manastash Creek water temperatures in 2000 at KRD South Branch Canal (courtesy of KRD/Kittitas County Water Purveyors)



Water Quantity

Manastash Creek flows have been gaged during 1909-1914 by USGS (gage was located at approximately RM 8, approximately 0.1 miles downstream of the confluence of the NF and SF), and recently by BOR (KCCD 1999). Flows during the early period averaged 60.8 cfs, or 0.82 cfs/mi^2 for this 74.5 mi^2 drainage, the same water yield estimated for Naneum Creek on the east side of the Kittitas Valley. Manastash Creek is considered representative of tributaries flowing into the west side of the Kittitas Valley. Flows at the Manastash gaging site (located approximately 3 miles upstream of the mouth of thecanyon) varied from a low flow of 10.2 cfs in October 1910, to a peak discharge of 1360 cfs in March 1910. Discharges remain at significant

levels through June, and averaged 30 cfs in July for the five years of record during the early part of the twentieth century.

The Kittitas Conservation District is monitoring instream flow at five locations on Manastash Creek between the canyon mouth and Brown Road (KCCD). Based on sampling during the record drought year of 2001, there appears to be a significant loss of instream flow in the reach from the diversion at RM 4.2 and the Westside Canal spill. Prior to any significant irrigation diversions in 2001, the reach between Cove Road and Serenity Lane (just upstream of the Westside Canal crossing) had very little or no instream flow, while the reaches upstream and downstream had flow (Figure 51). Instream flow in the reach downstream of the Westside Canal spill is supplemented by spill of Yakima River water from Westside Canal, in addition to any Manastash Creek flow that is present. Although instream flow in the reach from the diversion at RM 4.2 to Westside Canal is significantly affected by irrigation diversions, loss of surface flow to groundwater in the rocky substrate of this reach appears to naturally occur, even absent the diversions. It should be noted also that during the 2001 drought year there was essentially no spring freshet to charge /restore groundwater (Renfrow). This suggests there is a threshold for charging and maintaining the hyporheic zone of the creek sufficient to have surface flow across the alluvial fan during the late summer and early fall. The photos in Figure 52 illustrate the loss of flow typical from downstream of the diversion at RM 4.2 to approximately Serenity Lane (RM 2)(KCCD). The loss of surface flow in this reach is likely also exacerbated by continued development in the area, with many new residential or exempt wells. Surface flows increase again downstream of the Westside Canal, the result of a combination of Westside Canal operational spill and increasing groundwater return from irrigation return flows.

Figure 51: Manastash Creek instream flows at several points between the mouth of the canyon and Brown Road during record drought year of 2000-2001 (KRD data, as provided by KCCD)

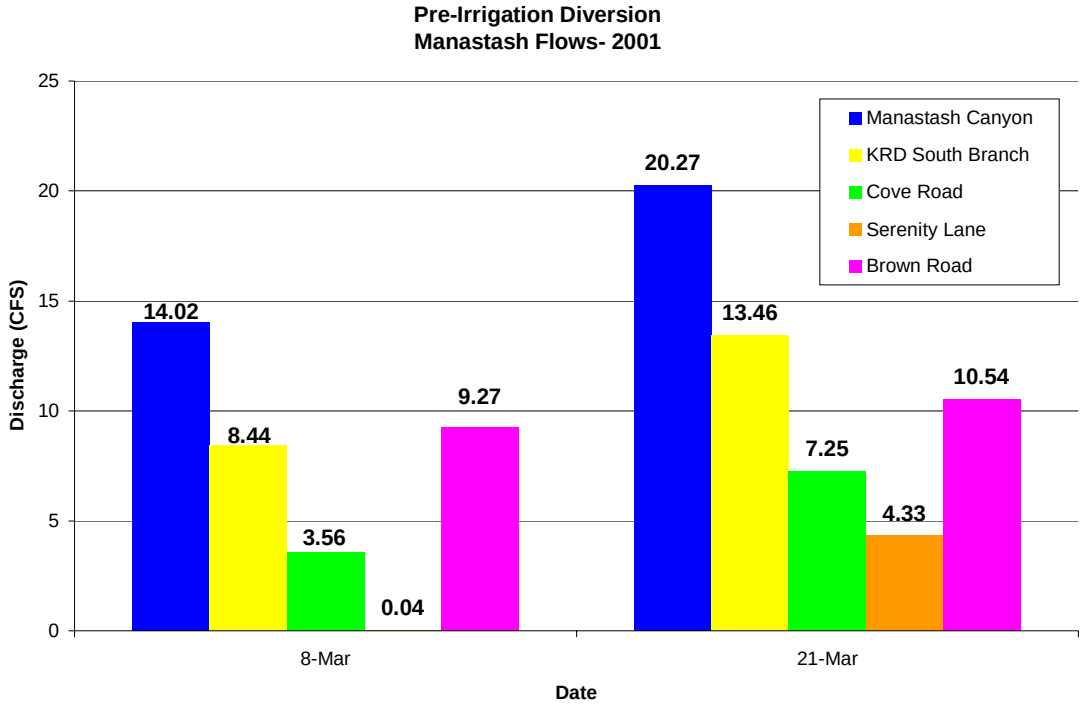


Figure 52: Manastash Creek photos taken on April 19, 2001at the diversion structure at RM 4.2 looking downstream (left), and at Cove Road (right); surface flow did not continue downstream of picture on right (photos courtesy of KCCD).

An assessment of water diversions on Manastash Creek, conducted by Yakama Nation biologists in 2000 identified 5 irrigation pumps and 7 irrigation diversion structures (2 of these were not in use)(see Figure 49 for diversion locations). The Barnes Road diversion is located at RM 1.25. Water is spilled from the Westside Canal for irrigation delivery to the diverters near Barnes Road (KCCD). Some of the water diverted at Barnes Road is Manastash Creek water, and some is delivery spill from the Westside Canal. At times, more water is spilled from Westside Canal than is diverted at Barnes Road, artificially restoring/increasing instream flows in lower Manastash Creek. During the summer months, water that reaches Brown Road is a combination of Westside Canal spill and groundwater, with very little surface water from upstream of the Westside Canal spill or irrigation return flow (KCCD). The diversion located at RM 3.1 is a spanning pole structure with hay bales upstream; no instream flow was present in June-July (Hank Fraser, YN). The diversion at RM 4.2 is formed by a broad concrete sill, with approximately 5 feet of head. Diversion amounts can be comprised of a combination of KRD South Branch operational spill and Manastash Creek water (KCCD). There are past observations of instream flow present downstream of the diversion at RM 4.2, with no instream flow present at Cove Rd. (KCCD, see Figure 52). The diversion at RM 4.9 includes and instream berm that feeds a pre-cast vault located in a small side channel. The diversion appeared to be non-functional on June 13, with the berm breached and instream flow passing freely. Athletic adult steelhead and coho can probably negotiate the diversion at RM 5.1 and diversion at RM 5.2 at higher flows that typically occur during their spawning migrations, but both structures are barriers to juvenile salmonids and many adults. The diversion timing from Manastash Creek at RM 5.1 is mainly prior to the activation of the KRD Canal; although water is diverted until the end of June (KRD is activated in April). Measurements of diversion amounts (cfs) and remaining instream flow (cfs) on the two assessment dates are summarized in Table 33. References to diversion amounts at these sites in the following text is for general information only, representing conditions on only 2 days in 2000; any analysis for salmon restoration purposes would need to consider water rights and instream flow conditions over one or several complete irrigation seasons.

Table 33: Measurements of water diversions and instream flows on Manastash Creek on June 22 and July 24, 2001 (data courtesy of Hank Fraser, YN)				
Location	Diversion (cfs)		Instream Flow (cfs)	
	June 22	July 24	June 22	July 24
Barnes Rd. Diversion	11.8	6.3	24.8	8.4
RM 3.1	0	0	0	0
RM 4.2	11.5	4.4	15	
RM 4.9	0		Entire Flow	Entire Flow
RM 5.1	28.3			
RM 5.2	17	12		
Mouth of canyon	NA	NA	75	16.4

Lack of instream flow has been a long-standing problem in Manastash Creek. Lower Manastash Creek is on the CWA 303(d) impaired water quality list for impaired instream flow. This reach is located downstream of the confined canyon, in an area where the creek flows across an expanded floodplain area (KCCD), and is characterized by rocky substrate and by what appears to be a naturally losing reach. It is unclear whether, or to what extent, upstream water diversions affect flows in this reach during low flow periods.

The West Side Canal and KRD South Branch Canal intersect mainstem Manastash Creek at RM 1.4 and 5.0, respectively (Figure 49). Water is diverted from the Westside Canal into Manastash Creek for irrigation delivery as well as operational spill (KCCD), with the reach from RM 1.4-1.25 being used as part of the irrigation delivery conduit. Operational spills occur from the KRD Canal into Manastash Creek; none of this water is committed to irrigation delivery in Manastash Creek, although some of the water may be taken coincident with Manastash Creek water rights and diversions downstream. There may be opportunities to pass additional flows through these delivery canals that would be specifically committed to augment instream flows downstream of the diversions (this could theoretically be accomplished without impairing existing irrigation diversions from Manastash Creek)(CBSP 1990). However, without significant water conservation improvements, KRD does not have the capacity to fully serve current customers during peak demand, much less augment stream flow (KCCD, Renfrow). Also, the impacts of false attraction of Yakima River water discharged to Manastash Creek would need to be considered (KCCD).

Instream flow recommendations were developed in the mid-1980s (see Instream Flow section at beginning of this chapter), but the TAG does not support implementation of those recommendations at this time. Rather, the TAG supports continued work to develop and implement a normative flow regime that combines "the goal of sustaining ecological integrity of the watershed, while also maximizing use of water resources by humans" (SOAC 1999).

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Manastash Creek:

- **Install fish screens on all irrigation diversions and pumps**
- **Implement actions to restore normative flows for fish passage and rearing**
- **Identify and assess alternate means of providing irrigation water that would include removal of instream diversions in Manastash Creek**
- **Prioritize and correct identified fish passage barriers at irrigation diversions**

- **Evaluate the natural role of LWD downstream of the Reed diversion; assess the potential to develop and implement a short-term LWD strategy to provide LWD presence and habitat diversity until riparian function is restored**
- **Restore riparian function where impaired**
- **Identify and correct recreational and forestry causes of fine sediment entry in the forested portion of the watershed**

Wilson 39.0604 (and tributaries Naneum, Coleman, Whiskey, and Mercer), and Cherry 39.0605 (and tributaries Caribou, Cooke, Parke, and Badger) Creeks

General

Figure 53: Historic map showing approximate course of Wilson/Naneum/Coleman creeks prior to irrigation rerouting (note that Cherry Creek tribs. not all included in map area)(from Kittitas County Centennial Committee 1989)

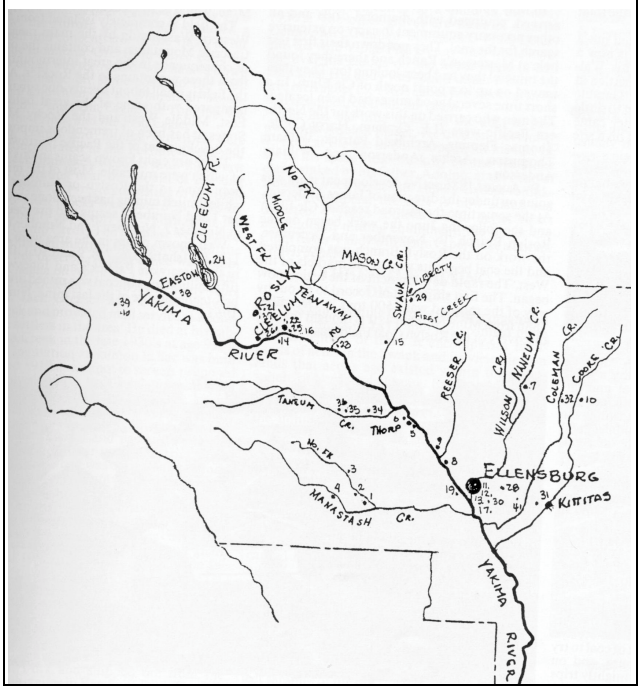
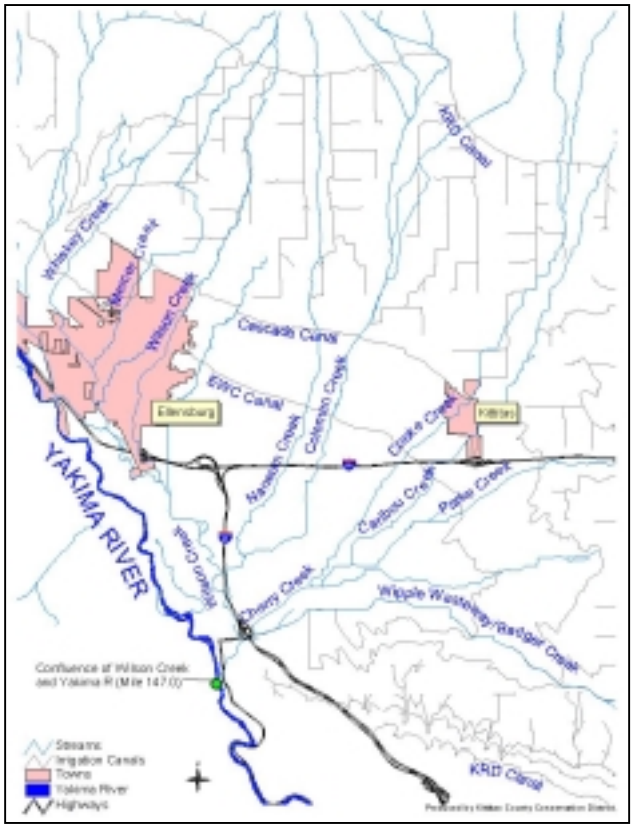


Figure 54: Map of current routing of streams in the Wilson/Cherry Creek watershed (courtesy of KCCD)



Wilson Creek is a left bank tributary to the upper Yakima River, entering at RM 147.0. The Wilson/Cherry watershed drains an area of 407.8 mi^2 (NRCS estimate, as cited in KCCD 1999), including most of the Kittitas Valley agricultural area. The routing of the streams in the watershed prior to irrigation development is shown in Figure 53. Post irrigation development, Naneum, Coleman, Whiskey, and Mercer creeks are routed into or through some part of Wilson Creek; Caribou, Cooke, Parke, and Badger (Wipple Wasteway) creeks are routed through Cherry Creek (Figure 54). Wilson and Cherry creeks merge into Wilson Creek approximately 0.5 miles upstream of the confluence with the Yakima River. Unless otherwise noted in this section, references to Wilson Creek apply to Wilson, Naneum, Coleman, Whiskey, and Mercer creeks,

and references to Cherry Creek apply to Badger (Wipple Wasteway), Parke, Caribou, and Cooke creeks.

Lands within the Kittitas Valley part of the watershed are generally privately owned and in a checkerboard ownership in the northern areas, which are dominated by State lands and U.S. Timberlands (previously Boise Cascade) holdings, with some Bureau of Land Management lands mainly to the south (KCCD 1999). Vegetative cover varies from shrub steppe (sagebrush, bitterbrush, etc. with grass & forb understory) on the hills to the east and south, to sagebrush and bitterbrush grading with increasing moisture to Ponderosa pine to the north. Mixed conifer forests consisting primarily of fir and larch, as well as ponderosa pine dominate where precipitation and elevation reach higher levels. At the highest elevations where temperatures are lowest, subalpine forests consisting of subalpine fir, Engelmann spruce, and lodgepole pine exist (WDNR 1994). The Kittitas Valley is an intensively irrigated cropland area that prior to irrigation supported a shrub-steppe community of native grasses and shrubs, with larger shrubs and trees near its many creeks.

Because of the extensive and long-standing alteration of this watershed for irrigation purposes, it was not possible to accurately determine to what extent natural flow regimes would have supported historic/potential salmonid presence. Suitable hydrology was likely present in the Wilson Creek tributaries, but is less certain for the lower elevation/shorter tributaries in the Cherry Creek drainage. Because of logging, grazing, channelization, and loss of beaver colonies, the watershed character has changed dramatically from what it was in the early 1800s (Renfrow). It is probable that salmonid use in the lower elevation/dryer watersheds varied substantially between dry and wet years.

Wilson/Cherry creeks support spring chinook, summer steelhead, and possibly some coho rearing in the very lower reaches, as well as other resident salmonids and non-salmonids throughout the watersheds (WDFW 1998). Old catch records, some dating to the 1930s, indicate the presence of small numbers of bull trout in Yakima River tributaries, including Coleman Creek (USFWS 2001 DRAFT). It is unknown whether the identified bull trout were of local origin; it is possible that they may have migrated from the upper Yakima through the irrigation canals and into Coleman Creek (KCCD). It is unknown whether there are still bull trout in Coleman Creek. Although current anadromous production from spawning in these watersheds is minimal, if the extensive passage and screening problems were rectified, and if steelhead and coho stocks were restored upstream of Roza Dam to utilize the habitat to which access had been restored, some of these streams would probably produce substantial numbers of anadromous salmonids (CBSP 1990). Spring chinook juveniles rear in large numbers downstream of the lowermost fish passage barriers in the lower 2-4 miles of Wilson, Cherry, Badger, Naneum, and Coleman creeks (Easterbrooks 1990, as cited in YSS 2001 DRAFT), and some spring chinook and steelhead spawning also occurs in these reaches.

There are unconfirmed indications of historic salmon presence in the watershed. Cle-lo-han, located approximately 10 miles northeast of Ellensburg on Caribou Creek, was a major summer camp for Native Americans, where they congregated to collect roots and fish (Kittitas County Centennial Committee 1989). Native Americans are known to have had salmon traps made from willow at the current site of the Ellensburg rodeo grounds and at the site of 4th and Main in Ellensburg. The stream now flows through a buried culvert at these locations. However, Allen Aronica (whose great grandmother once owned the land at the reported fish trap sites) does not recall there being fish traps at the rodeo grounds or 4th and Main, and disagrees with statements regarding the Caribou Creek camp as a fishing camp (as referred through KCCD). His recollection from passed down lore was that Cle-lo-han was primarily a spring and fall camp, and

that the Kittitas Valley was known much more for game (deer), roots and berries, than for fish production. The fishing sites were located mostly on the main stem Yakima River, Salmon La Sac, and the Teanaway River (Allen Aronica).

Historic/potential salmonid distribution is noted on the salmonid species distribution maps (included in a separate Maps file with this report) and in the supporting data table in Appendix A, for all creeks in this watershed that may have had adequate hydrology to support salmonid rearing or spawning, even if only during a portion of the year. There is greater uncertainty associated with the historic/potential salmonid use in lower elevation, smaller creeks, like those in the Cherry Creek system. However, salmonids are commonly found fish in small tributaries, including ones that often dry up in mid-summer, particularly if one looks at the right time of the year when water is present and cool (Renfrow). Hydrology is extremely variable from year to year in the Cascades; a good snow pack makes much difference in a watershed, as does good, natural storage (e.g., beaver colonies and saturated floodplains)(Renfrow).

Fish Access

The major salmonid habitat concern in this watershed is lack of salmon access to and from the headwater areas, particularly in the Wilson Creek tributaries, where suitable hydrology is present throughout the year. Several projects have been implemented since 1999 to restore juvenile and adult passage into the lower Wilson Creek drainage (Figure 55). Juvenile and adult salmonids were previously able to only access upstream to the lowermost diversion dam at RM 1.8 (the confluence of Wilson and Naneum Creeks); this barrier has been partially fixed, but may still be a barrier through much of the season due to lack of placement of the step boards in the middle two bays of the ladder (Chain). There is a remaining diversion dam on Wilson Creek that is a seasonal barrier at RM 4.3, and another at RM 6.0 that is likely a barrier to upstream juvenile migration. The prior diversion barrier on Wilson Creek at RM 7.7 has been modified to improve passage (Nicolai). With correct operation of the ladder at RM 1.8, adult salmon and steelhead would be able to migrate upstream to RM 9.0 on Wilson Creek (an adult spring chinook was observed at this location in 2001), and are also able to access an additional 2 miles of habitat in Whiskey and Mercer Creeks, which enter Wilson Creek at RM 8.5 (Nicolai). The lowermost barriers on Naneum and Cherry creeks are within 1-2 miles of their confluences with Wilson Creek (KCCD); the lowermost Naneum barriers are associated with the Bull Ditch crossings. The lowermost Coleman Creek barrier is approximately 0.5 miles upstream of its confluence with Naneum Creek (KCCD). The lowermost Cherry Creek and Badger Creek/Wipple Wasteway barriers are approximately one mile above the confluence of these creeks. Upstream of these lowermost barriers on all of the tributaries of Wilson and Cherry creeks, there are hundreds of unladdered and unscreened irrigation diversions (KCCD).

Some of the creeks pass through siphons underneath the three large irrigation ditches (KRD Canal, Cascade Irrigation District Canal, and Ellensburg Water Company Canal (a.k.a. Town Ditch), which in many cases represent passage barriers (YSS 2001 DRAFT). The KRD control structures found on Naneum, Cooke, and Caribou creeks are suspected, but unconfirmed fish passage barriers (BOR 2000). In some cases, stream water is commingled with these large ditches, allowing fish to be entrained into the irrigation delivery network (YSS 2001 DRAFT). Steelhead migration to the upstream reaches of Naneum Creek is likely blocked by the North Branch Canal at most flows, although numerous private diversions downstream of the KRD also create fish passage barriers in both the Wilson and Cherry Creek drainages. Wilson Creek and its three man-made branches pass through the heart of Ellensburg, often underground in culverts. Fish passage is likely impaired by these long culverts, although adult salmonids have been observed upstream. An option to address some of the passage and screening concerns may be to

Figure 55: Identified water diversions in lower Wilson Creek (courtesy of Hank Fraser, YN)

conduct a comprehensive assessment of the irrigation water delivery network in this watershed, including development of a revised water delivery strategy that includes identification and implementation of opportunities to consolidate diversions, move points of diversion, or to transfer water rights from individual creeks to larger water districts (Nicolai, Renfrow). However, any analysis of this type needs to consider capacity limitations of the large irrigation systems and effects to individual water rights (KCCD).

The KCCD is currently working with diverters who volunteered to begin the process of screening and creating fish passage at diversion dams on over 35 diversions on Naneum, Coleman, Cooke, Parke, Caribou, and Badger creeks (KCCD). Given appropriate funding, work could include both in-stream and on-farm improvements to meet NMFS screening requirements, as well as improving delivery systems to achieve water use efficiencies. The Kittitas County Conservation District, Kittitas County Water Purveyors and other local, state and federal agencies are currently working to secure funding and continued technical assistance for these projects.

Floodplain Modifications

Naneum and Coleman creeks have been channelized and diverted into lower Wilson Creek, and no longer have their natural confluences with the Yakima River. All streams in this watershed are heavily diverted on the valley floor, and have been channelized into an intricate drainage and irrigation system that bears little resemblance to the original drainage pattern (CBSP 1990). Historically, the Wilson Creek tributaries entered the valley and were primarily multi-channeled streams, probably filled with beaver dams and ponds, flowing through dense willows and patches of cottonwoods and aspen (YSS 2001 DRAFT): to some extent, these conditions would have also occurred in the lower elevation, shorter, more arid tributaries to Cherry Creek (Renfrow).

Perhaps more than any other drainage in the Yakima watershed, Wilson Creek and tributaries (including Cherry Creek and tributaries (Renfrow)) have been wholly converted to irrigation (YSS 2001 DRAFT). Many of the tributaries are used as irrigation delivery systems, and have been rerouted, channelized, and diked for that purpose. Most reaches that have been converted are straight, high-velocity chutes with few pools, no LWD, and poor riparian vegetation. Many of the channels have deeply incised over time or have been dredged to serve as agricultural drains, increasing the draining of groundwater and irrigation return flows from surrounding lands. The lower reaches of these channels now have significantly increased instream flows during the summer and early fall compared to natural conditions (KCCD, Renfrow). This is especially true for the Cherry Creek tributaries, some of which were likely not even perennial under pre-irrigation conditions

Channel Condition

Lack of LWD, and limited potential for future LWD recruitment, are concerns throughout the watershed. Within much of the irrigated portion of the lower watershed, downed wood is actively removed from channels, which are maintained as clean, uniform conduits for delivery and drainage of irrigation water (especially in the Cherry Creek tributaries (KCCD)). Downed wood in the forested zone is actively removed for recreational campfire use (Renfrow). Future LWD recruitment potential is impaired by riparian impacts resulting from intensive agriculture in the lower watershed and by a combination of grazing and recreational use in the riparian areas of the upper watershed.

Substrate Condition

Soils have been mapped by NRCS and erosion risk has been assessed based on soil and slope factors (KCCD 1999). Highest erodibility is on silt loam soils on steeper ground south of Thrall Road and in the hills to the north of the Kittitas Valley, particularly along Naneum Creek, and in uplands within the Caribou, Cooke, and Parke watersheds. Mass wasting is not rated as a major hazard for sediment delivery in Naneum Creek (WDNR 1994).

High presence of fine sediments due to ground disturbances and surface erosion were also identified in the mainstem Naneum within the forested zone, and in Pearson Creek (tributary to Naneum Creek)(WDNR 1994). Forest practices, including ground based harvest systems, road construction and stream crossings, and cut and fill slopes are identified as sources of fine sediment contribution. In addition, grazing and recreational use (vehicle and horse use of roads and trails during the wet fall hunting periods) increase surface erosion, particularly from roads located within 200 feet of the stream network (WDNR 1994). Summer recreational use can also create trail conditions conducive to water borne erosion (KCCD).

Gravel quality and size distribution is good upstream of the valley floor, but in the lower reaches irrigation priming and early season irrigation operations deliver high levels of fine sediment to the channels, and urban runoff from Ellensburg and Kittitas is discharged directly into Wilson Creek and its tributaries (YSS 2001 DRAFT). Furrow irrigated crops represent 5-10% of the irrigated cropland in any given year (KCCD 1999). Sediment from outside the agricultural area may also be entrained in the system and later carried downstream with irrigation return flows (KCCD). Most of the row crop production occurs in the Cherry Creek drainage, which has been shown to be higher in fine sediment delivery than the Wilson Creek system (BOR data as cited in KCCD 2000). Wide use of polyacrylamide (PAM) in rill irrigation on erodible ground has resulted in a significant decrease in total suspended sediment (KCCD 2000). A 1997 survey of growers confirmed PAM use on at least 4150 acres across the Valley (KCCD, 1999a). In addition, several projects have been implemented to convert from rill irrigation to pressurized irrigation systems, virtually eliminating irrigation induced sediment movement.

Riparian Condition

Wilson, Naneum, and Coleman creeks flow through timbered canyons in their upper reaches, where riparian condition is good (CBSP 1990). The lower elevation tributaries of the Cherry Creek system have less conifer presence in headwater areas, and the upper Cherry Creek watershed has lower natural precipitation compared to the Wilson/Naneum system. Within the agricultural zone, riparian condition on the Wilson/Naneum tributaries is a little better than on the Cherry Creek tributaries, which are more deeply incised, straighter, and have less large riparian vegetation than the Wilson/Naneum tributaries (KCCD). Riparian zones in the valley portions of these watersheds are extensively impacted by grazing, channelization and other agricultural practices, and highly variable in quality (YSS 2001 DRAFT). Grazing allotments in the upper Naneum drainage have been modified in recent years to reduce grazing associated riparian and channel impacts. Some riparian communities are properly functioning, while others are completely devoid of shrubs or overstory trees. Much of the mainstem of Naneum Creek and its major tributaries lack sufficient amounts of large woody debris in the channel because there are not trees along the banks to contribute this resource. This causes a homogenous channel structure and lack of suitable complex fish habitat (WDNR 1994). Restoration of woody riparian vegetation in the agricultural lands on the valley floor is inhibited by active spraying to control weeds (Renfrow), and by massive stands of reed canarygrass in many riparian areas (especially along waterways tributary to Cherry Creek) that actively suppress and compete with woody vegetation (Chain).

The Wilson Creek Riparian Restoration Project was initiated in 1996, primarily as an education/demonstration effort to show that agriculture and riparian protection could successfully coexist (Nicolai). The program involved fencing, planting, and maintenance of riparian buffers on 12 parcels, totaling approximately 3 miles of riparian area. The average riparian buffer width in the program was 35-feet. While the program initiated some improvement at these sites, there is much additional riparian restoration work needed in this watershed.

Water Quality

Wilson and Cherry creeks are designated as Class A (excellent) waters (WAC 173.201(a)), as are most tributaries in this watershed, which determines which water quality parameters need to be met. Exceptions include Owl Creek (a Naneum Creek tributary), which is classified as Class AA (extraordinary).

Cherry Creek is on the CWA 303(d) impaired water quality list for 4,4'-DDE, DDT, Dieldrin, and water temperature. Cherry Creek had the highest documented presence of pesticides in bed sediment of all 25 sites sampled in the Yakima watershed (Cuffney et. al 1997), although more recent water and agricultural soil samples show very low levels.

Cooke Creek is listed on the CWA 303(d) impaired water quality list for dissolved oxygen, fecal coliform, and water temperature. Naneum Creek is on the CWA 303(d) impaired water quality list for water temperature. Wilson Creek is on the CWA 303(d) impaired water quality list for fecal coliform and water temperature. A single excursion from the state water quality standard for Dieldrin was also documented in 1985 in Wilson Creek, but does not meet criteria for inclusion on the 303(d) list.

There is a long history of water quality sampling in the Wilson/Cherry watershed, dating back into the 1970s (KCCD 1999). Ecology conducted a study of the Wilson Cherry watershed in 1978-1979, and a survey of Cooke Creek in 1987. The USGS collected water quality data from Wilson/Naneum/Cherry creeks between 1986 and 1990. The BOR collected water quality data for Cherry Creek from 1971-1979 and from 1990-1992. The Kittitas County Conservation District collected water quality data in Cherry Creek, Wipple Wasteway, and in lower Caribou Creek from 1992-1994, and in all of the Cherry Creek tributaries from 1999-2001. The water quality studies generally found problems with elevated water temperature during summer months (unclear to what extent the elevated temperatures are associated with management actions), and elevated turbidity, suspended solids, and nutrients, with varying findings on dissolved oxygen and pH. High water temperatures documented by Ecology in Caribou, Cooke, and Coleman creeks back in the late 1970s was thought to be related to lack of vegetative cover along the streams, with row crop agriculture singled out as a significant source of nutrients and turbidity.

A comparison was conducted of water quality in the mainstem Yakima at Ellensburg with three tributaries that carry irrigation return flows (Cherry Creek, Wilson Creek, and Badger Creek/Wipple Wasteway)(BOR 2000). The tributaries with irrigation return flows were significantly higher in nutrients, suspended sediment, and fecal coliform bacteria than the mainstem. Pesticide concentrations in streambed sediments, which carry irrigation return flows were also significantly elevated when compared to background (Cle Elum River) conditions.

The Kittitas County Conservation District conducted water quality sampling for nutrients and suspended solids at 13 sites in the Kittitas Valley during 1992-1993 (9 of the sites were within the Wilson Creek drainage)(KCCD 1999). Results indicate significantly higher nutrient and suspended solids concentrations in the lower portions of the Wilson/Cherry drainage (e.g. lower Caribou Creek, lower Coleman Creek, Wipple Wasteway, Cherry Creek, and Wilson Creek near the mouth), as compared with upper watershed sites (upper Naneum Creek, upper Caribou Creek, upper Manastash Creek). The range of suspended solids was also greater in the Kittitas County Conservation District monitoring than was observed in earlier Ecology studies (1978-1979). Highest suspended sediment concentrations occurred outside the irrigation season during run-off events, and during the spring portion of the irrigation season, particularly early June.

Water quality monitoring was conducted by the Kittitas County Conservation District at 15 regular sampling sites in the Kittitas Valley in 1994 (considered a drought year)(KCCD 1999). Additional sites were sampled during run-off events. Water quality, as measured by dissolved oxygen, pH, and conductivity, was excellent at all sites. Nutrient content was low at all upper watershed stations, but was elevated at lower Kittitas Valley sites (e.g. Reecer Creek, Cherry Creek, and lower Wilson Creek), particularly for nitrates. However, it should be noted that the nitrate levels measured at these locations never exceeded the Washington State groundwater standard of 10 mg/L (the highest single measurement was 2.4 mg/L at lower Coleman Creek in June of 1993). Turbidity and temperature were also found to exceed water quality standards in lower Wilson and Cherry creeks, although it is unclear to what extent elevated temperature may be attributed to management practices.

The KCCD also sampled water and soils for pesticide presence in 1999 and 2000 at several sites in the lower Cherry Creek watershed (Cooke, Caribou, and Parke creeks)(KCCD). The data can be coupled with the KRD/KCWP data that encompass sites on these same waterways upstream of the KRD North Branch Canal. The data show an increase in sediment and nutrient levels from the upper area of the basin (upstream of intensive agricultural areas) to the lower end. Although nutrient levels are relatively low (nitrates are generally below the Washington State groundwater standard) in the lower Cherry Creek tributaries, there are noticeable peaks, which appear to correspond with the fertilization schedule of crops in the Kittitas Valley (KCCD). There are also peaks in the sediment levels, particularly in July, that likely correspond to the start of irrigation on many row crops (corn, potatoes).

The KCCD sampled water and soils for pesticide presence in 1999 (KCCD 2000). The analysis suite of organochlorine pesticides included 127 compounds, including DDT and its derivatives. The water samples collected from Cherry Creek and Badger Creek/Wipple Wasteway showed no detectable levels of DDT or its derivatives, or Dieldrin. The soil samples were collected in three agricultural fields, and analyzed for the same suite of pesticides as the water samples. Only one sample detected a DDT derivative (DDE), slightly above the laboratory quantification level, and one other detected Dieldrin above the laboratory quantification level. However, Ecology water quality sampling in Cherry Creek and Wipple Wasteway in 1999 found exceedances of the aquatic chronic toxicity criteria and human health standards for both DDT metabolites and Dieldrin in Cherry Creek; and exceedances of aquatic chronic toxicity criteria for DDT metabolites, and exceedances of human health standards for both DDT metabolites and Dieldrin, in Wipple Wasteway (Creech). Differences in these sample results may be due, in part, to lower detection level thresholds in the lab used by Ecology. USGS water quality sampling for pesticide presence in August 1999 detected the presence of 4 pesticide compounds in Wilson Creek and 5 pesticide compounds in Cherry Creek (Ebbert and Embrey 2001). The concentrations of suspended sediment and organochlorine pesticides were not well correlated in either Cherry Creek or Wipple Wasteway in the 1999 Ecology study, which is contrary to Ecology and USGS findings in the lower Yakima and many other sites (Creech). However, the affinity of organochlorine pesticides for soil particles is well established in the literature (and the lower Yakima), so the plan under the SS/OCP TMDL is to try to eliminate the organochlorine pesticides from upper Yakima River waterbodies by reducing suspended sediment input.

The Wilson/Cherry creek drainage discharges an estimated 18,200 tons of fine sediment (average of data collected in 1992, 1993, 1994 and 1996) to the Yakima River during the typical 180-day irrigation season (KCCD 1999). In a drier year (e.g. 1994), the 180-day irrigation season delivered an estimated 8400 tons of sediment. The turbidity impact of Wilson/Cherry Creek to the Yakima River is particularly significant during the irrigation season, with the watershed

contributing slightly more than 20% of the annual fine sediment load to the upper Yakima River. It should be noted that the irrigation season includes a significant portion of the regular spring runoff period and that high spring flows contribute to the sediment load as well. Within the watershed, KCCD (2000) data showed that Wilson Creek has the lowest turbidity, followed by Wipple Wasteway, and then Cherry Creek. The Upper Yakima suspended sediment and pesticides TMDL technical committee is setting goals for sediment reduction in the upper Yakima River watershed (Creech).

Little stormwater detention or water quality treatment is present in Ellensburg and most storm drains discharge to one of the branches of Wilson Creek or its tributaries (Mercer Creek and Whiskey Creek). Untreated, undetained storm water from industrial and retail business parking lots, gravel parking lots and city streets enters the stream through the storm drains. The storm water from the city provides a continuous source of fine silt and contaminants to the stream (Paul James, Fred Meyer SEIS). This is evident by the silt/mud stream bottom in many locations of the stream. Toxics in stormwater runoff are particularly of concern during the first rain of the fall (first flush after a summer of no rain); a substantial oil sheen can be seen in the creeks and in the gutters of the roads (Renfrow). The City of Kittitas also does not have a stormwater treatment program, and discharges stormwater into both Cooke and Caribou Creeks.

Water Quantity

Precipitation in the watershed is relatively low, ranging from <10 inches/year east of Ellensburg to ~30 inches/year (mostly in the form of snow) in the headwaters of Naneum Creek (WDNR 1994). A gaging station was maintained for 20 years (1957-1978) by USGS in the Naneum Creek Canyon, at a site upgradient from the Kittitas Valley irrigated area (KCCD 1999). This gaging station record illustrates tributary flow variation considered typical of the numerous creeks feeding the eastern Kittitas Valley. Streamflows averaged 57.1 cfs for the period of record, or 0.82 cfs/mi^2 of this forested watershed area of 69.5 mi^2. Low flows dropped to 10 cfs or less during most years; peak flows reached 968 cfs in June 1964. The unregulated hydrograph has an estimated peak flow of ~440 cfs in May and a minimum flow of 35 cfs in September (HKM 1990, as cited in YSS 2001 DRAFT).

All of the natural drainages in this watershed have been incorporated to varying extents into the complex irrigation delivery networks in the Kittitas Valley. The KRD system alone adds several hundred cfs per day to the area (through direct delivery spills, irrigation return flows, and groundwater augmentation from flood/rill irrigation)(KCCD). This infusion of water does not result in a reliable instream flow or a “normative” hydrograph (Renfrow). In fact, this flow results in significant flows present in waterways at times when it likely would not have been naturally/historically (KCCD).

Flows in lower Wilson/Cherry creeks are dominated by irrigation return flow from the eastern side of Kittitas Valley (KCCD 1999). Typical flows at the gage sites on Wilson Creek and Cherry Creek near Thrall Road were highest during the irrigation season and lowest in late autumn and mid-winter. In the upper portions of the irrigated valley, (generally upstream of the Vantage highway) streams are often severely de-watered during summer and fall from irrigation withdrawals despite the water contribution from KRD, CID, etc., although water that is present in the streams is delivery water or return flow from the irrigation districts that are picked up by downstream users, not necessarily natural flows (KCCD). As previously stated in this section, whether perennial flow existed in many of (at least) the Cherry Creek tributaries is unknown. Downstream from the Vantage highway, the gradual, cumulative increase of return flows significantly increases instream flows above natural summer flows to the confluence with the

Yakima River (Renfrow). In the case of Badger Creek, the KRD spills significant amounts of water into it through the Wipple Wasteway. Some streams have special structures that accommodate diversion of part of the natural flow, allowing remaining water to pass under or across the irrigation delivery canals (KCCD 1999). The Cascade Canal is supplied with water by numerous tributaries along its route; the diversions of natural flow are particularly important early in the irrigation season, when there is significant natural flow occurring in these drainages.

Flow measurements by the KRD and Kittitas County Water Purveyors (KCWP) illustrate the volume of water entering the irrigated area of the Kittitas Valley. Naneum/Wilson, Cooke, Parke, and Caribou creeks are monitored upstream of their intersections with the KRD North Branch Canal, approximately 12-14 miles upstream of the confluence of Wilson Creek and the Yakima River (KCWP/KRD & KCCD). In 2000 (an average flow year), measured flows in Naneum/Wilson creeks peaked at 180 cfs in April, with a low of <10cfs in August (KCWP/KRD 2000 WQ Data). Flows in Cooke Creek peaked at 40 cfs and dropped to <3 cfs by mid-June, and went dry by late-July. Flows in Caribou Creek dropped to <2 cfs by mid May; and flows in Parke Creek could only be sampled once (in April) before it went dry. The Aquavella Subbasin 10 Report of Referee indicates there is insufficient confirmation of natural flows to support water rights claims in several of the Cherry Creek tributaries (upper Badger Creek, Wipple Wasteway, Johnson Drain, etc.), although it is not clear in the report to what extent there may have been sufficient natural flow to support salmonid presence, even if only seasonally.

Instream flow recommendations were developed in the mid-1980s (see Instream Flow section at beginning of this chapter), but the TAG does not support implementation of those recommendations at this time. Rather, the TAG supports continued work to develop and implement a normative flow regime that combines "the goal of sustaining ecological integrity of the watershed, while also maximizing use of water resources by humans" (SOAC 1999).

Action Recommendations

Results of recent restoration efforts in the Wilson Creek watershed have been surprisingly positive (YSS 2001 DRAFT). Although solutions to the myriad of problems are complex and time consuming, feasible options do exist. The watershed is too large and intrinsically productive to not be restored. The following ranked salmonid habitat restoration actions are recommended for the Wilson/Cherry creek watershed:

- **Reduce discharge of fine sediment to the stream, particularly associated with irrigation priming and early irrigation season operations, both in the irrigation districts and on-farm**
- **Inventory and assess the barriers (irrigation diversions, culverts, etc.) on all of the Wilson/Cherry Creek tributaries; prioritize barriers for correction or removal.**
- **Conduct comprehensive assessment of restoration actions necessary to restore safe adult and juvenile passage from the Yakima River to the headwater reaches of Wilson and Naneum creeks, and to the falls on Coleman Creek**
- **Conduct a comprehensive assessment of the irrigation water delivery network in this watershed; assess potential to develop a revised water delivery strategy that includes identification and implementation of opportunities to combine diversion structures, move points of diversion, and possibly transfer water rights from individual creeks to larger water districts**
- **Continue the efforts initiated by the Wilson Creek Riparian Restoration Project to restore riparian function throughout all drainages in the watershed**

- **Develop and implement a short-term LWD strategy until full riparian function has been restored**
- **Assess impacts of stormwater releases to habitat in the lower watershed**

Reecer Creek 39.0968

General

Reecer Creek is a left bank tributary to the upper Yakima River, entering at RM 153.7. Reecer Creek provides anadromous salmonid rearing and limited spawning potential in the lower 100 feet (to the lowermost diversion). There is potential for rearing of juvenile steelhead and chinook, and potential for steelhead spawning upstream of this point, but actual use will be variable because of impaired passage at the lower diversion dam during much of the year (Renfrow). The stream above the lower diversion dam supports resident salmonids and non-salmonids upstream to the headwaters (WDFW 1998). Currier Creek is a main tributary to Reecer Creek, entering the left bank of Reecer Creek at about RM 1.5, in the vicinity the Ellensburg I-90 West Interchange (Renfrow). It is the larger of the two channels at that location because of accumulated irrigation return flows.

Fish Access

The Kline-Koble (sp?) diversion is located approximately 100 feet upstream of the mouth of Reecer Creek. It is a stoplog structure with a 3-foot drop. The stoplogs are generally pulled out in the fall and replaced in the spring; the diversion is unscreened. The Mill Ditch diversion out of Reecer Creek is located at Dollar Way, and is also unscreened. There is no dam structure where Reecer Creek flows into Mill Ditch; however, the check structure for a field ditch is located approximately 150 feet downstream of Mill Ditch, and when the stream is checked up, sufficient head is created to actively divert water into Mill Ditch and the field ditch. Although Mill Ditch is screened at the diversion point on the Yakima River, it intermingles with Reecer Creek, and there is no screen at the takeout point from Reecer Creek (Renfrow). In addition, there are several other unladdered/unscreened diversions elsewhere in Reecer Creek (upstream and downstream of SR10, and at and upstream of Dry Creek Road and the John Wayne Trail)(KCCD). Also, Reecer Creek intersects the Ellensburg Water Company and Cascade canals, although information was not available regarding barrier/screening status at these intersections.

Currier Creek also has numerous unscreened and unladdered diversions, as well as commingling with the Ellensburg Water Company Canal (KCCD). Fish passage in Currier Creek is impaired during summer at the irrigation diversion at SR-10 (Renfrow). Checkboards are placed in culverts to achieve approximately four feet of head. Another seasonal barrier occurs at Town Ditch where the canal and the creek co-mingle. There is one small irrigation diversion dam on the creek several hundred yards downstream from Hungry Junction Road. A seasonal barrier occurs at Cascade Canal where the canal water and creek co-mingle. The creek undershot at the KRD canal is a suspected barrier. Landowners have indicated to KCCD that there are several (2 or more) diversion barriers from downstream of the railroad RR tracks to the confluence of Reecer Creek with the Yakima River, and believes there may be more. A comprehensive inventory and assessment of barriers is needed in Reecer and Currier creeks.

Floodplain Modifications

The floodplain of Reecer Creek is constrained by a levee on the west side of the creek from Dollar Way to I-90. Upstream, the creek has been channelized for several miles for agricultural and irrigation convenience. No information was available on floodplain modifications in Currier Creek.

Channel Condition

There is general lack of LWD throughout both Reecer and Currier creeks. The few pools that are present are typically in the immediate vicinity of patches of remaining large willows trees (Renfrow).

Although there is a history of channelization and removal of woody debris, Currier Creek has sufficient flows and riparian cover to provide good rearing habitat for salmonids upstream to Town Ditch (Renfrow). The stream is perennial and salmonid presence has been verified to the KRD Canal by elelctroshocking. With riparian restoration and consideration of select instream habitat improvement with woody debris, rearing of juvenile anadromous fish could potentially occur upstream as far as the KRD Canal.

Substrate Condition

No quantitative information available on substrate quality; substrate thought to likely be good in the upper watershed and embedded through the valley (Renfrow).

Riparian Condition

There are intermittent patches of large willows adjacent to Reecer Creek from the mouth upstream to Cascade Way, and on Currier Creek from the mouth upstream to at least the John Wayne Trail (KCCD). Elsewhere, riparian condition is generally poor, with sporadic narrow patches of mature willow (Renfrow).

Currier Creek has a narrow intermittent riparian zone of large willow trees from its confluence with Reecer Creek upstream to the John Wayne Trail (KCCD). Further upstream to approximately to the vicinity of Smithson Road, the creek flows through pastures and woody riparian plants are present in patches, or not at all, depending on land use history. From the vicinity of Smithson Road to the headwaters, Currier Creek has a brushy riparian zone of willows and hawthorn (Renfrow?). Reecer Creek has small patches of willow in the reach between the Ellensburg Water Company and Cascade canals (KCCD).

Water Quality

Reecer Creek is designated as Class A (excellent) waters (WAC 173.201(a)), which determines which water quality parameters need to be met. Reecer Creek water quality was monitored in 1994 by the Kittitas County Conservation District at the Cascade Way bridge near the western edge of Ellensburg (KCCD 1999). Water temperature reached 20°C during the summer; turbidity averaged 34.7 NTU during high runoff periods in the winter. Reecer Creek was also sampled during the 1992 and 1993 irrigation seasons and averaged 0.13 mg/l total phosphorous, 0.37 mg/l nitrate nitrogen, and 16.2 mg/l suspended solids, only slightly higher than measurements taken

above the irrigation areas at reference points, such as upper Naneum Creek (these measurements do not result in a violation of Washington State water quality standards).

Despite having higher flows than Dry Creek, suspended solids were relatively low, reaching about 25% of the Dry Creek settleable solids levels observed during flood periods (KCCD 1999). Reecer/Dry creeks are estimated to deliver 730 tons of fine sediment to the Yakima River annually. The Upper Yakima suspended sediment and pesticides TMDL technical committee is setting goals for sediment reduction in the upper Yakima River watershed (Creech).

Water Quantity

Irrigation water is delivered to Reecer Creek through the KRD, Cascade, Ellensburg Water Company (Town Ditch) canals, and the Reed-Mill Ditch. There is perennial stream flow in the headwaters of Reecer Creek, but surface flow is intermittent from the base of the canyon to the Highline Canal during the late summer. There are also dry reaches downstream. Surface water from First Creek (LB trib. to Swauk Cr. at ~RM 6) is also diverted into the upper end of the Reecer Creek watershed for irrigation (KCCD 1999). Trendwest is in the process of acquiring 58% of the senior water right and 51% of the junior water right (combined total of ~7 cfs) at the First Creek diversion (Nicolai). The intent is to maintain the water as instream flow in First Creek, as mitigation for development impacts elsewhere. The resulting reduced diversion of water into the Reecer Creek watershed will likely reduce instream flows in the upper end of Reecer Creek, but the loss is unlikely to result in significant effect to instream flows lower in the watershed.

Flows in Currier Creek are likely a mix of irrigation return flows and natural flow, although it is difficult to quantify contributions (Renfrow). Based on the size of the Currier Creek drainage, it is possible that springs would have provided perennial flow, at least in the upper watershed.

Lakes

No lakes are present in this watershed.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Reecer Creek:

- **Conduct a comprehensive inventory and assessment of fish passage barriers and screening needs in Reecer and Currier creeks; prioritize and correct as warranted**
- **Assess salmonid habitat conditions in the watershed and develop a prioritized habitat restoration plan, including opportunities to restore floodplain function in the diked reach from Dollar Way to I-90 and improve channel configuration and function in channelized reaches**

Dry Creek 39.1049

General

Dry Creek is a left bank tributary to the upper Yakima River, entering at RM 157.6. Dry Creek supports spring chinook rearing, and steelhead rearing and potential spawning downstream of the water irrigation diversion at McManamy Road that is a fish passage barrier. The stream currently supports rainbow trout and has potential to support juvenile salmonid rearing further upstream.

Fish Access

The left-bank diversion located at SR 10 (RM 1.3) is not a barrier, but is unscreened, with a high potential for entrainment of juvenile salmonids. The Cascade Diversion, located at McManamy Road, is the lowermost known fish passage barrier. In addition, there are active hydraulic permits for seasonal dams (e.g. ecology block, plastic and bale dams, and push-up gravel berms) elsewhere in Dry Creek, but it is unknown to what extent these are being actively exercised (Renfrow).

Floodplain Modifications

Dry Creek enters a historic Yakima River floodplain meander that has been disconnected from the river at the upper end by I-90; the meander remains open to the Yakima River at the lower end. Dry Creek has been channelized from essentially its confluence with the old river meander to very near the KRD canal crossing (Renfrow). WSDOT maintains a left bank levee from the I-90 upstream to SR-10, and has a maintenance right-of-way upstream to Clark Road. The creek has been channelized to an "engineered channel" for most of this reach.

Channel Condition

The channel is somewhat incised from channelization as ones moves up the valley to the KRD Canal (Renfrow). Upstream of the KRD Canal, the channel is incised and appears to have been heavily affected by past grazing. There is little LWD, except within patches of remaining riparian vegetation from the Cascade Canal to Smithson Road (Renfrow).

Substrate Condition

The stream substrate is gravels and cobbles (Renfrow). The gravels are generally embedded with fines except for areas where cleaned by local scour.

Riparian Condition

There is a gallery of mature cottonwoods at the confluence of Dry Creek with the historic Yakima side-channel and throughout the side channel (Renfrow). Upstream of this side channel, Dry Creek passes through hay fields to near SR-10 where essentially all woody riparian cover has been removed, although there is brushy riparian cover of willows and hawthorns on the right bank of Dry Creek between the upper springbrook and Hwy 10 (Figure 8). In the vicinity of SR-10 upstream to the Old Milwaukee Railroad grade, there is brushy riparian cover of willows and hawthorn. Upstream of the old Milwaukee Railroad, woody riparian cover is patchy and sparse. In many places there are overstory trees but no understory because of grazing history. There are

only small patches of woody riparian vegetation from Cascade Canal upstream to Howard Road, with riparian condition improving somewhat upstream from Howard Road to Smithson Road (KCCD). Upstream of Smithson Road, there was a nice gallery of cottonwoods that has died, apparently from desiccation (Renfrow).

Water Quality

Dry Creek is designated as Class A (excellent) waters (WAC 173.201(a)), which determines which water quality parameters need to be met. No routine water quality sampling information is available for Dry Creek (KCCD 1999); however, observations of snowmelt in 1994-96 indicate earlier peaks than other tributaries, due to lower elevation and lack of tree cover. High suspended sediment levels (exceeding 2000 mg/l) were observed based on Imhoff cone test results of 2.5 ml/l on 1/31/95 and 1.9 ml/l on 2/8/96. The Upper Yakima suspended sediment and pesticides TMDL technical committee is setting goals for sediment reduction in the upper Yakima River watershed (Creech).

Water Quantity

Fish are typically present in Dry Creek upstream to the KRD Canal (Renfrow). However, in summer and early fall, flow is intermittent from above the KRD downstream to the Old Milwaukee Railroad (Renfrow), lack of surface flows has been noted even in the spring (Hall). Flows above the KRD canal are seasonal. Since the watershed is relatively low elevation, spring runoff is generally over by May (Renfrow).

Figure 56: Spring-brook channels in lower Dry Creek (courtesy of Brent Renfrow)

There are generally perennial flows downstream of McManamy Road. There are two "springbook channels" in the Yakima River floodplain, which enter Dry Creek (Figure 56). One comes in half way between SR-10 and the Dry Creek confluence with the side-channel, and the other comes in just above the side-channel confluence. The greatest immediate value for juvenile salmonid rearing is in these spring brooks, in the creek from SR-10 to the Yakima River side-channel, and in the side-channel itself.

Lakes

No lakes are present in this watershed.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Dry Creek:

- **Provide juvenile screening at the left-bank diversion at SR 10 (RM 1.3)**
- **Restore floodplain function from SR 10 downstream to the mouth**
- **Restore riparian function throughout watershed**
- **Assess salmonid habitat conditions in the remainder of the watershed and develop a prioritized habitat restoration plan**

Taneum Creek 39.1081

General

Taneum Creek is a right-bank tributary to the upper Yakima River, entering at RM 166.1. The NF and SF branch from the mainstem at RM 12.7, and are 12 and 9 miles long, respectively. Taneum Creek supports spring chinook (to Bruton diversion) and steelhead spawning and rearing into both forks. It also supports other resident salmonids and non-salmonids (WDFW 1998). Taneum Creek is considered to have substantial potential for producing steelhead and coho, and spring chinook to a lesser degree. Bryant and Parkhurst (1950, as cited in CBSOP 1990) report the stream supported good runs of coho prior to the construction of Taneum Ditch in 1910. Salmonid population densities in Taneum Creek were the highest of ten upper Yakima tributaries that were evaluated (Pearsons et al. 1994, as cited in KCCD 1999).

Topographic slopes vary from gently sloping alluvial terraces near the Yakima River to steep sided canyons, upland meadows, and ridges reaching to >6000 feet at Quartz Mountain and Lookout Mountain in the upper Taneum Creek watershed (KCCD 1999). The Taneum Creek watershed has narrow valleys with steep sides. Annual precipitation ranges from >60 inches in the upper Taneum to ~10 inches near the Yakima River.

The Taneum Creek watershed is largely undeveloped; the primary land use is agricultural crop production and forestry. The NF and SF flow through heavily forested land. The lower areas of the watershed are privately owned, whereas the upper watershed includes both public and private lands, some of which is in a checkerboard ownership pattern. The major constraints on salmonid production include very low summer and fall flows in the lower 3.3 miles of Taneum Creek (downstream of the major diversions), adult fish passage barriers, lack of juvenile bypass systems

at the diversions, and a wastewater return downstream of the Bruton diversion that may present a false attraction flow (CBSP 1990).

Fish Access

The natural flow of Taneum Creek is fully appropriated for irrigation. The lower portion of Taneum Creek is heavily diverted, with 4 irrigation diversions in the lower 3.5 miles. Low flows in the lower 3.3 miles of Taneum Creek in the late summer preclude anadromous salmonid access to good spawning habitat upstream (CBSP 1990, WDFW 1998). Fishways and screens were installed on all Taneum Creek diversions by 1990, though operation/function of the Bruton Diversion fishway is problematic and the Taneum Ditch diversion is problematic at low flows (when natural flows are low and KRD is not supplementing 20 cfs)(KCCD). The Knudson diversion was upgraded with new screens and fish passage structures (rock v-wiers) in the fall of 2000 and has shown no operation/function problems. Instream flow is now the most significant irrigation-related problem. In 1994, an agreement was reached involving the Bureau of Reclamation, the Kittitas Reclamation District, the Dept. of Fish and Wildlife, and the Yakama Indian Nation, transferring up to an additional 20 cfs, when available (typically available in the spring, not available in summer through late-August, and available in September), from the Yakima River through the KRD Canal to enhance instream flow in the lower reaches of Taneum Creek (KCCD 1999, BOR 2000). Consequently, the ability for adult salmonids to access the watershed upstream of RM 1.6, and the ability of juvenile salmonids and smolts produced in the upper watershed to safely migrate out of Taneum Creek has only recently been accommodated. Even with these modifications, adult summer steelhead will be able to pass upstream in most years, but adult spring chinook and coho passage is significantly impaired.

Floodplain Modifications

Taneum Creek channel length, wetted width, and depth have changed very little between 1936 and 1990 (Smith 1993). In general, channel length, width, and depth decreased slightly, indicating that the channel is aggrading. Taneum Creek has been channelized within the large floodplain reach from the Heart-K Ranch downstream to the Springwood ranch where the channel is naturally confined (Renfrow).

The BOR and WDFW have recently acquired 680 acres of the Taneum Creek watershed upstream of I-90 (the Heart-K Ranch), including Taneum Creek floodplain and adjacent uplands (Tracy Yerxa, BOR, personal communication). This parcel has been actively farmed and grazed since the late-1800s. There is opportunity to return the valley bottom through these parcels to historic condition, which likely included channel braiding and associated wetlands. There is a flume on the BOR property that runs from the KRD Canal, down the hillside, and across the Taneum Valley to Taneum Creek. This flume serves as an operational and safety spill relief for the KRD Canal, and also serves as an irrigation delivery conduit (for up to 80 cfs) to Taneum Creek, which is then diverted several hundred yards downstream into the Taneum Ditch. The flume drops into an incised open channel across the valley floor. It is unclear whether or to what extent this incised channel may be acting as a drain, affecting water table and hyporheic flow along the valley bottom. Wet areas and green grass growth areas are present on the floodplain downstream of the incised flume (Stan Isley, BOR, personal communication). Restoration of the natural topography and drainage patterns through the current flume course may assist in reestablishing the historic wetland and braided channel conditions.

Channel Condition

Channel conditions are generally rated as fair (Teske). Instream cover, in the form of LWD and boulders, is abundant on the NF and SF, except where LWD was cleaned out of the channel as part of past logging activities. The moderately steep gradient in the lower reaches tends to limit pool frequency, resulting in the habitat being relatively more suitable for steelhead than coho (CBSP 1990).

Timber harvest and other development has led to 20% of the watershed above the National Forest boundary being in a hydrologically immature condition; 30% of the land below the USFS boundary is in a hydrologically immature condition (USDA 1995, as cited in USFWS 2001 DRAFT; figures are for Manastash and Taneum watersheds combined). The watershed is also heavily roaded (Taneum subwatershed at 5.25 mi/mi^2, NF Taneum subwatershed at 2.51 mi/mi^2, SF Taneum 1.12 mi/mi^2). Past logging and associated road construction are felt to be contributing to loss of in-channel woody debris, loss of off-channel habitat and some bank instability (Mayo 1999, as cited in USFWS 2001 DRAFT).

There is significant bank erosion through the agricultural area downstream of I-90 (Renfrow). Habitat complexity is limited in the lower reach, which is now almost exclusively a single channel providing pocket-water habitat, with little LWD (YSS 2001 DRAFT). However, there is evidence of limited anastomosing (channel braiding) in the valley bottom of Taneum Creek. Habitat complexity and LWD abundance increase dramatically in the upper reaches, particularly upstream of RM 12.7 in NF and SF Taneum Creek, and in the Fishhook Flats area of NF Taneum Creek (RM 3).

Substrate Condition

Soils are generally stony or very cobbly loams, with deeper loams and silt loams in the agricultural areas near the Yakima River (NRCS Soil Survey, as cited in KCCD 1999). Higher reaches include sandy and gravelly loams. Erosion risk is rated high along most of Taneum Creek in the upper reaches and is generally rated as low in most of the flatter agricultural area near the mouth.

Substrate in the moderately steep lower reaches is composed primarily of rubble. However, patches of good gravel are numerous, and are more than adequate to satisfy steelhead and coho spawning needs (CBSP 1990).

The headwaters of Taneum Creek have an extensive forest road network that delivers fine sediment to the channel. There are multiple sites on the NF and SF of Taneum Creek that are undergoing or are at risk for mass wasting or surface erosion due to road construction, timber harvesting (especially on NF), and natural processes (Plum Creek 1994). There are sites where clearcutting has triggered landslides because the underlying geology is unstable. There are also slumps associated with road cuts in wet, clay soils. These factors contribute to fine sediment accumulation in pools and riffles. Surface erosion is most active on cutslopes where vegetation is sparse and from unsurfaced logging roads. The delivery of fine sediments as runoff from roads is a significant factor that degrades spawning and winter rearing habitats in both the NF and SF. Surface erosion is also caused where soils are exposed by skid trails, campsites, or burned slash piles. Some stream segments are particularly vulnerable to bank erosion and landslides where streamside slopes exceed 70%. These places may be protected by the added strength of tree roots, which increase bank stability and may limit the dimensions of future slides. In these areas,

future road building or logging operations would increase the risk of mass wasting and surface erosion and therefore potential damages to the stream habitat. In upper Taneum Creek, depth measurements indicate the channel is aggrading in most areas and deposits of small gravel are being buried by increased amounts of fine sediments (Smith 1993). Continued logging, chronic surface erosion from sparsely vegetated slopes in the area, and accelerated timber harvesting in steep headwater areas could sustain or increase the amount of fine sediment delivered to the channel for a long time to come.

Fine sediments in spawning gravels were noted in most stream segments in the Taneum Creek watershed, where 21 of the 51 segments were rated as poor (KCCD 1999). Rearing areas were slightly better, with only 10 winter rearing areas and 7 summer rearing areas rated as poor. Evaluations of stream gravels at riffle sites (1990-1992) in the Taneum drainage found fine sediment levels at 17 of 18 sites exceeded 15% by volume, the level established as the threshold of concern separating fair and poor spawning habitat (Arango et al. 1993, as cited in KCCD 1999). Most sample sites contained <25% fine sediment, with none of the sites exceeding 30% fine sediment. Erosion in the lower five miles within the National Forest boundary was related to bank disturbance and slope erosion attributed to road or bridge construction and livestock access. Upstream sediment sources were from bank disturbances and slope failure attributed mainly to natural causes (including a large slope failure in the SF), recreation, and roads. Much of the erosion on Taneum Creek tributaries was attributable to impacts from logging.

Riparian Condition

The lower section of Taneum Creek has been intensively grazed and cultivated since the 1880s (Smith 1993). In the past, much of this section has been channelized and LWD has been aggressively removed (Renfrow). These land uses, along with earlier timber harvest, construction of roads and sawmills, combined with lower precipitation in the downstream reaches, appear to retard the recovery of both coniferous and deciduous riparian vegetation.

The NF and SF flow through heavily forested land. Roads run along both the mainstem and the forks, impairing riparian potential on one side of the channel. In addition, there are numerous dispersed campsites along the channel within the forest service ownership that have resulted in soil compaction and erosion, lowered riparian vegetation densities, and removal of downed wood from the channel and riparian areas (TAG). Riparian condition is generally good in forested areas not impacted by roads, recreational campsites, or past logging.

Water Quality

The lower 8 miles of Taneum Creek (downstream of the Forest Service boundary) are designated as Class A (excellent) waters (WAC 173.201(a), which determines which water quality parameters need to be met. Taneum Creek from the Forest Service boundary upstream to the headwaters is designated as Class AA (extraordinary) waters.

Taneum Creek, SF Taneum Creek, and Lookout Creek (tributary to Taneum Creek) are on the CWA 303(d) impaired water quality list for water temperature, and the lower reaches of Taneum Creek are listed for non-compliance with instream flow.

Maximum summertime water temperatures in the lower (flow impaired) sections of Taneum Creek can occasionally approach 70°F (Johnston 1989, as cited in YSS 2001 DRAFT), but these episodes are brief, diurnal fluctuations are large, and excessive temperature is not believed to be a

serious problem (YSS 2001 DRAFT). Water temperature is likely exacerbated by low instream flow.

The Kittitas Reclamation District and Kittitas County Water Purveyors are actively sampling Taneum Creek at two locations, upstream of the intersection of Taneum and the KRD South Branch Canal (RM 2.8) and approximately 20 yards upstream of the mouth of Taneum Creek (KCWP 2000 Water Quality Data, as provided by KCCD). The sampling schedule includes two events outside of the irrigation season and bi-weekly sampling during the irrigation season. In 2000, the turbidity median was 2 NTU with a maximum of 8 NTU at each of the sites. Nitrogen levels were very low, with the median value for each of the sites at 0.01 mg/L and total phosphorus median levels were 0.027mg/L at the upper site and 0.032mg/L at the lower site. Dissolved oxygen and pH were within Washington State standards. Continuous water temperature monitoring has occurred on Taneum by the KRD since 1997. The stream temperature exceeds 18°C regularly during the warmest summer months. Stream flow at the upper site ranged from 243 cfs in April to 2.7 cfs in August. At the lower site, the flows ranged from 208 cfs in April to 5.3 cfs in August.

Taneum Creek is estimated to deliver 1850 tons of fine sediment to the Yakima River annually (KCCD 1999). The Upper Yakima suspended sediment and pesticides TMDL technical committee is setting goals for sediment reduction in the upper Yakima River watershed (Creech).

Water Quantity

The lower portion of Taneum Creek is on the CWA 303(d) impaired water quality list for impaired instream flow. The lower portion of Taneum Creek is heavily diverted, with 4 irrigation diversions in the lower 3.5 miles. Low flows in the lower 3.3 miles of Taneum Creek in the late summer preclude anadromous salmonid access to good spawning habitat upstream (CBSP 1990, WDFW 1998). Fishways and screens were installed on all Taneum Creek diversions by 1990, leaving instream flow as the remaining irrigation related problem. In 1994, an agreement was reached involving the Bureau of Reclamation, the Kittitas Reclamation District, the Dept. of Fish and Wildlife, and the Yakama Indian Nation, transferring up to 20 cfs through the KRD Canal to enhance instream flow in the lower reaches of Taneum Creek (KCCD 1999, BOR 2000). The 20 cfs for instream flow enhancement is provided only when surplus water is available, and flow may vary weekly from 7-20 cfs (S. Isley, BOR, personal communication). In addition, there is a flume that drops from the KRD Canal, down the hillside, and through an incised channel across the Taneum floodplain to Taneum Creek on the Heart-K Ranch. The flume serves as a safety and operational spill relief for the KRD Canal, and also serves as an irrigation delivery conduit for the Taneum Ditch (up to 80 cfs). The capacity of the canal is ~200 cfs, but the channel across the valley bottom can effectively only handle 160-180 cfs prior to overtopping the channel banks. In 2001, there were extended releases of ~160 cfs down the flume into Taneum Creek, to reduce safety risks to rafters at the main KRD spill site into the mainstem Yakima River. It is unknown to what extent these transfers of water may result in false attraction of adults into Taneum Creek.

The recent BOR/WDFW acquisition of the Heart-K Ranch property includes an irrigation water right that will be transferred to instream flow (T. Yerxa, BOR, personal communication). The water right has the same priority date as other water rights in the Taneum, and is for up to 12 cfs, when water is available, or approximately 14% of the flow when there is insufficient flow to meet overall irrigation needs. None of the irrigation water right was used on the Heart-K Ranch property in 2000, but because the right had not been transferred to trust water rights, it could be considered as unused irrigation water and diverted further downstream, if needed. The BOR is in the process of trying to work through the state water adjudication process to complete the transfer

of the water right, to ensure that it will be reserved for instream flow. Additional options to reduce water diversions from Taneum Creek should also be identified and pursued.

Instream flow recommendations were developed in the mid-1980s (see Instream Flow section at beginning of this chapter), but the TAG does not support implementation of those recommendations at this time. Rather, the TAG supports continued work to develop and implement a normative flow regime that combines "the goal of sustaining ecological integrity of the watershed, while also maximizing use of water resources by humans" (SOAC 1999).

Lakes

No lakes are present in this watershed.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Taneum Creek:

- **Increase instream flows for rearing spring chinook and steelhead, and adult spring chinook passage; assess options that will reduce water diversions from Taneum Creek**
- **Correct passage problems associated with the Bruton Diversion**
- **Correct identified streambank erosion problems downstream of I-90**
- **Restore floodplain function through the Heart-K Ranch**
- **Restore riparian function through agricultural area in lower watershed; improve riparian function in forested portion of upper watershed**
- **Develop and implement a short-term LWD strategy for the lower watershed until full riparian function has been restored**
- **Restore beaver presence in Taneum Creek, particularly on the recently acquired Heart-K Ranch**

Swauk Creek 39.1157

General

Swauk Creek is a left bank tributary to the upper Yakima River, entering at RM 169.9. The Swauk Creek watershed drains an area of 100 mi^2 (Perala). Swauk Creek supports spring chinook (probably rearing only), steelhead (vestigial run), and bull trout (captured 200m upstream of mouth in 1993), as well as other resident salmonids and non-salmonids. Spawning coho were observed in the creek as late as the early-1960s (J. Easterbrooks, as cited in CBSP 1990). Swauk Creek was historically a substantial producer of steelhead and coho, but probably was too steep, narrow, and shallow for spring chinook, and there are no records it ever supported chinook spawning (CBSP 1990).

Although the drainage area of Swauk Creek is fairly large, precipitation is minimal and unregulated summer stream flows are very low (CBSP 1990). The lower three miles of the watershed are located in an arid canyon; the upper reaches of the watershed (upstream of RM 8) are forested. Substantial recreational and commercial gold prospecting occurs upstream of Liberty (RM 11)(WDFW 1998).

There are a number of habitat impacts that impair salmonid production in the Swauk Creek watershed. However, despite these problems, the USFS and WDFW rate salmonid production potential in the Swauk watershed as high, compared with most other watersheds in the upper Yakima River drainage (KCCD 1999).

Fish Access

Naturally occurring low flows throughout the system, and the absence of flow in the lower 4-6 miles in the fall, severely limit steelhead production, and totally preclude coho production (CBSP 1990). The lower portion of Swauk Creek goes dry in the summer, with flows being very low or intermittent as far upstream as RM 6. The streambed remains dry through early fall, precluding adult anadromous salmonid access into the upper watershed until arrival of significant fall precipitation (Renfrow). It is unknown to what extent the low flows are affected by a combination of loss of natural floodplain water storage, floodplain confinement, impaired riparian function, and water withdrawals, but by addressing these concerns it is thought that it may be possible to provide perennial flow through the lower river, or at least achieve rewatering of the channel earlier in the fall.

An irrigation diversion at ~RM 3.5 on First Creek (a right bank tributary to Swauk Creek entering at ~RM 6) diverts the entire summer /early fall flow out of the basin to the Reecer Creek watershed, drying up First Creek and precluding salmonid spawning and rearing (Pearsons). Trendwest is in the process of acquiring 58% of the senior water right and 51% of the junior water right (combined total of ~7 cfs) at the First Creek diversion (Nicolai). The intent is to maintain the water as instream flow in First Creek, as mitigation for development impacts elsewhere. This may increase accessibility into First Creek for rearing and potential spawning.

The Deer Gulch Road culvert on Williams Creek (the major left bank tributary to Swauk Creek) is a total fish passage barrier. Most of the culverts on Williams Creek are undersized and somewhat perched, creating at least partial fish passage barriers.

Floodplain Modifications

Historically, Swauk Creek is believed to have included a series of short, flat, unconfined areas, through which the stream meandered in multiple channels (YSS 2001 DRAFT). These areas were wet meadows, containing beaver dams and ponds, and functioned to conserve spring runoff and augment late summer and fall base flows. The elimination of beaver in the 1830s, in combination with a long history of mining (peak activity in 1870s, but continues at low levels today), and livestock grazing eliminated these habitat areas (Renfrow). With the loss of beaver dams and the incising of the channel, the critical water retention function of the wet meadow areas was lost.

Coal and hard rock mining were primary contributors to initial settlement in upper Kittitas County (Kittitas County Centennial Committee 1989). Placer gold was originally found in Swauk, Baker, and Williams creeks, located primarily in the gravel bars and bedrock of streams. Miners used all means available to search the streams for gold. Figure 57 shows the construction of an instream sluice box in the Swauk Creek streambed. Figure 58 shows the hydraulicing of a streambank or hillside to expose aggregate for sluicing. Much of the coarse sediment and most of the fine sediment likely ended up in the stream channels. In 1925, a large floating dredge was used for mining in Swauk Creek. The dredge was only used for 71 days, as they encountered

Figure 57: Mining sluice box constructed in Swauk Creek (from Kittitas County Centennial Committee 1989)

Figure 58: Hydraulicing of streambank or hillside for mining near Liberty (from Kittitas County Centennial Committee 1989)

insurmountable problems. However, 60 years later, evidence of dredge operations exists in the form of large tailing piles of boulders stacked along the banks of Swauk Creek where it runs near SR 97. There is some hard rock mining, but other than an operation near the confluence with First Creek, most of the current mining activity consists of small-scale suction dredging (MacDonald et al 1999, as cited in USFWS 2001 DRAFT)).

Swauk Creek is naturally relatively confined from the mouth upstream to Hidden Valley. However, through the lower canyon, the creek is constrained in places by an old railroad bed; over the years, the grade has washed out so it is currently difficult to distinguish (Bruce Coe, Hidden Valley Ranch). Road construction and mining have resulted in the straightening of most stream reaches (Renfrow), steepening channel gradients, and causing downstream bank erosion (KCCD 1999). Culverts are also undersized in places, causing debris blockages, fish passage barriers, and localized erosion during peak flows. Beginning at Lauderdale Junction (confluence of SR 97 and SR 970) Swauk Creek is confined to varying extents by SR 97 to the headwaters. Highway confinement of floodplain function is most severe from Lauderdale Junction upstream to Hurley Creek, with conditions improving somewhat upstream of Hovey Creek. In addition, floodplain function is impaired by an abandoned railroad grade on the opposite bank from the highway from Swauk Creek Campground upstream to Hovey Creek. There is a general lack of channel sinuosity where there is road or railroad encroachment. There is opportunity to restore floodplain function and engineer floodplain water storage through modification of the highway crossings and removal of the old railroad grade.

Floodplain function is also impaired along much of Williams Creek, as a result of channel incision caused by a combination of grazing, mining, and road impacts.

Channel Condition/Substrate Condition

Soils are typically gravelly or stony loams or silt loams throughout most of the Swauk Creek watershed (NRCS Soil Survey, as cited in KCCD 1999). Loams of varying textures are found in the upper areas of the drainage. Erosion risk is rated as high in most of the upper half of the watershed. USFS assessments of soil erosion risk placed nearly 74% of the Swauk River drainage at high risk of erosion (USFS 1997, as cited in KCCD 1999). Surface erosion has likely been exacerbated by increased fire frequency. There have been 237 fires in the watershed in the past 40 years. Human activity has been responsible for 70% of these fires, with lightning causing the others. Most fires were small; large fires include a 160-acre fire in the Mineral Springs area in 1974, and a 148-acre fire near Liberty in 1989.

Assessments of spawning habitat by USFS range from fair to poor in ~60% of the Swauk River watershed, due in part to fine sediment accumulations in the gravels and reduced presence of pools and LWD that trap gravels and form pool habitats (KCCD 1999). McNeil core substrate sampling at Mineral Springs indicated ~25% fines, potentially heavily influenced by sanding of SR 97 (Mayo). Influences cited by the USFS for the poor habitat condition include mining activities (hydraulic mining and dredging), timber harvest near riparian areas (44% of the watershed has been logged), grazing, roads, and recreation. There is a lack of LWD in the lower 3 miles of Swauk Creek, and a general lack of LWD and other structure that would provide habitat complexity throughout upstream areas, where floodplain and riparian functions are impaired by encroachment from the highway and an old railroad grade. LWD condition improves in the USFS ownership, although abundance is reduced due to dispersed recreational impacts. Upstream of Blue Creek, pool and LWD presence are poor (Mayo).

Road densities in subwatersheds range from 2.2-6.3 mi/mi^2 with numerous roads within riparian reserves (MacDonald et al 1999, as cited in USFWS 2001 DRAFT). In addition to the roads, there are numerous old skid roads. These old skid roads are often “opened” by recreationists as 4x4 routes. Due to roads and past skidding activity, an estimated 20% of the soils in the watershed are compacted. While there is no quantitative sediment data for the watershed there appears to be high risk of accelerated fine sediment delivery due to erosion of road surfaces.

A long history of suction dredging for gold has likely increased the presence of fines (embeddedness) in the substrate, impairing survival of salmonid redds (WDFW 1998). Biologists for the U.S. Bureau of Fisheries surveyed Swauk Creek in July 1936, and their notes state: “Due to gold sluicing operations … the entire downstream area is turbid … This activity has silted the stream considerably” (Yakima Basin Field survey 1936, as cited in Tuck 1993). A large amount of recreational gold mining (suction dredging), and a smaller amount of professional placer mining, occurs upstream of the Liberty area (RM 11)(CBSP 1990). The substrate is composed mainly of large rock and boulders in the lower 2-3 miles, which are located in a steep-gradient arid canyon (CBSP 1990, WDFW 1998). The substrate upstream of RM 3 consists mostly of coarse rubble, with a patchy distribution of spawning gravel suitable for steelhead and coho spawning (CBSP 1990). Past suction dredging and use of backhoes and bulldozers in the channel upstream of Lauderdale Junction entirely altered the natural substrate conditions, leaving temporary pits in the channel, and removing LWD and even heavy boulders from the channel (Renfrow). The loss of structural complexity in the channel has likely contributed to substrate instability and the channel incision observed downstream.

A Jeep/off-road trail has developed over time in Deer Gulch on First Creek. The trail runs right up the stream channel, and results in heavy fine sediment runoff downstream.

Riparian Condition

The lower 3 miles of the watershed are located in a steep arid canyon (YSS 2001 DRAFT). Progressing upstream, willows, alder, and cottonwoods gradually increase until, by RM 8, the stream flows through a conifer forest of increasing density.

Riparian condition is poor in the lower 3 miles, with a general lack of shade and LWD (Mayo, Renfrow). There are some mature cottonwoods through Hidden Valley, although riparian width is generally only one tree wide on the edge of grazed pasture, and the channel is incised from past grazing and runoff energy. There has been no commercial agriculture from Hidden Valley Ranch to the mouth of Swauk Creek in at least the last 22 years, and grazing on Hidden Valley Ranch has generally been by horses only and only for 3-4 months during the year (Bruce Coe, Hidden Valley Ranch). Upstream of Hidden Valley, riparian function has been adversely impacted by past mining (mostly suction dredging, but also use of backhoes and bulldozers), which has mined the bank and left large piles of rocks and gravels along the edge of the channel, which are not conducive to riparian vegetation growth. Upstream of Blue Creek, there is some channel shading, but condition would likely still rate as poor/fair due to trampling of riparian vegetation by dispersed recreation activities (Mayo, Renfrow).

Lower Williams Creek is heavily grazed, with little riparian vegetation. Riparian condition improves upstream in Williams Creek; riparian restoration/enhancement would also be beneficial in this area (Mayo, Renfrow).

Water Quality

The lower reaches of Swauk Creek are designated as Class A (excellent) waters (WAC 173.201(a), which determines which water quality parameters need to be met. The upper reaches and tributaries are designated as Class AA (extraordinary) waters. Five water segments within the Swauk Creek watershed are included on the CWA 303(d) impaired water quality list as not meeting state water quality standards for water temperature. The listed waters include two segments of Swauk Creek covering the entire mainstem from the mouth to the headwaters, and the waters of Blue Creek, Iron Creek, and Williams Creek (all based on data from 1990 and 1992). Water quality sampling by Kittitas County Conservation District in 1994 found water temperatures from 18.5 to 20°C during summer and early fall (KCCD 1999). Water temperatures exceeding the Class A standard of 18°C are also documented back to 1978 and 1982. Nutrients were generally low.

Water quality monitoring, during the spring runoff in 1994, measured turbidity to be >20 NTU (KCCD 1999). USFS monitoring in 1996 also measured high turbidity in the Swauk River watershed (118 NTU in Hurley Creek, 129 NTU in Medicine Creek, 80 NTU in upper mainstem Swauk Creek, and 40 NTU in Williams Creek and lower Swauk Creek downstream of Liberty). Turbidity is naturally elevated due to presence of sandstone in many of these drainages, but is exacerbated by runoff from SR 97 and forest roads, and dispersed recreation (Mayo). Swauk Creek is estimated to deliver 1620 tons of fine sediment to the Yakima River annually. The Upper Yakima suspended sediment and pesticides TMDL technical committee is setting goals for sediment reduction in the upper Yakima River watershed (Creech).

Water Quantity

The lack of instream flow in lower Swauk Creek during late summer and early fall is considered to be a natural occurrence. Swauk Creek was proposed for inclusion on the CWA 303(d) impaired water quality list for impaired instream flow, but was not included due to any conclusive link between human actions and observed lack of instream flows. However, there are a number of authorized water diversions on Swauk Creek and tributaries that cumulatively may be the difference between low flow and no flow in the lower watershed. The absence of flow in the lower 4-6 miles in the fall severely limits steelhead production, and totally precludes coho production. The lower portion of Swauk Creek goes dry in the summer, with flows being very low or intermittent as far upstream as RM 6. The streambed remains dry through early fall, precluding adult anadromous salmonid access into the upper watershed until the arrival of significant fall rains (WDFW 1998). Upstream of RM 8, where the stream enters a forested zone, flows are marginally adequate through the summer (CBSP 1990).

There are 10 authorized diversions on Swauk Creek totaling 13.8 cfs, 3 diversions on First Creek totaling 7.5 cfs, 16 on Williams Creek totaling 6.2 cfs, and 13 diversions on miscellaneous tributaries totaling 3.7 cfs (Ecology vs. Aquavella, Report of Referee, Vol. 29A). Some of these authorized diversions are no longer in place (Nicolai), and some may not be able to divert the maximum authorized amount due to insufficient water availability during dry summer and early fall months. The diversions on First Creek (LB trib. to Swauk Cr. at ~RM 6) divert the entire summer/early-fall flow into the Reecer Creek watershed, drying up the lower portion of First Creek, and precluding salmonid spawning and rearing (KCCD 1999, Nicolai). Trendwest is in the process of acquiring 58% of the senior water right and 51% of the junior water right (combined total of ~7 cfs) at the First Creek diversion (Nicolai). The intent is to maintain the water as instream flow in First Creek, as mitigation for development impacts elsewhere. It is unclear to what extent this additional instream flow will benefit flows in lower Swauk Creek. Telemetry metering may be necessary at this site to ensure that the desired instream flow enhancement is achieved.

Flood events over the last 20 years have lasted no longer than 4 days, typically even shorter duration (Bruce Coe, Hidden Valley Ranch). Due to a combination of impaired riparian function, channel confinement/loss of floodplain function, lack of channel complexity, and loss of presence of beavers, the channel is no longer able to store runoff. Consequently, snowmelt and stormwater runoff cannot be stored in the floodplain and passes out of the system. This lack of storage potentially contributes to the lack of instream flow through the dry summer months. There is opportunity to increase floodplain function and associated natural floodplain water storage upstream of Lauderdale Junction. This would improve rearing conditions, and may improve instream flows through the summer, or at least allow the stream to “rewater” with surface flow earlier in the fall (Renfrow, Nicolai, Mayo).

Instream flow recommendations were developed in the mid-1980s (see Instream Flow section at beginning of this chapter), but the TAG does not support implementation of those recommendations at this time. The instream flows recommended by Simmons (USFWS) far exceed the natural flow in the creek (Perala). Rather, the TAG supports continued work to develop and implement a normative flow regime that combines "the goal of sustaining ecological integrity of the watershed, while also maximizing use of water resources by humans" (SOAC 1999).

Lakes

No lakes are present in this watershed.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Swauk Creek:

- **Restore historic floodplain conditions in the lower 3-5 miles of the watershed; restore beaver presence**
- **Assess impacts of water diversions on base flows and hyporheic recharge**
- **Assess current status and potential options to increase natural floodplain water storage; investigate alternatives to increase current stormwater/snowmelt runoff to hyporheic/groundwater storage**
- **Reduce adverse effects of dispersed recreational access to riparian condition and LWD presence upstream of First Creek**
- **Assess, prioritize, and correct fish passage barriers, particularly in Williams Creek**
- **Eliminate unrestricted domestic livestock access to Swauk Creek through Hidden Valley and lower Williams Creek**
- **Reduce fine sediment runoff to channels from road runoff; reduce/eliminate unintended consequences of highway sanding to adjacent streams**
- **Develop and implement a short-term LWD strategy to provide LWD presence and habitat diversity until riparian function is restored**
- **Restore riparian function, where impaired, throughout the watershed**

Teanaway River 39.1236, SF Teanaway, MF Teanaway 39.1351, NF Teanaway 39.1260, Jack Creek 39.1282, Jungle Creek 39.1246, De Roux Creek 39.1342

General

The Teanaway River is a left bank tributary to the Yakima, entering at RM 176.1. The watershed drains an area of 244.3 mi^2 (estimate also includes Crystal Creek drainage, tributary to the Yakima River)(NRCS estimate, as cited in KCCD 1999). The mainstem is 11.7 miles long, with additional steelhead accessibility of 16 miles in the NF, 12 miles in the MF, 8 miles in the WF, and 3 miles in small NF tributaries (YSS 2001 DRAFT). The Teanaway supports spring chinook, steelhead, and bulltrout, as well as a number of other salmonid and non-salmonid species (WDFW 1998). Resident and fluvial bull trout are present; the status of Teanaway River bull trout is critical. Fluvial bull trout were identified upstream of DeRoux Campground in the NF in 1997. Bull trout juveniles have been found in Jack Creek and Jungle Creek, although no adult spawning has been observed in these tributaries; bull trout spawning has been observed in De Roux Creek (WDFW 1998).

The Teanaway was historically one of the top producers of spring chinook, steelhead, and coho in the Yakima watershed (Bryant and Parkhurst 1950, as cited in CBSP 1990). With correction of a number of significant habitat problems, the physical diversity and size of the Teanaway guarantee it could still be a major producer. A recent Ecosystem Diagnosis and Treatment (EDT) simulation for spring chinook in the Yakima River watershed indicated that the Teanaway River

was one of the top five portions of the entire watershed in terms of restoration potential, and that if it were fully restored to historic conditions, productivity and equilibrium abundance would be doubled watershed-wide (YSS 2001 DRAFT). Suitable spawning gravels and gradients for all three species are present in most reaches of the mainstem and the lower portions of the forks, and are abundant in many areas. The upper reaches of the forks, as well as the lower reaches of some smaller NF tributaries (DeRoux, Eldorado, Johnson, Beverly, Jungle, Jack, Rye, Indian, Middle, Dickey, Lick, Stafford, Bear, and Standup creeks) provide additional spawning habitat for steelhead and coho (CBSP 1990, YSS 2001 DRAFT). Eldorado Creek is so small that it can't have potential for much, if any, spawning (KCCD).

The lower Teanaway (downstream of the forks) flows through a broad valley consisting mainly of irrigated hayfields, with recent heavy conversion to recreational/residential homesites (Teske).

In decreasing order of importance, the main factors limiting production in the Teanaway have been identified as low flows and associated high water temperatures during the summer and fall in the lower mainstem, the MF, and the WF; loss of natural floodplain function through the lower watershed; and a "flashy" runoff pattern (the Teanaway has a naturally high flow variation due to extent of watershed that is in the rain-on-snow zone; flow variation has been exacerbated by extensive logging in the upper watershed (TAG)).

Fish Access

WDFW identified 17 diversions with screening facilities (several of which were not operating) in a 1988 survey) (CBSP 1990). All of the diversions were created by pushing up temporary gravel berms across the channel, which would wash out during high flows; none had permanent diversion structures (CBSP 1990). Three diversions and associated open earthen ditches and laterals that were major contributors to lack of instream flow in the lower river were recently converted to modern pump and pipeline irrigation systems (YSS 2001 DRAFT). The water saved has been transferred to instream flow, and the points of diversion were re-located to downstream pump sites, allowing the water to remain as instream flow for an additional 3 miles. These changes should minimize juvenile stranding and improve instream flows during the adult migration period, providing improved access to the upper portion of the watershed. There are opportunities for the Kittitas County Conservation District to work with remaining water right holders to upgrade their irrigation systems (both on-farm and delivery) to more efficient systems (KCCD).

Floodplain Modifications

Historically, the valley bottom was a network of unconfined, anastomosing channels over deep alluvial deposits (YN 2001, CWU Geology Dept. Workshop 1995; both as cited in YSS 2001 DRAFT). Beaver ponds were very numerous, and the wide valley bottom was largely wet meadow and wetlands. These beaver ponds greatly reduced the destructive impact of annual smowmelt floods, and the cold snowmelt water stored in the ponds and wetlands supplemented base flows in the summer and fall and maintained cool stream temperatures. This type of system supported runs of spring chinook numbering in the thousands prior to development in the late 19th and early 20th centuries (Bryant and Parkhurst 1950, as cited in YSS 2001 DRAFT). The structure and character of the river has been completely changed as the river has been disconnected from its floodplain and the floodplain itself has been radically altered (YSS 2001 DRAFT). These alterations include the draining of ponds and wetlands and the filling of side-channels, significant loss of beaver presence in the lower watershed, straightening of the river,

and consolidation and diking of channels. These changes greatly reduced the frequency of spring runoff spreading over the floodplain and the degree to which shallow aquifers were recharged with cold spring runoff. The channel "simplification" accelerated flow, promoting downcutting, and further drying out remaining wet meadows and wetlands (Renfrow). The effects, frequency, and magnitude of peak runoff events (snowmelt and rain-on-snow) have also been exacerbated by the long history of logging and splash damming in the Teanaway watershed, which has significantly reduced channel roughness and complexity and increased the rate of runoff.

Logging railroad lines were constructed in the stream valleys in ~1916, replacing earlier splash damming log drives down the Teanaway (KCCD 1999). These rail lines affected channel alignments in areas such as Rye, Jungle, and Middle creeks. Subsequent conversion to tractor logging in the mid-1930s, with associated construction of logging roads, resulted in gullying and channel entrenchment in areas with highly erodible soils (e.g., Lick Creek).

Although the river has been channelized and riprapped where it approaches SR 970, there are extensive reaches where the river and the highway are far apart; well over half of the mainstem is still anastomosing, even though the number of channels and interconnections is much lower than historically (YSS 2001 DRAFT). However, SR 970 functions as a levee in the lower 4 miles, constraining floodplain function and natural channel migration during peak flow events (Renfrow, Teske). A fairly extensive wet meadow/wetland complex still exists in the lowermost several miles of the mainstem, and this area has been identified as a critical piece of habitat and a top priority for preservation (YSS 2001 DRAFT).

Most of the channel through the agricultural area downstream of the forks has been rerouted to move it to the edge of the valley to improve agricultural access (Renfrow). It has been confined with "sugar dikes" (dikes made of pushed up river gravels) to keep it in that location, and LWD has generally been removed from this reach to minimize the potential for bank erosion or channel change. There has been some increase in stream meandering in this reach since the 1990 flood, but much of the reach remains channelized and armored.

Channel Conditions

Figure 59: Teanaway log drive (Contratto Collection, from Kittitas County Centennial Committee 1989)

Channel conditions have been severely impacted by a long history of splash damming and log drives down the Teanaway River. The earliest record of splash damming and log drives was down the NF, MF, and WF Teanaway in 1891 (Kittitas County Centennial Committee 1989). Each year millions of board feet were floated from the Teanaway to the Cascade Lumber mill in Yakima (Figure 59). From 1905

until 1916, logging companies were blasting in the stream channels and driving logs down the river, which may have contributed to the destruction of the salmon runs (Bryant and Parkhurst 1950). The massive energy associated with water releases and large volumes of logs severely affected the bed, banks, and substrate of the Teanaway and Yakima rivers. Instream log drives were replaced with construction of rail lines in the watershed in 1911-1912.

Instream habitat in the mainstem Teanaway has been impaired by disturbances associated with the annual berming of irrigation intakes (CBSP 1990, WDFW 1998). However, of the 17 diversions identified in a 1988 survey by WDFW, there are only two remaining on mainstem Teanaway, and one on NF Teanaway that use gravel berms. Cover in the form of LWD is generally lacking in the NF, but is abundant in the MF and WF (CBSP 1990), and is generally lacking downstream of the forks (Renfrow). There is a good mix of pools, runs, and riffles, and the channels and banks are generally stable (CBSP 1990).

Bureau of Fisheries (BOF) stream surveys in 1936 catalogued the number of pools by depth and area in the upper mainstem Teanaway (McIntosh et al. 1995, as cited in Boise Cascade 1996). The BOF surveyed 6.59 miles of the mainstem and found 70 pools greater than 3-feet deep, of which 23 were greater than 6-feet deep. Habitat mapping for the Teanaway Watershed Analysis (Boise Cascade 1996) identified only 14 pools >2.75-feet deep, and two pools >5-feet deep (the lower depths are accounting for the lower flows in October, versus the BOF surveys in July). Based on the 1936 survey data, we would have expected that roughly 22 pools >2.75 feet deep and 7 pools >5-feet would have been observed. This indicates that there has been a significant decline in pool frequency and depth in the mainstem since 1936.

Substrate Condition

Soil characteristics and erodibility vary widely throughout the Teanaway River watershed (NRCS Soil Survey, as cited in KCCD 1999). Soils are generally deep with higher erodibility in the lower areas, particularly near the channels of the three forks. There are extensive areas of very high erosion risk, particularly in the NF and in the hills lying along the lower reaches of the WF. Erosion risk is high in most of the upland areas, dropping to moderate or low in extensive areas of the MF and WF. Areas near the Teanaway River, in the lower reaches of the three forks and the mainstem itself, are characterized by low to moderate erosion risk.

Substrate condition in the mainstem is fair to good, with sedimentation conditions also being fair to good; substrate condition in the NF is rated as fair, with little sedimentation (WDFW 1998). Although the NF carries most of the flow in the upper tributaries, substrate is generally large, and quality spawning gravel is limited (CBSP 1990). Excellent spawning gravel exists in both the MF and WF, but summer discharge can be quite low in the WF. Historic sluice-damming/log drives in the NF severely impaired habitat in the basin by scouring gravels and exposing bedrock (WDFW 1998).

Stream channel entrenchment (downcutting) is widespread in the Teanaway River watershed, leading to accelerated streambank erosion and accumulations of fine sediments in stream gravels (KCCD 1999). Channel entrenchment is attributed to past timber harvest activities and concentrated peak flows in the watershed.

Several forest roads in the Teanaway watershed have been identified as contributing fine sedimentation to streams, with potential adverse impacts to bull trout habitat (USFWS 2001 DRAFT), including:

- USFS Road 9738 is adjacent to the stream and delivers fine sediment to Jack Creek and has at least one section that is being undermined by the stream. Some sections of the road confine the stream channel.
- The lower sections of USFS Road 9701 are adjacent to the stream and deliver fine sediment to Jungle Creek. At least one section of the road was undermined by the stream during high flows and has since been riprapped.
- Indian Creek Road parallels Indian Creek and has road sections that deliver fine sediment and confine the channel migration zone.
- Middle Creek Road parallels Middle Creek and has fine sediment delivery to the stream system.
- Dickey Creek Road parallels Dickey Creek and has fine sediment delivery to the stream system.
- Lick Creek Road parallels Lick Creek and has fine sediment delivery to the stream system. Upper sections of the road have been captured by the stream.
- Carlson Canyon Road parallels Carlson Canyon and has fine sediment delivery to the stream system.
- Dingbat Creek Road parallels Dingbat Creek and has fine sediment delivery to the stream system.
- Sandstone Creek Road parallels Sandstone Creek and has fine sediment delivery to the stream system.

Sediment load reductions from a combination of riparian restoration and improved road maintenance are estimated to be beneficial by contributing to reductions in width of the active channel and channel width-to-depth ratio, and contributing to lowered stream temperatures (Stohr and Leskie 2000, see Water Quality section below).

Channel width and channel width-to-depth ratios are important to stream temperature, because a wide shallow stream will absorb heat much quicker that a deeper narrower channel. The PACFISH/INFISH reports (USDA 1995, as cited in Stohr and Leskie 2000) suggest channel width-to-depth ratios of 10 or less as ideal for salmon. The channel width-to-depth ratios in the Teanaway are much larger, ranging from 18 to 70 (Stohr and Leskie 2000). Although the INFISH goals may not be appropriate for the Teanaway, the current width-to-depth ratios appear to be higher than optimum, and are thought to be the result of widening and shallowing of streams due to sediment input. Much of the sediment in the Teanaway watershed comes from natural sources, such as landslides and erosion. However, some sediment input is due to road building and maintenance, cattle grazing, and agricultural and recreation activities near the stream. These activities discourage the growth of riparian vegetation, causing additional bank erosion. A stream channel assessment of lower McDonald Creek (Rashin 2000, as cited in Stohr and Leskie 2000), conducted to evaluate stream channel conditions before and after timber harvest activities, showed extensive streambed scour and deposition of materials transported from upstream erosion sites, as well as an almost doubling of the average channel width.

Riparian Condition

Many mature cottonwoods still line the banks of the mainstem and the lower portions of the forks, but simplification of the channel and the lack of LWD (particularly “key pieces” not easily mobilized by high flows) have resulted in regular spring and winter flood widening of the channel to the extent that the shade from these trees in the summer does not reach the remaining flow concentrated in the center of the channel (YSS 2001 DRAFT, Renfrow). Riparian condition is good/excellent on all three forks, although widely dispersed logging and grazing have had localized impacts (CBSP 1990). The impacts of past grazing are relatively more severe for the

WF and MF, the lower reaches of which flow through canyons in which cattle were concentrated (CBSP 1990); numbers of cattle in these areas has been substantially reduced since 1990 (KCCD). Past grazing (mainly sheep) activities have had pronounced effects on riparian vegetation and streambank stability (e.g., Indian Creek)(Boise Cascade watershed analysis for NF Teanaway River, as cited by KCCD 1999). Analysis and stream temperature modeling shows that increases in riparian shade would contribute to reductions in mean daily and daily maximum stream temperatures (Stohr and Leskie 2000, see Water Quality section below). It is also expected that restricting the access of cattle and other animals to the stream will be necessary to encourage riparian growth, and thus reduce damage to stream banks

Water Quality

The upper reach of the Teanaway River (upstream of the USFS boundary) is designated as Class AA (extraordinary) waters; the lower Teanaway River and tributaries are designated as Class A (excellent) waters (WAC 173.201(a)), which determines which water quality parameters need to be met. The mainstem, MF, NF, and WF are all included on the CWA 303(d) impaired water quality list for water temperature, with numerous excursions from state water quality standards noted in each area. Stafford Creek (tributary to NF Teanaway) is also on the CWA 303(d) impaired water quality list for water temperature. Various water quality sampling efforts have identified summer/fall water temperatures in the mainstem of 20-23°C (KCCD 1999). Water temperature data collected in 1998 show that the entire summer is of concern, with the lower altitude sites exceeding 18°C in over 75% of the days monitored (Stohr and Leskie 2000).

The Department of Ecology, in cooperation with landowners in the Teanaway watershed and other agencies, has developed the Teanaway River Basin Temperature Pilot Technical Assessment (Stohr and Leskie 2000). Analysis and stream temperature modeling show that mean daily water temperature could be reduced by 1.5-3.0^{o}C, and maximum daily water temperature could be reduced by 3-6°C, under the most favorable simulated conditions during critical conditions of low flow and high air temperature periods characteristic of late-summer, by a combination of increased riparian shade, reduction in active channel width (resulting from reduced sediment load), and increased streamflow. At critical low flow and high temperature conditions, establishment of a full mature riparian stream corridor is estimated to result in shading that would produce a 35-62% reduction in solar radiation load. This solar load reduction correlates to an estimated 1.5^{o}C reduction in mean daily temperature, and a 3°C reduction in maximum daily temperature. Sediment load reductions resulting from an established mature riparian corridor and improved road maintenance (as recommended in the NF and WF Teanaway Watershed Analysis reports) are estimated to reduce the width of the active channel and channel width-to-depth ratio. The sediment control is estimated to provide an additional 10% reduction in solar radiation load, resulting in a 0.5^{o}C reduction in mean daily temperature, and a 0.5-1.0^{o}C reduction in maximum daily stream temperature. Doubling the flow in the lower segment of the NF from 20 to 40 cfs, and in the mainstem from 27 to 50 cfs, using existing riparian shade, is estimated to decrease the mean daily stream temperature by 1°C and the maximum daily stream temperature by 2°C. In addition, the technical assessment identified other unquantifiable benefits associated with restoration of mature riparian buffers, including:

- Increase of LWD to the stream – providing salmon habitat, formation of pools, and retention of bedload
- Additional support for smaller riparian vegetation that provides additional stream shading
- Gravel bed shading – resulting in cooler conditions for water moving under or through those gravels

- Cooling of ambient air temperature – resulting in further reduction in heat transfer to the stream

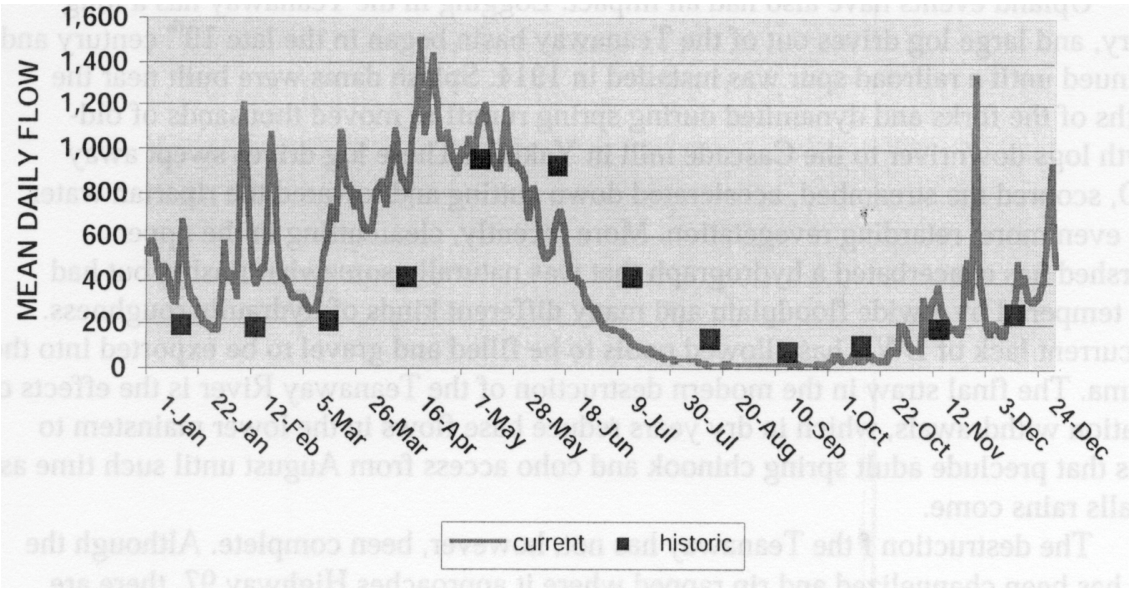
Sampling for heavy metals and other elements has been conducted by USGS and KCCD (Tri-County 2000). The USGS observed that elevated chromium and nickel concentrations occurred in the Teanaway River basin and also raised concerns over lead-arsenate pesticide use in this watershed. KCCD sampling noted measurable chromium (0.008 mg/l) and nickel (0.021 mg/l) during April 1994, when river flow/turbidity was relatively high. Lead and arsenic were not detected in the Teanaway River samples in 1994.

Peak flows in the Teanaway River drainage are often quite turbid. Frequent visual observations along the Yakima River confirm that the Teanaway River significantly increases Yakima River turbidity during winter-spring run-off periods. Suspended sediment and turbidity measurements during run-off events show suspended sediment concentrations exceed 250 mg/l during high flow periods (KCCD 1999). The estimated annual delivery of fine sediment from the Teanaway River to the Yakima River is 23,500 tons (based on the 7 years preceding the 1996 flood). The Upper Yakima suspended sediment and pesticides TMDL technical committee is setting goals for sediment reduction in the upper Yakima River watershed (Creech).

Water Quantity

Streamflow information is available for the BOR stream gage located on the Teanaway River below the confluence of the three major forks (Stohr and Leskie 2000). The gage is upstream of major irrigation diversions, and drains ~172 mi^2. The 1971-1998 period of record shows a peak flow of 8000 cfs and a low flow of 6 cfs, with an average annual peak of 1000 cfs and an average annual 7-day low flow of 15 cfs. Minimum mean daily flows for the years 1994-2000 range from 6-15 cfs, which not only preclude upstream adult passage, but also strand or isolate juveniles in small pools, where they are at increased risk of predation, and also result in increased water temperatures (YSS 2001 DRAFT). A comparison of the 1994-2000 hydrograph with the

Figure 60: Current (1994-2000 and estimated historic hydrograph for the Teanaway River downstream of the forks (from YSS 2001 DRAFT)



estimated historic hydrograph is presented in Figure 60. Note the change to earlier spring runoff from smowmelt, and the lower baseflows through the summer and early fall.

Water uses in the Teanaway watershed include diversions for seasonal irrigation (primarily hay and pasture production), stockwater, and for domestic water supply (KCCD 1999). Irrigation diversions are numerous and range from domestic irrigation involving 1-2 acre feet/year, to irrigation ditches serving 200-300 acres or more (Report of Referee, No. 3, Teanaway River; as cited in KCCD 1999). Most withdrawals occur along the lower Teanaway River or from springs, a few surface water rights are in the NF and WF, or from tributaries such as Mason Creek. Three diversions and associated open earthen ditches and laterals that were major contributors to lack of instream flow in the lower river were recently converted to modern pump and pipeline irrigation systems (YSS 2001 DRAFT). Part of that project involved conversion of 432 acres to pressurized delivery and on-farm application systems; in 2000, they used only one third of their water right (KCCD). The water saved has been transferred to instream flow, and the points of diversion were re-located to downstream pump sites, allowing the water to remain as instream flow for an additional 3 miles (YSS 2001 DRAFT). These changes should minimize juvenile stranding and improve instream flows during the adult migration period, providing improved access to the upper portion of the watershed.

The lower Teanaway River is included on the CWA 303(d) impaired water quality list for impaired instream flow. The lower 10 miles of the watershed flow through a broad valley, which consists mainly of hayfields that are irrigated with water withdrawn from the river. Low late-summer and fall flows preclude significant spring chinook and coho spawning access in most years. Flows decrease progressively from the forks to the mouth in the summer and fall, and may be below the minimum for salmon passage from mid-July to mid-November. However, steelhead would encounter good passage flows from December through April (CBSP 1990). Of the three tributaries, the NF carries most (70-80%) of the flows; summer discharge can be quite low in the WF (CBSP 1990). Summer flows are adequate through approximately 15 miles of the NF and 9 miles of the MF. In addition to improving fish passage conditions, increased instream flows in the NF and mainstem are also identified as desirable in contributing to lowered stream temperatures (Stohr and Leskie 2000, see Water Quality section above).

The Teanaway River is noted to have “flashy” flows, responding more quickly to storm events than other neighboring watersheds. The Teanaway has a naturally high flow variation due to extent of watershed that is in the rain-on-snow zone, and due to the extent of the watershed that has open and exposed south-facing slopes, but the extent of peak flow has likely been exacerbated by extensive logging in the upper watershed, particularly in the NF (TAG).

At the same time that significant effort and expense is being committed to improve instream flows through modification of irrigation diversions, there is increasing residential development in the watershed, most of which are drilling exempt wells. There is a significant potential that the exempt wells are in continuity with the stream, potentially adversely affecting the instream flow improvement efforts associated with modification of the irrigation diversions. The cumulative impact of exempt wells on instream flow should be further assessed (Hall).

Instream flow recommendations were developed in the mid-1980s (see Instream Flow section at beginning of this chapter), but the TAG does not support implementation of those recommendations at this time. Rather, the TAG supports continued work to develop and implement a normative flow regime that combines "the goal of sustaining ecological integrity of the watershed, while also maximizing use of water resources by humans" (SOAC 1999).

Lakes

There are no significant lakes present in this watershed.

Action Recommendations

Recent EDT simulations indicate that non-normative flow clearly has the greatest adverse impact to spring chinook production. The relative impacts of low habitat diversity, low channel stability, excessive temperature, entrainment or predation associated with irrigation withdrawals, and sedimentation are, respectively 75, 60, 50, 20, and 10% of the impact of flow (YSS 2001 DRAFT). The following ranked salmonid habitat restoration actions are recommended for the Teanaway River:

- **Increase instream flows and improve adult passage conditions in the channel for spring chinook and coho**
- **Protect and restore historic anastomosing floodplain conditions downstream of the forks**
- **Develop and implement a short-term LWD strategy, to provide LWD presence and habitat diversity until riparian function is restored**
- **Restore riparian function where impaired**
- **Assess causes of high turbidity and bedload instability during peak runoff events, correct as warranted**
- **Protect remaining mature forest vegetation in the upper watershed until hydrologic maturity of the watershed is reestablished and maintained**

These Action Recommendations are generally consistent with the Recommendations in the Teanaway River Basin Temperature Pilot Technical Assessment (Stohr and Leskie 2000), and these processes should be considered as complimentary in achieving improvements in water quality and salmonid habitat.

Cle Elum River 39.1434

General

The Cle Elum River is a left bank tributary to the upper Yakima River, entering at RM 185.6. The watershed drains an area of 231.3 mi^2 (NRCS estimate, as cited in KCCD 1999) or 133,382 acres (USFS 1996), with the vast majority of watershed area upstream of Cle Elum Dam. There are an estimated 554 miles of Type 1 through 5 streams in the watershed. The Cle Elum River supports chinook, coho (historic), steelhead, and bulltrout, as well as a number of other salmonid and non-salmonid species (WDFW 1998). There is no known anadromous salmonid presence in Domerie Creek, a right-bank tributary entering the Cle Elum River approximately 1 mile downstream of Cle Elum Dam. The lower Cle Elum River is a high-density chinook spawning area (WDFW 1998). In most years, 40-50% of the spring chinook redds in the upper Yakima watershed are located in the Cle Elum River and in the Yakima River immediately upstream and downstream of the confluence of the Cle Elum River with the Yakima River (BOR 2000). The watershed historically also had abundant anadromous sockeye, which were extirpated with the construction of the Cle Elum Dam in 1933 (USFS 1996), although there is evidence that the run was extirpated or severely reduced with the earlier construction of the log crib dam in 1906 (Mongillo and Faulconer 1982). Bull trout also were historically abundant, with only a remnant population still existing. There is a long history of planting of non-native salmonids in the

watershed, with the earliest recorded planting of non-native salmonids in 1940, and the first recorded planting of brook trout in 1957 (reports of possible plantings in the 1920s)(USFS 1996). Cutthroat and rainbow trout are found in all of the fish-bearing streams and lakes in the watershed, but it is currently unknown if the native cutthroat are westslope cutthroat, another species, or hybrids. Upstream of Cle Elum Dam, the watershed supports kokanee and bulltrout, as well as other resident salmonid and non-salmonid species. Kokanee and bull trout in this area spend their life in Cle Elum Reservoir, except for spawning and egg incubation to emergence.

Knowledge of resident salmonid and non-game fish population densities and stability within this watershed is very limited (USFS 1996). Historically, bull trout were found throughout the Cle Elum River watershed, except for the Cooper River drainage. It is believed that the populations of bull trout in the watershed have been severely reduced. Bull trout were occasionally trapped in Cle Elum Lake between 1987 and 1994. Mongillo (1993, as cited in USFS 1996) verified that bull trout were caught from Waptus Lake in the early-1970s. More recently, WDFW verified bull trout presence as the result of surveys at Waptus Lake and tributaries from 1996-1998; several juvenile and two adult bull trout were observed, and no redds were found (Cummins). Factors thought to be suppressing populations in the Waptus River drainage include poaching and non-native fish species (Mongillo 1993, as cited in USFS 1996).

From the types of artifacts found in the area, it is believed that native American occupancy extends back 8,000-11,000 years. Of particular note to the Cle Elum River watershed is that an important summer camp occupied a site at the outlet of the natural Cle Elum Lake, where a huge salmon trap was maintained, attracting as many as 1,000 persons during June and July (Kittitas County Centennial Committee 1989). European settlement in the watershed is thought to have started in the 1860s. The watershed has a long history of trapping, hunting, fishing, grazing, logging, and mining. Private developments and industrial forest lands are intermingled with National Forest lands, resulting in some land management conflicts. The watershed is comprised of >50% mature forest habitat. It is also a popular year-round recreational area, and serves as the gateway to the Alpine Lakes Wilderness.

Coal and hard rock mining were primary contributors to initial settlement in upper Kittitas County (Kittitas County Centennial Committee 1989). Extensive mining occurred in the upper Cle Elum drainage (south side of Mt. Hawkins) from 1881 to the 1930s. Particularly during the early years, there were “hordes of prospectors” working in this area. It is likely that mining activities significantly affected the quality of fish habitat, but no information was located on the extent of impact or persistent habitat effects.

Private (Plum Creek) timberlands are scattered throughout the National Forest in a checkerboard pattern and in the Domerie Flats area in the lower part of the drainage (KCCD 1999). The watershed includes the community of Ronald, various developments near Lake Cle Elum (e.g., Wildwood) and recreational areas such as Salmon la Sac. A major resort development (Trendwest) is proposed on a 7400-acre site along the lower Cle Elum River. The development plan includes 3000 homes, condominiums, hotel facilities, and several golf courses to be built over the next 15-20 years.

Fish Access

Cle Elum Dam (RM 8) is a complete fish passage barrier, precluding access to 18.4 miles of the Cle Elum River upstream of the lake to Hyas Lake, 3.2 miles of the lower Cooper River, and 3.5 miles of the lower Waptus River. This area is estimated to be capable of sustaining a spawning population of 328 spring chinook, with a productivity of 2.7 adult progeny per spawner (EDT

simulation, YIN). Flagg and Ruehle (2000) indicate that Cle Elum Falls, a series of 3 principal waterfalls over a distance of 100m between Camp and Fortune creeks may be the uppermost extent of historic anadromous distribution. This lost productivity is roughly equivalent to the current spring chinook production from the American River in the Naches River watershed. The dam blocks upstream migration of spring chinook, steelhead, and sockeye, and resulted in extirpation of the anadromous sockeye run to Cle Elum Lake. Construction of the dam also isolated the bull trout population in the watershed from populations in the Yakima River.

Another structural concern for Cle Elum Dam is that the outlet works are unscreened (USFWS 2001 DRAFT). Bull trout, and other salmonids, which enter the submerged outlet structure would be subjected to a rigorous and potentially fatal flush to the river downstream. While bull trout mortality due to lack of screening has not been documented, dead burbot have been observed on occasion below Cle Elum Dam. These lacustrine fish had undoubtedly been entrained in the respective outlet works, giving good cause to conclude that bull trout might be as well.

Floodplain Modifications

The Cle Elum River downstream of Cle Elum Dam is characterized by a large channel with several large side channel complexes, which do not become connected to the mainstem unless flows exceed 500 cfs (BOR 2000). There are numerous side channels along the river below the dam, which afford excellent rearing habitat for fry and parr in the spring and summer. However, the side channels are dewatered during flip-flop to encourage spawning at lower river levels, and similar flows are maintained through the winter to keep the redds watered (Monk). The BOR has recently attempted to ensure that releases from Cle Elum Dam are sufficient to keep the large anastomosing side-channel complex on the lower Cle Elum River from being dewatered (YSS 2001 DRAFT).

Channel Conditions

The upper Cle Elum River (upstream of Lake Cle Elum) was and is remarkably complex (complexity is mainly in the different types of channel types, not in physical habitat complexity (Teske)), containing a large, unconfined distributary fan near the lake, a confined canyon reach, a moderately steep (1.5-4% gradient) alluvial reach, and two lakes (one at the headwaters and one dividing to low gradient lake outlet reaches with abundant, clean spawning gravel, an intact riparian corridor, and plentiful LWD (YSS 2001 DRAFT).

Several streams within the Cle Elum River watershed are identified as having naturally low LWD recruitment potential, including along the mainstem of the Cle Elum River, along mainstem Fortune Creek downstream of the confluence with SF Fortune, along lower Big Boulder Creek, along high elevation tributaries to Cooper River and Waptus River, and portions of Thorp Creek passing through steep confined valleys (USFS 1996). Riparian and LWD recruitment potential has been impaired by various land uses along several streams, including Fortune Creek (from timber harvest and motorized trail encroachment into the riparian area), the lower portion of Big Boulder Creek at the confluence with Cle Elum River (clearing of riparian vegetation for housing development), and Thorp Creek, French Cabin Creek, and Domerie Creek (from recent timber harvest, road encroachment, and dispersed recreation). Specific sites classified as having high LWD recruitment hazard can be found in the Cle Elum Watershed Analysis (USFS 1996). It had been a fairly common practice until the last decade to salvage timber (LWD) deposited along the Cle Elum River floodplain after major storm events.

Road densities in the middle Cle Elum, Lower Cooper River and Thorp/French subwatersheds are greater than 2.4 mi/mi^2. Past activities in these disturbed watersheds may be contributing to a lack of pools in the Cle Elum River, eroding banks and accelerated bedload deposition and unstable bars. Past wood removal and dispersed recreation are likely contributing factors as well (MacDonald 1999, as cited in USFWS 2001 DRAFT). Much of the upper portion of the watershed is in wilderness or lightly managed and natural watershed processes appear intact.

In the portions of the watershed surveyed for the USFS Watershed Analysis (tributaries upstream of the dam and Cle Elum River upstream of Salmon la Sac), only one of the reaches on the Cle Elum River met Forest Plan standards for primary pools (USFS 1996). The low number of quality pools and in-channel LWD may indicate an overall lack of habitat complexity important for salmonids. In particular, the low population size of bull trout in the Cle Elum watershed may indicate that the stream habitat complexity has been reduced.

Substrate Condition

Soils are typically shallow and tend to be weakly developed across a substantial portion of this watershed (USFS 1996). These characteristics generally reflect low soil cohesion, droughty conditions, and increased susceptibility to surface erosion. Road densities are generally relatively low; subbasins with road densities of concern include Lower Cooper (2.75 mi/mi^2), and Cle Elum Lake (4.48 mi/mi^2). The Cle Elum watershed exhibits significant variation in erosion, mainly due to topographic slope (KCCD 1999). Very high erosion risk is mapped in the Waptus River drainage, which is within the Alpine Lake Wilderness. In contrast, lands downstream of Cle Elum Dam generally exhibit low erosion risk. Most of the extensive and mountainous drainage to the west of Cle Elum Lake have high erosion risk, as do most of the areas of the upper Cle Elum River, most of which drain National Forest or wilderness areas. There are extensive areas of the lower Cooper River drainage that have high erosion risk that are in a checkerboard ownership between the National Forest and Plum Creek Timber Company. Mass wasting hazard ratings were “high” throughout most of the upper Cle Elum watershed (Alps Watershed Analysis, as cited in USFS 1996).

Substrate condition in the Cle Elum River downstream of Cle Elum Dam is fair to good, with little sedimentation (WDFW 1998). The substrate is composed of large materials, but there are adequate numbers of good gravel bars for spawning (CBSP 1990). Substrate sampling in 1990 in the Cle Elum River watershed upstream of the dam (3 riffles between the reservoir and Fortune Creek) and in Cooper River (1 riffle) documented fine sediment levels at all sampled riffles to average <10% (Watson 1991, as cited in USFS 1996). Based on the limited sampling, fine sediment does not appear to be a concern in this watershed. However, dispersed recreational activity along the Cle Elum River (upstream and downstream of the dam) and along Cle Elum Lake have led to conditions where increased delivery of fine sediments to the stream and lake are likely (USFS 1996). Forest roads are not considered to be a leading contributor of fine sediment in the watershed, although there are concerns at a few localized areas.

Riparian Condition

Riparian condition downstream of Cle Elum Dam is good, including good forested buffer areas (BOR 2000, CBSP 1990, WDFW 1998).

Water Quality

All surface waters within the Cle Elum River watershed are designated as Class AA (extraordinary) waters (WAC 173.201(a)), which determines which water quality parameters need to be met. Cle Elum River is on the CWA 303(d) impaired water quality list for water temperature, with numerous excursions from state water quality standards documented just upstream of the mouth of Fortune Creek in 1993. In addition, Thorp Creek, Cooper Creek, and Waptus Creek (all of which are tributaries to Cle Elum River upstream of Cle Elum Lake) are on the CWA 303(d) impaired water quality list for water temperature.

Water temperature sampling in the early 1990s documented exceedance of the Forest Plan standards in French Cabin Creek (all 3 years), Thorp Creek (all 3 years), Fortune Creek (1 of 3 years), Camp Creek (1 of 2 years), Cooper River (both years), Paris Creek (1 of 2 years), and Waptus River (1 year)(USFS 1996). It could not be determined whether the temperature exceedances are due to natural conditions or management impacts. Stream canopy cover surveys in the Cle Elum River watershed indicate there are large segments where riparian cover is naturally sparse.

Water quality profiles in Cle Elum Lake, extending as deep as 150 feet, were obtained monthly from mid-April through September 1987, from mid-May until late September 1979, and once in mid-summer 1990. Water temperatures exceeding 16°C were observed in near surface samples in July and August 1978; in July, August, and September 1979; and in July 1990. Water clarity, as measured by Secchi disc, was generally in the range of 6.3-9.2m, although a value of 3.0m was recorded in June 1979. Nutrient levels were extremely low. Chlorophyll measurements also showed extremely low values (<1 ug/l).

Water quality in the Cle Elum River downstream of the dam is considered to be good to excellent (CBSP 1990).

The Cle Elum River is estimated to deliver 9835 tons of fine sediment to the Yakima River annually (KCCD 1999). This is primarily in the form of suspended sediment, as bedload from the headwaters is retained in Cle Elum Lake. The Upper Yakima suspended sediment and pesticides TMDL technical committee is setting goals for sediment reduction in the upper Yakima River watershed (Creech).

Water Quantity

The City of Cle Elum diverts water (1100 acre feet/year) from Yakima River and the Cle Elum River for municipal water supply and maintains a standby well (KCCD 1999). The City relies heavily on the Cle Elum River source. The City of Roslyn diverts water (446 acre feet/year) from Domerie Creek for their city supply and for sale to the community of Ronald. These two municipal diversions result in exportation of water from the Cle Elum watershed to the adjacent Crystal Creek watershed. Large residential developments (e.g., Wildwood) near Lake Cle Elum pump groundwater to their customers. Other surface water users are identified in the Acquavella et al. Water Rights Adjudication Report of Referee for the Cle Elum Lake Subbasin, and include domestic use from various unnamed spring and creek diversions (e.g., Spring Creek, Big Boulder Creek). The small domestic diversions generally range from 0.5-2.0 acre feet/year.

The French Cabin and Salmon la Sac drainages are presently at the highest risk of experiencing cumulative hydrologic effects associated with vegetation disturbance, with >35% of their area in

a hydrologically immature condition (USFS 1996). Cle Elum Lake, lower mainstem Cle Elum River, lower Cooper Creek, and Domerie Creek drainages are a moderate risk of experiencing cumulative hydrologic effects associated with vegetation disturbance, with >20-35% of their area in a hydrologically immature condition.

The natural hydrology of the Cle Elum River is significantly altered, by water storage for flood control and irrigation water delivery. Instream flow evaluations for the Cle Elum River did not take into consideration the large side channel complexes that are only watered with flows >500 cfs. High flows (>500 cfs) during the irrigation season provide access to many side-channel complexes, which provide good summer rearing habitat, but once flows are lowered during flip-flop operations, the side channels are dewatered, eliminating most of the side channels as winter rearing habitat (BOR 2000). Flows downstream of the dam are reduced to ~200 cfs in September and October for spawning spring chinook. From October until spring runoff, flows of ~145 cfs are released for spring chinook incubation and early rearing. Both flows are at the low end of the instream flow recommendations of USFWS (see Instream Flow section at the beginning of this chapter). High flows during the summer irrigation period are well above the maximum recommended instream flows, but side channels may provide some relief from the high flow impacts on rearing suitability in the mainstem. Yakima Project operations may limit the availability of rearing habitat at low and high flows in the Cle Elum River for all stages of juvenile salmonid rearing.

There are also adverse impacts associated with abrupt changes in instream flow (CBSP 1990). Sudden increases in flow cause fish to vacate feeding territories and migrate to new areas, increasing competition and stress, reducing growth, and increasing the likelihood of mortality, either through predation or being displaced to unsuitable downriver habitat. Sudden decreases in flow result in the stranding or death of salmonids that are unable to relocate to nearby pools or runs. Abrupt changes in flow in the Yakima watershed are concentrated in reaches downstream of storage reservoirs and diversion dams, including the Yakima River between Keechelus and Easton dams, and the Cle Elum River downstream of the Cle Elum Dam (Mongillo and Falconer 1980, as cited in CBSP 1990). The BOR has implemented significant changes in river operations since 1994 (YSS 2001 DRAFT). These changes include the attempt to maintain minimum flows during winter reservoir refilling at certain locations and the attempt to constrain ramping rates to 1-2 inches/hour for flow decreases and 2 inches/hour for flow increases.

Instream flow recommendations were developed in the mid-1980s (see Instream Flow section at beginning of this chapter), but the TAG does not support implementation of those recommendations at this time. Rather, the TAG supports continued work to develop and implement a normative flow regime that combines "the goal of sustaining ecological integrity of the watershed, while also maximizing use of water resources by humans" (SOAC 1999).

The three largest floods of record, the 1907, 1990, and 1995 events (18,700 cfs, 20,394 cfs, and 20,600 cfs, respectively) approximate the 100-year recurrence interval flood (USFS 1996). Bankfull capacity below the mouth of the reservoir is 5,200 cfs, which approximates the 2-year recurrence interval.

Lakes

The Cle Elum Reservoir is one of the major irrigation storage reservoirs in the Yakima River watershed, with an active storage capacity of 436,900 acre-feet and a surface area of 4,800 acres, when full (USFS 1996). Lake Cle Elum was originally a natural lake with a capacity of 100,000 acre feet. A log crib dam was built at the outlet of Lake Cle Elum in 1906 to provide water

storage for downstream irrigation. Cle Elum Dam was constructed in 1933 as an earth and gravel-fill structure on top of a glacial moraine, to increase storage capacity for irrigation. The reservoir goes through an annual cycle of filling in the winter/spring, and draining through the irrigation season in the summer, with an average fluctuation of 60 feet (WDFW 1998). The United States Congress passed legislation in 1994 to look into the feasibility of increasing the water storage capacity of Cle Elum Lake by raising the dam height by an additional three feet; the additional water storage would be used to implement SOAC recommendations. The feasibility study for the proposal has not yet been completed.

Lake level fluctuation and drawdown of Cle Elum Lake likely reduces production of phytoplankton, zooplankton, and aquatic insects (BOR 2000), which reduces the food web base for bull trout residing in the reservoir.

Before construction of the dam, the lake contained a variety of sport fish, including mountain whitefish, rainbow and cutthroat trout, bull trout, and burbot. Sockeye salmon used the lake for rearing and, along with coho and chinook salmon, the streams above the lake for spawning (Robison 1957, Mongillo and Faulconer 1982, both as referenced in Flagg and Ruehle 2000). The carcasses of spawning salmon in streams running into Cle Elum Lake provided a substantial and reliable source of nutrients, which was greatly reduced once the dam obstructed the salmon runs (Flagg and Ruehle 2000). Bioassays conducted by Mongillo and Faulconer (1982) found growth of algal mass to be phosphorous limited. Statistical analysis of sediment cores in the lake indicate that prior to 1906 (the year of initial crib dam construction that blocked fish passage), there was an average of 19% more phosphorous deposited in lake sediments each year than there has been since 1906. These results suggest that salmon runs were probably eliminated by construction of the crib dam in 1906, rather than by the 1933 dam, and that salmon carcasses once contributed appreciably to the phosphorous load of Cle Elum Lake.

In addition, the high flushing rate, and hypolimnetic discharge of water from Cle Elum Lake during discharge both contribute to poor conversion of available phosphorous by algae (Mongillo and Faulconer 1982, as cited in Flagg and Ruehle 2000). Whereas Mongillo and Faulconer concluded that a relatively high flushing rate was the most significant cause of poor phosphorous conversion in Cle Elum Lake, a U.S. Dept. of Interior report (1975) estimated that 64% of the inflow loading of phosphorous to Cle Elum Lake was lost to outflow. Another factor affecting phosphorous utilization and productivity in Cle Elum Lake is the fluctuating water level (Flagg and Ruehle 2000). Among the Yakima Basin reservoirs, the farther a reservoir is drawn down, the fewer and smaller the invertebrates present (Mongillo and Faulconer 1982, as cited in Flagg and Ruehle 2000). In Cle Elum Lake, fish probably must feed in the pelagic zone on zooplankton, because water level fluctuations have all but removed benthic invertebrates in the littoral area. Combined, these factors contribute to reduced primary productivity in the lake, affecting the bull trout and resident trout stocks that remain in the lake. Reintroduction of anadromous salmonid passage upstream of the dam may increase phosphorous production, with associated increases in primary productivity, but productivity would still be impaired to some extent by the hypolimnetic discharge and lake level fluctuations. Lake fertilization may be a viable option to increase productivity in the lake, without altering water quality downstream of the lake, but would require additional limnological studies prior to implementation (Flagg and Ruehle 2000). Restoration of salmon runs upstream of Cle Elum Dam would offset the needs for fertilization (through nutrient input from carcasses) allowing the fertilization process to be phased out as salmon runs were restored.

There are numerous lakes in this drainage in addition to Lake Cle Elum; larger lakes include Cooper Lake, Waptus Lake and Hyas Lake and there are numerous smaller alpine lakes within

the Alpine Lakes Wilderness Area (e.g. Deep Lake, Circle Lake, Spade Lade, Venus Lake, Shovel Lake)(KCCD). No information was located on habitat conditions in these other lakes.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Cle Elum River:

- **Continue to evaluate the feasibility of restoring fish passage over Cle Elum Dam** (includes consideration of upstream adult passage and downstream adult and juvenile passage)
- **Assess the impacts of flip-flop; assess flow regime impacts on side-channel use and potential stranding in the lower Cle Elum River**
- **Develop and implement a short-term LWD strategy to provide LWD presence and habitat diversity downstream of the dam**
- **Restore natural LWD transport processes through Cle Elum Lake downstream to the Cle Elum River**

Little Creek 39.1674

General

Little Creek is a right bank tributary to the Yakima River, entering at RM 194.6. The combined Big Creek/Little Creek watershed is approximately 42 mi^2. Little Creek supports spring chinook and steelhead juvenile rearing and potential steelhead spawning in the lower reaches, as well as other resident salmonids and non-salmonids. It also has the potential to support coho spawning and rearing. The Yakima River terrace near Big Creek/Little Creek was logged and cleared from 1880-1900 and developed for agricultural crops (KCCD 1999). The Northern Pacific Railroad was built by 1887, and followed along the Yakima River. Water diversions were established on Little Creek by 1881.

Fish Access

There is at least one water diversion at ~RM 1.2 that totally dewaters the channel downstream to just upstream of the confluence with the Yakima River. There may also be other water diversions. Indications are that there is suitable habitat to RM 5.0, if fish are able to access upstream of the barrier at RM 1.2 (Teske).

Floodplain Modifications

The channel and associated floodplain appear to have been rerouted in the reach of the stream that traverses the Yakima River floodplain, in order to route the creek around the residential development at the mouth of the stream (Renfrow). Originally the stream would have flowed through an area of wetlands and springs associated with the hyporheic zone of the Yakima River. The present course of the stream takes it mid-slope along the edge of the terrace above the active river floodplain.

Channel Condition

Lack of LWD, resulting from past fire activity, is a significant concern in the Little Creek watershed (Plum Creek Timber Co. 1997, as cited in Tri-County 2000). The one reach where the USFS sampled habitat conditions on Little Creek met the Forest Plan standard for LWD presence, but did not meet the standard for pool frequency (USFS 1997). The USFS (1997) rated spawning, summer rearing, and winter rearing habitat quality (resident and anadromous salmonids) in the Little Creek drainage. Estimates are presented in Table 34.

Table 34: Habitat conditions (miles) in the Little Creek River watershed (from USFS 1997)

Habitat Type	**Good**	**Fair**	**Poor**
Spawning habitat	4	2	7
Summer rearing habitat	7	5	2
Winter rearing habitat	7	2	5

Little Creek also lacks in-channel LWD downstream from USFS boundary and commercial forest land (Renfrow). This is likely due, in part, to lack of recruitment from upstream, and also from a history of channelization and deliberate debris removal.

The channel upstream from the Nelson Siding Road appears to be unstable (Renfrow). A substantial amount of bedload is periodically transported by the creek during high flows and is evident at the BPA powerline crossing and Storey Lane. During the 1990 flood the creek channel became completely filled with bedload upstream of Storey Lane for hundreds of yards, diverting most of the flow to a new location to the west. A channel approximating the old alignment was constructed with a bulldozer and the stream diverted back into it. There have been subsequent problems with bedload deposition at this location.

Substrate Condition

Erosion risk, based on NRCS soil survey data, ranges from low to moderate on the river terraces to high to very high in the steeper regions of the upper watershed (KCCD 1999). An independently derived erosion risk map prepared for the Big Creek/Little Creek watershed by Plum Creek Timber Company show a similar erosion risk pattern, ranging from low on the Yakima River terraces and lower riparian areas along the creeks to moderate and high in the upper reaches. Landslides are a significant concern in the Little Creek watershed (Tri-County 2000). There is extensive bedload movement and accretion during peak flows (Teske, Renfrow); the suspected sediment source is in the vicinity of the powerline crossing of the stream.

Riparian Condition

Riparian condition is severely impacted through the powerline crossing of Little Creek, where vegetation is limited to shrubs and small trees that do not cause potential interference to the powerlines. Vegetation control is currently done selectively by hand or with a tractor-mounted flail, but in the past, powerline maintenance crews would periodically use a bulldozer with brush rake to grub out the woody vegetation within the right-of-way (Renfrow). This vegetation management eliminates localized potential for shade and future LWD recruitment, and may contribute to localized bank erosion and sediment accretion during peak flows.

Water Quality/Water Quantity

Little Creek is designated as Class A (excellent) waters (WAC 173.201(a)), which determines which water quality parameters need to be met. Little Creek surface water diversions total ~5.0 cfs for irrigation of 100 acres (Report of Referee re. Subbasin No. 2 (Easton); as cited in KCCD 1999). Little Creek was considered for listing for deficient instream flow based on input from the Yakama Indian Nation, but was not approved for listing by Ecology due to insufficient documentation.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Little Creek:

- **Assess water quantity status to determine impacts of water diversions on instream flows; look for alternative water sources for current water diversion(s)**
- **Assess, prioritize, and correct fish passage and screening at diversions**
- **Restore natural floodplain configuration and function where Little Creek crosses the Yakima River floodplain**
- **Restore riparian function where impaired, particularly through the powerline corridor crossing of Little Creek**

Big Creek 39.1687

General

Big Creek is a right bank tributary to the Yakima River, entering at RM 195.8. The combined Big Creek/Little Creek watershed is approximately 42 mi^2. Big Creek supports spring chinook and steelhead juvenile rearing and potential steelhead spawning in the lower reaches, as well as other resident salmonids and non-salmonids. Big Creek is known to have produced steelhead historically, and appears to have potential to produce steelhead, coho, and to a lesser degree, spring chinook (CBSP 1990). Spring chinook juveniles rear in the lower reaches in substantial numbers (CBSP 1990). The major habitat factors limiting salmonid production in Big Creek are the impassable dam and unscreened irrigation diversion at RM 2.1 (KRD), and the lack of instream flow from the dam to the mouth of the stream (CBSP 1990, WDFW 1998).

The Yakima River terrace near Big Creek/Little Creek was logged and cleared from 1880-1900 and developed for agricultural crops (KCCD 1999). The Northern Pacific Railroad was built by 1887, and followed along the Yakima River. Water diversions were established on Big Creek by 1887.

Fish Access

There are two diversion dams located on Big Creek; a small (2-3 cfs) berm diversion at RM 0.7, and a larger (10-15 cfs, 5-foot head) impassable diversion dam at RM 2.1 (which services both a left bank and a right bank diversion) (Renfrow). The upper diversion dam is located 1300 feet upstream of the KRD Canal crossing of Big Creek, although the lands serviced by this diversion are located below the KRD Canal. The lower diversion dam is easily passable to adults; the upper diversion is impassable most years. A fishway was previously installed at the diversion at

RM 2.1, but shortly thereafter failed and is not fixable. Neither of the diversions from the dam at RM 2.1 are screened. The lack of passage at the diversion dam at RM 2.1 precludes anadromous salmonid access to high quality spawning habitat upstream.

Flow remains as a significant concern even after Water Rights Adjudication (Renfrow). During late summer essentially all water is appropriated for irrigation purposes. Depending upon the year, there may be no instream flow remaining in August or September. Trendwest Corporation purchased Big Creek water rights for 1.5 cfs in support of its development in the Cle Elum River Basin. Trendwest has been leaving this water instream, rather than diverting it through the Lund Ditch. If the development is successful, it is part of the long-term plans of the corporation that this water will remain as instream flow in Big Creek, to provide base flow.

The USFS (1997) has identified 2 fish passage barrier culverts in tributaries to Big Creek. These barriers may impact resident salmonids, are high in the watershed, are not likely to impact anadromous salmonids, and may have already been repaired by USFS (Teske). It is unknown whether these barriers impact bulltrout. Consult the USFS Yakima Watershed Analysis for specific locations of these barriers.

Floodplain Modifications

The creek is heavily channelized downstream of RM 3.0, with associated channel instability and bedload deposition in the lowermost 0.25 mile (WDFW 1998). The sediment source appears to be due to channel and bank instability upstream and downstream of the KRD crossing, possibly associated with the lack of LWD and riparian vegetation through this area.

Channel Condition/Substrate Condition

None of the sampled reaches on Big Creek or Greek Creek met the Forest Plan standard for LWD presence or pool frequency (USFS 1997). Habitat complexity is limited in the lower reach, which is now almost exclusively a single channel providing pocket-water habitat, with little LWD (YSS 2001 DRAFT). Habitat complexity and LWD abundance increase dramatically in the upper reaches, particularly upstream of the KRD Canal (RM 2.1). The channel used to have abundant LWD, which was actively removed by channel cleaning (Renfrow). Flood flows of 1990, 1995 and 1996 have recruited some woody debris jams and locally improved habitat complexity. In general, however, there is currently little LWD from the powerline crossing to the mouth.

The USFS (1997) rated spawning, summer rearing, and winter rearing habitat quality (resident and anadromous salmonids) in the Big Creek drainage. Estimates are presented in Table 35.

Table 35: Habitat conditions (miles) in the Big Creek River watershed (from USFS 1997)

Habitat Type	**Good**	**Fair**	**Poor**
Spawning habitat	9	6	17
Summer rearing habitat	15	8	8
Winter rearing habitat	15	4	13

Erosion risk, based on NRCS soil survey data, ranges from low to moderate on the river terraces to high to very high in the steeper regions of the upper watershed (KCCD 1999). An independently derived erosion risk map prepared for the Big Creek/Little Creek watershed by Plum Creek Timber Company show a similar erosion risk pattern, ranging from low on the Yakima River terraces and lower riparian areas along the creeks to moderate and high in the

upper reaches. USFWS (2001 DRAFT) indicates that forest road 152 parallels Jim Creek and has fine sediment delivery to the stream system, potentially adversely affecting bull trout habitat.

Riparian Condition

Riparian condition is believed to be good in the canyon upstream of the powerline crossing, deteriorating downstream of the canyon, and becoming fair in the channelized reach near the mouth (Renfrow).

Water Quality/Water Quantity

Big Creek is designated as Class A (excellent) waters (except for Greek Creek which is designated as Class AA (extraordinary) waters)(WAC 173.201(a)), which determines which water quality parameters need to be met. Big Creek is on the CWA Section 303(d) impaired water quality list for instream flow, reflecting the lack of instream flow from the upper diversion (RM 2.1) to the mouth of Big Creek. Big Creek is also on the CWA Section 303(d) impaired water quality list for water temperature. Maximum summertime water temperatures in the lower sections of Big Creek can occasionally approach 70°F (Johnston 1989, as cited in YSS 2001 DRAFT), but these episodes are brief, diurnal fluctuations are large, and excessive temperature is not believed to be a serious problem (YSS 2001 DRAFT). KCCD and BOR monitoring of Big Creek found no exceedances of water temperature in sampling events from December 1985 to September 1987 and April to November 1989 (KCCD 1999).

Big Creek is estimated to deliver 630 tons of fine sediment to the Yakima River annually (KCCD 1999).

Natural runoff in Big Creek is fully appropriated for irrigation. Lack of instream flow from the mouth upstream to the diversion dam at RM 2.1 precludes anadromous salmonid access to high quality spawning habitat upstream (WDFW 1998, CBSP 1990). Big Creek surface water diversions total ~8.7 cfs for irrigation of 435 acres plus stockwater needs (Report of Referee re. Subbasin No. 2 (Easton); as cited in KCCD 1999). (For comparison, the total flow in the creek upstream of the diversion at RM 2.1 measured in August of 1999 was only 9.29 cfs (Renfrow)) Upstream of RM 3, there are perennial instream flows. The creek has substantial perennial flows (~10 cfs in August 1988) upstream of the upper diversion, but flow downstream is ~1 cfs, most of which is leakage (CBSP 1990, 303(d) Decision Matrices). Flows are recharged by groundwater over the next mile, and increase to ~3 cfs at RM 1.2 (also in August 1988). Most of this recharge is subsequently removed at the lower diversion, and the stream may be totally dry or intermittent from RM 0.6 to the mouth depending upon the year (Renfrow).

Lakes

No lakes are present in this watershed.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Big Creek:

- **Restore instream flows downstream of the diversion at RM 2.1 to the mouth; look for alternative water sources for current water diversion(s)**
- **Restore anadromous fish passage upstream of the current barrier at the diversion at RM 2.1; screen intakes of both water diversion on Big Creek**

- **Develop and implement a short-term LWD strategy for the reach from the powerline crossing to the mouth, to provide LWD presence and habitat diversity until riparian function is restored**
- **Restore riparian function from the powerline crossing to the mouth**

Tucker Creek 39.1709

General

Tucker Creek is a right bank tributary to the Yakima River, entering at RM 199.9. Tucker Creek supports spring chinook and steelhead juvenile rearing and potential spawning in the lower reaches, as well as other resident salmonids and non-salmonids.

Fish Access

A concrete siphon passes the KRD Main Canal flow underneath Tucker Creek, and the stream is armored to protect the siphon from erosion (BOR 2000). The creek flows directly over the top of the concrete canal siphon, creating a cascade that is a fish passage barrier at most flows (Monk, Renfrow). An engineered design for a series of boulder weirs has been developed that would provide passage upstream of the diversion; the project is currently held up in discussions with BOR. There are approximately 1.5 miles of suitable habitat upstream of the KRD siphon, which will be accessible once the barrier is corrected (Fraser).

Floodplain Modifications

Natural floodplain function for Tucker Creek appears to be impaired where the creek flows through a development upstream of the confluence with the Yakima River (Renfrow). The extent of potential impairment, and potential for habitat restoration needs further assessment.

Water Quality/Water Quantity

Tucker Creek water quality has not been classified, but is considered as Class AA (extraordinary) waters, as it is a tributary to a Class AA reach of the Yakima River (WAC 173.201(a)). A surface water diversion of 0.3 cfs is identified for irrigation of 10 acres in the Tucker Creek watershed.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for Tucker Creek:

- **Correct fish passage barrier at KRD Canal**
- **Assess channel and floodplain function where the creek flows through a development upstream of the confluence with the Yakima River**

Cabin Creek 39.1798

General

Cabin Creek is a right bank tributary to the Yakima River, entering a short distance upstream of Lake Easton, at RM 205.0. The Cabin Creek watershed encompasses 20,292 acres (32 mi^2), virtually all of which is in commercial forestland (ownership is 51% Plum Creek Timber, 27% USFS, 8% U.S Timberlands, 7% State of Washington, and 7% private landowners)(Cabin Creek Watershed Analysis-DRAFT 1997). The majority of precipitation falls in the form of snow, and ranges from 45 inches at the lower elevations to 71 inches at the higher elevations. Elevations in the watershed range from 2,200 feet at the confluence with the Yakima River to 5,135 feet at Snowshoe Butte in upper Cabin Creek. Soils are generally deep (60+ inches), well drained, and of moderate permeability, with the top several inches being dominated by a volcanic ash layer. Below the ash-influenced layer, soils are predominantly weathered bedrock material from the underlying geologic formation. The natural recurrence of large stand-replacing fires is likely on the order of 100-200 years, although fire suppression has been implemented in the watershed since the 1930s. Prior to 1955, timber harvest in the watershed occurred mainly in the lower valley and hillslopes along the mainstem below Falls Hill. Much of the rest of the basin was harvested in the 1960-1980 period.

Cabin Creek supports spring chinook (presumed presence), steelhead, coho (historic), cutthroat, rainbow, and brook trout. All of these species are found downstream of the impassable Falls Hill landslide (RM 3.6); only cutthroat are present upstream of the landslide. Historic spring chinook presence is presumed to the Falls Hill landslide, but current utilization is limited by poor habitat conditions in lower Cabin Creek and limited spawner access of these species to the upper Yakima basin. Anecdotal reports suggest that juvenile spring chinook utilize the lowermost segment of Cabin Creek as rearing habitat. There is no evidence that bull trout have ever occurred in the Cabin Creek watershed (Cabin Creek Watershed Analysis-DRAFT 1997). Cole Creek, a right-bank tributary entering Cabin Creek at ~RM 2.0, has resident salmonid presence.

Unlike the other west-side upper Yakima tributaries, there are no irrigation dams or diversions on Cabin Creek. The major habitat impacts limiting salmonid production in Cabin Creek are access over a series of cascades and waterfalls between RM 3.1 and 3.8, and an extremely flashy hydrograph, largely attributable to massive clear-cuts in the upper watershed (YSS 2001 DRAFT), and from poor quality unstable habitat in the accessible anadromous area, primarily associated with a suite of impacts from past logging (Cabin Creek Watershed Analysis-DRAFT 1997).

Plum Creek Timber Co. initiated a Level 2 Watershed Analysis in the Cabin Creek Watershed Administrative Unit (WAU) under the Forest Practices Act (WAC 222-22-040(3)) in July 1996. A draft report for the Watershed Analysis Prescription Team was developed in January 1997, providing a detailed reach analysis of habitat conditions throughout the Cabin Creek watershed. It is suggested that this report be consulted for more detailed, reach-specific habitat information.

Fish Access

At least two waterfalls associated with the deep-seated landslide at Falls Hill (RM 3.6) are barriers to upstream anadromous fish passage (Cabin Creek Watershed Analysis-DRAFT 1997). It is unknown to what extent the falls hill slide is attributable to anthropogenic effects (Bill Ehinger, USFS, personal communication). The nature of the falls upstream of RM 3.1 in historic

times is unknown, but it is at least possible that they did not present nearly so formidable a barrier the as they do now (YSS 2001 DRAFT). There is ongoing discussion regarding providing anadromous salmonid passage upstream of the Falls Hill slide; the cost to provide passage would be very high, and technically very difficult (Renfrow).

Two man-made fish passage barriers were identified in the watershed. A perched culvert at the second road crossing of Krystad Creek is likely an impediment to upstream migration of resident salmonids during high flows due to water velocities and culvert-mouth elevation. Another culvert barrier (perched mouth and gradient) was identified at the juncture of channel segments C14 and C13 (Cabin Creek Watershed Analysis-DRAFT 1997).

The USFS (1997) has identified 7 fish passage barrier culverts in miscellaneous tributaries to Cabin Creek. These barriers may impact resident salmonids, but the barriers are upstream of known anadromous access. Consult the USFS Yakima Watershed Analysis for specific locations of these barriers.

Floodplain Modifications

Channel instability downstream of RM 3.1 is massive and regular, precluding successful spawning by any species and severely compromising the value of the reach for summer rearing or overwintering (YSS 2001 DRAFT).

The natural floodplain function across the delta fan in the lower mile of Cabin Creek is constrained by a road and by an old log yard at RM 1.0 that is no longer used. In Log Creek (a right bank tributary to Cabin Creek, upstream of the Falls Hill slide) natural floodplain function is non-existent, as the stream and Forest Road 4110 are one in the same for much of the length of the road (Teske).

Channel Conditions

Analysis of channel changes in Cabin Creek downstream of Falls Hill indicated that the width of the active channel increased steadily from 1955 through 1989, and began to decrease by 1993 (Cabin Creek Watershed Analysis-DRAFT 1997). The width of unvegetated terraces fluctuated in concert with the timing and scale of the mass wasting events at Falls Hill.

Inputs of LWD significantly affect channel form and fish habitat in the low-gradient alluvial and entrenched mainstem channels, which comprise most of the mainstem reaches. Habitat complexity is limited in the lower reach, which is now almost exclusively a single channel providing pocket-water habitat, with little LWD (YSS 2001 DRAFT). Habitat complexity and LWD are also lacking in upper Cabin Creek as a result of its recent history of intensive logging, which exaggerated the natural flashy hydrograph to such a degree that LWD is swept from the system, and streamside clearcuts preclude new LWD recruitment.

There is a widespread lack of LWD in most stream channels, as well as presence of few pools and low levels of instream cover (Cabin Creek Watershed Analysis-DRAFT 1997). LWD in stream channels was quite limited; removal of LWD (stream cleaning) has occurred in the past. LWD recruitment potential in the next 60 years is low in approximately two-thirds of the watershed, where past harvest of riparian trees occurred. Most channel segments sampled in the watershed ware rated as poor to fair fish habitat. The highest quality habitat was found in Log, Cole, and Krystad creeks and their tributaries, and in some reaches of Cabin Creek upstream of Falls Hill.

Low pool frequency, and general shallowness of pools, was indicative of degraded summer rearing habitat in most stream reaches; wood cover in pools was also limited. Limited pool area and depth, and a lack of off-channel habitat were found in most of Cabin Creek, limiting winter rearing. Food sources for rearing salmonids may be limited, particularly in unstable stream channel areas downstream of Falls Hill.

The Cabin Creek drainage is expected to be deficient in large diameter downed logs (both in-channel and upland) due to high levels of timber harvest on private and/or federal land (USFS 1997). Downed logs in this area should be retained.

Substrate

Erosion risk, based on NRCS soil survey data, ranges from low to moderate on the river terraces to high to very high in the steeper regions of the upper watershed (KCCD 1999). An independently derived erosion risk map prepared for the Cabin Creek watershed by Plum Creek Timber Company show a similar erosion risk pattern, ranging from low on the Yakima River terraces and lower riparian areas along the creeks to moderate and high in the upper reaches.

Large dormant deep-seated landslides are a dominant geomorphic feature in the watershed (Cabin Creek Watershed Analysis-DRAFT 1997). A total of 84 landslides were inventoried in the watershed, with the actual number of landslides assumed to be higher than 84. Forty-nine percent of all landslides were associated with timber harvest units in which the estimated stand age is <20 years; 40% of the slides were associated with roads and landings; <10% were associated with forested areas; 67% of the landslides delivered sediment directly to fish bearing streams.

Over the 30-year period of aerial photography, activity from deep-seated landslides has been relatively insignificant (with the exception of the Falls Hill landslide). Some of the deep-seated landslides have created low-gradient alluvial valleys upstream of the deposits. Shallow landslides in inner gorges have been the most frequent form of mass wasting observed in the watershed. The Falls Hill landslide is concentrated at the toe of an ancient and previously dormant deep-seated landslide. Significant slide activity is evident in 1950 aerial photos (B. Ehinger, USFS, personal communication), but activity at the site has been most intense in the late-1980s/early-1990s that appears to be associated with channel incision induced by a forest road along the valley floor (Cabin Creek Watershed Analysis-DRAFT 1997). Sediment from this slide has caused aggradation of the lower 3.6 miles of Cabin Creek, and is the largest sediment source (by two orders of magnitude) compared to other individual landslides in the watershed. Extensive bank erosion and channel shifting observed in lower Cabin Creek since 1974 are in response to sediment delivery from Falls Hill, and to a lesser extent from channel and bank erosion from peak flows. The Falls Hill landslide has materially affected channel form and function and fish habitat downstream in Cabin Creek. Landslide activity appears to be slowing, base-level incision appears to be halted, and the sediment supply appears to be decreasing. Channel instability is expected for the foreseeable future, but fish habitat is expected to improve as the channel stabilizes and revegetates (Cabin Creek Watershed Analysis-DRAFT 1997).

Substrate condition is poor downstream of the cascades at RM 3.1; there is a large amount of gravel, but the channel and bed are highly unstable (Renfrow). Streambed scour is evident in the high gradient reaches upstream and downstream of the mouth of Cole Creek (RM 2.5) (CBSP 1990). Substrate samples in 1996 indicated fine sediment levels of ~15-20% in mainstem spawning areas in Cabin Creek (Mayo), although fine sediment levels appear to be lower in one of the lower channel segments. Spawning gravel quantity is limited upstream of Falls Hill, with gravels usually associated with instream LWD. Gravel samples upstream of Falls Hill indicate

that presence of fine sediments has been increasing since 1990. Inputs of fine sediment into Cabin Creek and tributaries are primarily from road runoff and from mass wasting. Estimates of increased fine sediment produced from road runoff are 49% for Cole Creek, 95% for Log Creek, 64% for lower Cabin Creek, and 69% for upper Cabin Creek, with road traffic level being the primary factor affecting the rate of delivery (Cabin Creek Watershed Analysis-DRAFT 1997). The most dramatic effects of sedimentation (coarse and fine sediment) have occurred in the lower parts of the watershed; steeper tributaries and headwater channels are typically tightly confined, and route sediment downstream to more sensitive channels.

The USFS (1997) rated spawning, summer rearing, and winter rearing habitat quality (resident and anadromous salmonids) in the Big Creek drainage. Estimates are presented in Table 36.

Table 36: Habitat conditions (miles) in the Cabin Creek watershed (from USFS 1997)

Habitat Type	**Good**	**Fair**	**Poor**
Spawning habitat	14	7	21
Summer rearing habitat	22	14	6
Winter rearing habitat	22	7	14

The Cabin Creek Forest Planning Unit is identified as having high open road and/or total road densities, although it is not identified as having a high risk of road-related sediment problems (USFS 1997). They recommend consideration of road obliteration or gating of roads to reduce effective road densities. Specifically, FS Rd. 4100-133 may have existing water quality/aquatic habitat concerns that require further analysis (for obliteration) and BMP implementation (USFS 1997). USFWS (2001 DRAFT) identified the following forest road concerns, as they relate to potential adverse impacts to bull trout:

- Lower portions of USFS Road 140 and the stream crossing (ford) deliver fine sediment to Cole Creek.
- Portions of lower USFS Road 41 have been captured by Cabin Creek. The road in this area lies with the channel migration of Cabin Creek.
- Sections of USFS Road 4110 and stream crossings deliver fine sediment to Log Creek.

Riparian Condition

The riparian zone is generally intact and good in the lower mile, but has been destroyed from RM 1 to the head of the cascades by late winter and spring floods that have demolished the riparian zone and streambed (CBSP 1990). Virtually all of the upper drainage (with the notable exception of Cole Creek) has been logged to the stream edge, so shading and LWD are limited (CBSP 1990). Much of the logging within the Cabin Creek watershed occurred from 1950 to the 1980s; buffer strips were not required along Cabin Creek and its tributaries when most of the timber harvest occurred (KCCD 1999). As a result, riparian condition upstream of the cascades is early successional, but dense vegetation (WDFW 1998).

Water Quality/Water Quantity

Cabin Creek is designated as Class AA (extraordinary) waters (WAC 173.201(a)), which determines what water quality parameters need to be met. Cabin Creek is on the CWA 303(d) impaired water quality list for water temperature, with numerous excursions from water quality standards documented at the Forest Service boundary from 1989 to 1994. Log Creek (tributary to Cabin Creek) is also on the CWA 303(d) impaired water quality list for water temperature.

Shading levels on many of the larger fish bearing streams are not adequate to control summer water temperatures (Cabin Creek Watershed Analysis-DRAFT 1997). Temperatures higher than the preferred range for salmonids, although sublethal, have been recorded in lower Cabin Creek (Dept. of Ecology 1996, as cited in Cabin Creek Watershed Analysis-DRAFT 1997). Water quality data from 1989-1990 show a maximum water temperature of 21°C, with the 16°C water quality standard exceeded during most years sampled by USFS (1989-1994), usually for 3-6 weeks, and for nearly 2 weeks in 1996 based on Plum Creek sampling (KCCD 1999). Maximum summertime water temperatures in the lower sections of Cabin Creek can occasionally approach 70°F (Johnston 1989, as cited in YSS 2001 DRAFT), but these episodes are brief, diurnal fluctuations are large, and excessive temperature is not believed to be a serious problem (YSS 2001 DRAFT).

Precipitation in the watershed is >100 inches/year, and runoff is now extremely fast because of clearcuts that extended from the water's edge to the ridge tops (YSS 2001 DRAFT). Peak flows have consequently become extraordinary for a stream the size of Cabin Creek, and the erosion to the natural cascade area upstream of RM 3.1 (that may have historically been passable) must have been significant. There is evidence of flows piping through the Falls Hill slide and reappearing as surface flow at the bottom of the slide, and it is possible that increased runoff from the upper watershed may be increasing saturation of the slide and accelerating slide instability compared to natural conditions (B. Ehinger, USFS, personal communication).

Unlike most Yakima River tributaries, Cabin Creek has no irrigation diversions to limit access or instream flows (CBSP 1990, YSS 2001 DRAFT). Heavy seasonal runoff has impaired habitat quality; the intensity of runoff is exacerbated by large clearcuts throughout the basin and rain-on-snow events (CBSP 1990). Hydrologic modeling predictions of peak flow changes, resulting from timber harvest, was large enough (especially for moderate storms) to potentially be significant in upper Cabin Creek and Log Creek (Cabin Creek Watershed Analysis-DRAFT 1997).

Limited water quality data and observations suggest that Cabin Creek experiences input of turbid water during storm events (Cabin Creek Watershed Analysis-DRAFT 1997). Cabin Creek is estimated to deliver 9130 tons of fine sediment to the Yakima River annually (KCCD 1999).

Lakes

No lakes are present in this watershed.

Action Recommendations

The USFS is pursuing restoration from the headwaters downstream (Mayo). The following ranked salmonid habitat restoration actions are recommended for Cabin Creek:

- **Assess habitat restoration opportunities in the reach from the mouth to the railroad bridge (would provide rearing and potential spawning habitat in lower reach as interim measure until upper watershed stabilizes)**
- **Develop and implement an LWD strategy throughout the upper watershed (upstream of Falls Hill) to provide LWD (would need to use large pieces due to hydrology) presence and habitat diversity until riparian function is restored**
- **Abandon/reroute the Log Creek road out of the channel and floodplain**
- **Restore riparian function downstream of Falls Hill slide**

Kachess River 39.1739, Box Canyon Creek

General

The Kachess River is a left bank tributary to the Yakima River, entering at RM 203.5. The watershed drains an area of 81.4 mi^2 (NRCS estimate, as cited in KCCD 1999). The USFS has conducted a Watershed Analysis for Box Canyon Creek, but there is little information available for other tributaries to Kachess Lake or for the Kachess River downstream of Kachess Lake.

The Kachess River supports spring chinook, summer steelhead, and coho (historic) spawning and rearing downstream of Kachess Dam, as well as other resident salmonids and non-salmonids. Nearly all the Kachess River watershed is inaccessible to anadromous salmonids, due to presence of Kachess Dam at RM 1.0. Historically, the Box Canyon Creek supported sockeye, bulltrout, and cutthroat (USFS 1995). Sockeye were extirpated upstream of Kachess Dam with the construction of a crib dam at the outlet to Kachess Lake in 1904, and completion of the current dam in 1911. Historic sockeye presence in Box Canyon Creek is presumed at least to the barrier falls at RM 1.6. Currently, bull trout are distributed in mainstem Box Canyon Creek up to the barrier waterfall at RM 1.6, and may have extended higher into the watershed. Bull trout are known to have passed further upstream prior to washout of a logjam below the falls during the 1990 Thanksgiving flood. The bull trout population is considered at high risk of extirpation (Mongillo 1993, as cited in USFS 1995), with an estimate of <50 adults in Kachess Lake (Brown 1992, as cited in USFS 1995). Cutthroat and rainbow trout are found in all of the fish-bearing streams and lakes in the watershed, but it is currently unknown if the native cutthroat are westslope cutthroat, another species, or hybrids. The watershed has been planted with non-native salmonids since at least 1955, and possibly as early as the 1920s.

The entirety of the watershed is forested, with the headwaters in the Alpine Lakes Wilderness.

Fish Access

Due to the short distance from the mouth to the dam, this reach is not actively managed for fish (Renfrow). Flows in this short river reach are managed for irrigation purposes and to allow river flows more favorable to fish in reaches of other rivers (e.g. Yakima River - Easton to Keechelus reach). Kachess Dam (RM 1.0) has no fish passage facilities, and precludes upstream migration of salmonids to Lake Kachess, 1.6 miles of Box Canyon Creek, and 0.5 miles of the Kachess River upstream of Lake Kachess (YSS 2001 DRAFT). A falls on Box Canyon Creek at RM 1.6 blocks upstream fish passage (Craig 1997, as cited in BOR 2000).

Adult bull trout overwinter in Kachess Lake. The population appears to utilize Box Canyon Creek as its primary spawning ground (Anderson 1995, as cited in USFS 1995). Other potential spawning streams around Kachess Lake have extensive alluvial aggradations and are highly impacted by lowering of Kachess Lake in late-summer and early-fall. The combination of drawdown and aggradation causes these streams to go subsurface at the critical time when adult bull trout are beginning their spawning migration. As the lake is drawn down, the exposed Box Canyon Creek channel on the lake bottom lacks definition as it flows across the permeable lake sediments and may become too shallow for adult bull trout passage (YSS 2001 DRAFT). The BOR attempted to correct this in 1996 with construction of a single channel through the inundation zone, but passage problems may still persist under some circumstances. Similar

passage problems for bull trout also occur in the Kachess River as it annually dewaters upstream of the reservoir inundation zone.

Bulltrout were found in Mineral Creek (a tributary to Kachess River) in 1998 (WDFW 1998, as cited in BOR 2000). WDFW found bull trout actively spawning in late-October/early-November 2000 and 2001 in the upper Kachess River upstream of the confluence with Mineral Creek, but not in Mineral Creek (Cummins). The Kachess River is dry near its confluence with Kachess Reservoir in late –summer through mid to late-October, depending on fall precipitation. In 2000 and 2001, bull trout were found spawning in the Kachess River aver fall rains restored flow. In October 2001, one adult bull trout and no redds were found in the lower 0.25 mile of Mineral Creek. Although further investigation is required, a series of cascades on Mineral Creek may block upstream migration of bull trout beyond the lower 0.25 mile, and spawning gravel in the lower end of the creek is scarce.

The USFS (1997) has identified 5 fish passage barrier culverts in miscellaneous tributaries to the Kachess River, and one on Gale Creek (tributary to Lake Kachess). These barriers may impact resident salmonids, but no anadromous salmonids presently occur upstream of Kachess Dam, and bull trout are not known to utilize the streams on which the barriers are located. Consult the USFS Yakima Watershed Analysis for specific locations of these barriers.

Floodplain Modifications

The mouth of the stream is within the inundation area of Lake Easton. The historic riverine habitat between Kachess Lake and Little Kachess Lake, and at the upper end of Little Kachess Lake, has been eliminated, as it is inundated by the reservoir, when full. Floodplain encroachment and impacts are anticipated in the future downstream of the dam, where a major residential development has been approved. Lots are generally undersized, likely requiring variances in order to build desired structures (Renfrow, Teske). Shoreline setbacks for buildings in some places are as small as ~15 feet.

Channel Condition

No information was found on channel habitat conditions in the Kachess River downstream of Kachess Dam. Due to the short distance from the mouth to the dam, this reach is not actively managed for fish (Renfrow).

In all of the surveyed reaches of Box Canyon Creek, WF Box Canyon Creek, and Mineral Creek, LWD abundance and pool frequency were found to be below the Forest Plan standards, with LWD abundance declining moving upstream from Lake Kachess (USFS 1995, USFS 1997). Although pool frequency either meets, or is close to meeting, the Forest Plan standards in the surveyed portions of mainstem Box Canyon Creek, none of the reaches would meet the 3-foot pool depth standard (USFS 1995). The low number of quality pools and in-channel LWD may indicate an overall lack of habitat complexity important to many fish species, particularly bulltrout. The lack of LWD in-channel and in riparian reserves is suspected to be the result of a combination of factors, including: flooding, timber harvest adjacent to stream channels, dispersed and developed recreation, use of vehicles off-road in riparian reserves, road construction and maintenance in riparian reserves, and the result of stream segments naturally low in LWD (USFS 1995). LWD recruitment potential for Box Canyon Creek was roughly equally split between reaches rated as having fair/good potential and those with poor potential, with unknown status in

most of Box Canyon Creek upstream of the WF. The upper headwaters of the WF were determined to be naturally deficient in LWD. Most impaired areas are due to past timber harvest.

The Kachess and Gale/Thetis drainages are expected to be deficient in large diameter downed logs (both in-channel and upland) due to high levels of timber harvest on private and/or federal land (USFS 1997). Downed logs in this area should be retained.

Substrate Condition

Stream surveys conducted in 1989 indicated that a fairly high percentage of the stream length of Box Canyon Creek has excellent bed and bank stability, as a result of bedrock and small boulder dominated substrate (USFS 1995).

McNeil gravel core samples collected in mainstem Box Canyon Creek in 1990 (measurements taken at 3 riffle locations in 4 separate reaches) found fine sediment levels averaging 8.2%, by volume, of the streambed substrate (Watson 1991, as cited in USFS 1995). Based on this monitoring, fine sediment levels do not appear to be of concern in the Box Canyon Creek watershed. Surface erosion potential in the entire watershed is mostly rated as low, with some areas rated moderate.

The USFS (1997) rated spawning, summer rearing, and winter rearing habitat quality (resident and anadromous salmonids) in the Kachess River watershed. Estimates are presented in Table 37.

Table 37: Habitat conditions (miles) in the Kachess River watershed (from USFS 1997)

Forest Planning Unit	Habitat Type	Good	Fair	Poor
Kachess Lake and small tribs.	Spawning habitat	2	1	17
	Summer rearing habitat	4	2	15
	Winter rearing habitat	4	1	16
Mineral Creek	Spawning habitat	2	1	16
	Summer rearing habitat	3	5	11
	Winter rearing habitat	3	2	14
Box Canyon Creek	Spawning habitat	5	3	12
	Summer rearing habitat	8	4	8
	Winter rearing habitat	8	2	10
Gale/Thetis Creeks	Spawning habitat	1	4	8
	Summer rearing habitat	5	6	2
	Winter rearing habitat	5	3	5

The Gale/Thetis Forest Planning Unit is identified as having high open road and/or total road densities, as well as having a high risk of road-related sediment problems (USFS 1997). The Kachess and Box Canyon Forest Planning Units were also identified as having a high risk of road-related sediment problems. They recommend consideration of road obliteration or gating of roads to reduce effective road densities, and improvement of road drainage patterns and more ditch relief pipes. Specifically, road segments 4934-126 and 4936-209 in the Gale/Thetis drainage may have water quality/aquatic habitat concerns that require further analysis (for obliteration) and BMP implementation (USFS 1997).

Riparian Condition

Comparison of aerial photos from 1942 and 1992 showed a reduction from 69% to 26% in the Conifer/Mature/Dense riparian status for mainstem Box Canyon Creek, with much of the change being converted to the Deciduous/Young/Sparse classification (USFS 1995). Timber activities have removed segments of riparian vegetation in mainstem and WF Box Canyon Creek, reducing the ability of these drainages to provide future LWD recruitment. Timber harvest has also reduced the percent of canopy cover in portions of the mainstem and WF, possibly reducing the ability of these subwatersheds to maintain water temperatures at levels suitable for bull trout and other salmonid species. Recreation activities along Box Canyon Creek have had an additional impact on riparian vegetation by removing vegetation and causing soil compaction.

Riparian impacts are anticipated in the future downstream of the dam, where a major residential development has been approved. Lots are generally undersized, likely requiring variances in order to build desired structures (Renfrow, Teske). Shoreline setbacks for buildings in some places are as small as ~15 feet.

Water Quality

Gale Creek (tributary to Kachess Lake) is on the CWA 303(d) impaired water quality list for water temperature.

Maximum summer water temperatures from Box Canyon Creek for the period 1990-1994 ranged from 57 to 68°F (USFS 1995). The monitoring results showed Box Canyon Creek exceeding the Forest Plan Standards and Guidelines in 1990 through 1992, and within the standards and guidelines in 1993.

Water quality profiles in Lake Kachess were developed in July 1990, by sampling at four levels (3.3 to 23.1 feet deep) about 100 meters upstream of the dam (KCCD 1999). Water temperatures were in the range of 20.2-21.2^{o}C, significantly exceeding the 16°C Class AA standard. Total phosphorus ranged from 0.009 mg/l near the surface to 0.019 mg/l at the 23.1 foot depth. Nitrate and ammonia nitrogen were below detectable limits (0.01 mg/l). Chlorophyll A was 0.55 ug/l in the surface sample. There is concern that release of warm surface waters from Kachess reservoir could excessively warm the upper Yakima River in years of low flow (Crase 1985, as cited in CBSP 1990).

The Kachess River is estimated to deliver 2200 tons of fine sediment to the Yakima River annually (KCCD 1999).

Water Quantity

The natural hydrology of Kachess River downstream of the dam is completely reversed as a result of impoundment above Kachess Dam and water releases for Yakima basin irrigation needs. Natural high stream flows would occur through the winter, spring, and early summer, with low flows through late summer and fall. The revised hydrology in the lower river results in low flows (~100 cfs) in winter, spring, and summer, and high flows in the fall (~1,000 cfs)(WDFW 1998).

Instream flow recommendations were developed in the mid-1980s (see Instream Flow section at beginning of this chapter), but the TAG does not support implementation of those recommendations at this time. [Note: Instream flows recommended by Simmons represent

164,000 acre-feet out of the average annual total of 210,000 acre-feet (Perala).] Rather, the TAG supports continued work to develop and implement a normative flow regime that combines "the goal of sustaining ecological integrity of the watershed, while also maximizing use of water resources by humans" (SOAC 1999).

Lakes

The Kachess Reservoir is the largest lake of the major irrigation storage reservoirs in the Yakima River watershed, although it has the second largest active storage capacity. The lake is approximately 10 miles long with an active storage capacity of 239,000 acre-feet and a dead-storage capacity 671,272 acre-feet (BOR 2000), covering an area of 4540 acres when full. The lake does not always fill to capacity, however, so the maximum amount of water available will vary by year (Renfrow). Kachess Dam is 115 feet high, was originally constructed in 1912, and was improved to the current condition in 1935 (USFS 1997). Releases from Kachess reservoir are used to increase river flow downstream of Lake Easton during “mini flip-flop” operations, when flows from Lake Keechelus are reduced to ensure that chinook spawning in the reach between Keechelus and Lake Easton occurs in portions of the channel that will remain under water during the egg incubation period when river flows are usually reduced (KCCD 1999).

Lake level fluctuation and drawdown of Kachess Lake likely reduces production of phytoplankton, zooplankton, and aquatic insects (BOR 2000), which reduces the food web base for bull trout and kokanee residing in the reservoir. Productivity in Lake Keechelus is likely limited by factors similar to those identified in Cle Elum Lake (loss of nutrients provided by anadromous fish passage, hypolimnetic discharge, and fluctuating lake levels). Please refer to the “Lakes” element in the Cle Elum River section of this chapter for a discussion of these factors.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the Kachess River:

- **Assess benefits to anadromous salmonids and bull trout of restoring fish passage upstream of the dam, including consideration of restoring carcass nutrients to the upper watershed**

Upstream of Keechelus Dam

Lake Keechelus and tributaries drain an area of approximately 55.4 mi^2 (NRCS estimate, as cited in KCCD 1999). Although bull trout and anadromous fish use of many tributary streams was likely prior to the construction of Keechelus Dam, the only tributary to Lake Keechelus that is documented to have historically supported anadromous salmonids and bull trout is Gold Creek. Gold Creek currently supports a remnant run of bull trout and historically supported spring chinook, summer steelhead, and coho. In addition, at least three other tributaries to Lake Keechelus (Meadow, Cold, and Coal creeks) have potential to be restored to support anadromous salmonids and/or bull trout (surveys in ~1994 by CWU students found only cutthroat in these streams (Renfrow)). It is likely that anadromous fish also may have historically used the smaller tributaries (Mill, Resort, Roaring, etc. creeks). The best habitat in the smaller creeks would have been in the area now inundated by the reservoir (reservoir drawdown photos indicate presence of likely suitable lower gradient habitat for anadromous salmonid juveniles, and even adults when good flow is present). Adult steelhead would most likely utilize these habitats when adequate

flow was available. Currently, reservoir operations/inundation and the existence of man-made barriers limits anadromous fish use of most of the smaller tributary streams.

Soils are generally sandy loams with gravelly or stony sandy loams near Lake Keechelus and downstream areas along the upper Yakima River (KCCD 1999). Topography is relatively flat to moderately steep through most of the watershed, with extensive flat areas along the Gold Creek valley and the Yakima River. Erosion risk ranges from low in the valley areas to high in the hills on either side of Lake Keechelus. The high erosion risk areas occur mainly within Wenatchee National Forest and Plum Creek Timber lands, and on the west side of I-90.

Fish Access

There is no fish passage at Keechelus Dam, at the outlet to Lake Keechelus, precluding anadromous fish access to approximately 7 miles of Gold Creek, extending upstream from the upper end of Lake Keechelus (YSS 2001 DRAFT), as well as several other tributaries to the lake. Upstream migration of bull trout from Keechelus Lake into Gold Creek is affected by low base flows in Gold Creek (BOR 2000). Complete dewatering of portions of the Gold Creek channel upstream of the maximum lake elevation has been noted in most recent years. At times, when the channel above the lake is dewatered, that portion of the channel traversing the reservoir bottom may also be impassable due to low Gold Creek flows, shallow water conditions, and the poor stream habitat conditions created by periodic inundation of the stream channel by the reservoir. Migrating fish commonly can swim through the channel across the exposed lakebed, but cannot swim up the channel above Gold Pond (Renfrow). Gold Creek has a natural falls at RK 11.4 that is a barrier to upstream fish passage (Craig 1997, as cited in BOR 2000).

The USFS (1997) has identified 14 fish passage barrier culverts in miscellaneous tributaries to Lake Keechelus (excluding Gold Creek). These barriers affect resident salmonids only, as anadromous fish runs are now blocked by Keechelus Dam. Bull trout have not been observed in these streams to date (bull trout would likely be present in at least the larger streams if the barriers and altered habitat conditions were corrected (Renfrow)). Consult the USFS Yakima Watershed Analysis for specific locations of these barriers.

The culvert at the old Milwaukee Railroad grade crossing of Cold Creek (~100 yards upstream of the mouth) is perched and is a total barrier to fish passage. The USFS Yakima Watershed Assessment (USFS Cle Elum RD, 1999) reports three culverts on road crossings of Meadow Creek that exceed gradient criteria for fish passage design (located in T21N, R11E, Sections 8 and 16). Coal Creek has at least two culvert fish passage barriers (one round CMP and one twin concrete box culvert) at crossings under I-90 (Renfrow).

Floodplain Modifications

The main floodplain modification that has occurred is the increased inundation area associated with the reservoir, which inundates the lower reach of each of the tributaries. Generally these lower tributary reaches were meandering, low gradient channels with more complex habitat than that remaining above the inundation line. Inundation alters the sediment deposition fan characteristics at the mouth of each of the tributaries, and the repeated cycle of inundation/drawdown prevents the establishment of riparian vegetation and recruitment of LWD. These alterations affect the channel characteristics and impair fish passage into the tributaries during low flows at low pool levels.

Natural floodplain function in Coal Creek is highly altered by I-90. The channel has been relocated, confined and straightened as it runs adjacent to the highway (Renfrow). Much of the drainage is paved (highway, ski areas, and residential development) or clearcut, altering the water storage and runoff characteristics.

Channel Conditions

The USFS (1997) rated spawning, summer rearing, and winter rearing habitat quality (resident and anadromous salmonids, although no current anadromous access upstream of Keechelus Dam) for habitat upstream of Keechelus Dam. Estimates are presented in Table 38.

Table 38: Habitat conditions (miles) upstream of Keechelus Dam (from USFS 1997)

Forest Planning Unit	**Habitat Type**	**Good**	**Fair**	**Poor**
Tribs. to Lake Keechelus (exc. Gold Cr.)	Spawning habitat	9	11	33
	Summer rearing habitat	19	22	11
	Winter rearing habitat	19	7	26
Gold Creek	Spawning habitat	6	2	12
	Summer rearing habitat	8	4	9
	Winter rearing habitat	8	1	11

None of the sampled reaches in Cold Creek, Meadow Creek, or Rocky Run Creek (all tributaries to Keechelus Lake) met the Forest Plan standards for LWD presence or pool frequency (USFS 1997). Gold Creek only met the Forest Plan standard for LWD in one of the six reaches sampled. The Keechelus Forest Planning Unit is expected to be deficient in large diameter downed logs (both in-channel and upland) due to high levels of timber harvest on private and/or federal land (USFS 1997). Downed logs in this area should be retained.

Historically large woody debris in Gold Creek included large “old growth” trees, which would serve as stable key pieces in debris jams. In-channel wood likely was a critical channel roughness element, dissipating stream energy and maintaining the stability of the alluvial channel. All of the large, old growth timber in the lower watershed was logged by 1990; there is now little or no residual key-piece size LWD in-channel and no opportunity for recruitment of new LWD key pieces. Although there is a substantial amount of small and medium sized woody debris in Gold Creek (and more is recruited from the banks with each flood), most all of it is readily mobilized by flood flows. Pieces are not large enough to provide bank protection, stable debris jams and stable LWD-related channel features. Bank erosion is occurring throughout lower Gold Creek and the resulting bedload has caused the channel to become broad and braided. During late summer low flow, the stream flows subsurface within these gravels. Potentially, the reintroduction of stable LWD features would restore bank stability, and aid in the return of deep pools and prolong the period when upstream fish passage is possible.

Habitat conditions in Cold Creek are rated as good (Renfrow, Mayo), with good LWD presence, riparian shade, and cold water. Meadow Creek has good LWD and pool presence, but high water temperatures due to past logging likely preclude significant bull trout use until regrowth provides shade. Habitat conditions in Coal Creek are fair/poor, as much of the stream has been straightened/channelized along I-90.

Lake level fluctuation and drawdown of Keechelus Lake likely reduces production of phytoplankton, zooplankton, and aquatic insects (BOR 2000), which reduces the food web base for kokanee, bulltrout, etc. residing in the reservoir.

Substrate Condition

The Keechelus Forest Planning Unit (Lake Keechelus and tributaries, excluding Gold Creek) is identified as having high open road and/or total road densities, although it is not identified as having a high risk of road-related sediment problems (USFS 1997). The Gold Creek drainage is identified as having a high risk of road related sediment problems.

The USFS (1997) evaluated spawning habitat conditions in tributaries to Lake Keechelus, excluding Gold Creek, and rated 9 miles as good, 11 miles as fair, and 33 miles as poor spawning habitat.

The sanding of I-90 is causing substantial sedimentation in Coal Creek (Ski Lifts Inc. EIS, as cited in USFS 1997), with sedimentation subsequently being carried into the upper end of Keechelus reservoir. There is a need to work with WSDOT to avoid/minimize this unintended consequence.

The lower portion of Cold Creek lies within the drawdown zone of the reservoir. The repeated inundation/drawdown cycle precludes the establishment of a natural riparian zone (Renfrow). With the loss of trees for shade, bank stability and LWD recruitment, coupled with the adverse affects of inundation on sediment deposition, the channel is currently unstable and does not develop the typical pool/riffle habitat associated with high quality habitat for salmonids.

In conjunction with the channel reconstruction necessary to restore fish passage through the barrier culvert in the old Milwaukee Railroad grade, the addition of anchored wood and rock structures within the channel reach in the lake drawdown zone would contribute to more natural in-channel habitat and restoring channel stability (Renfrow).

The watershed upstream of Keechelus Reservoir is estimated to deliver 1990 tons of fine sediment to the Yakima River annually (KCCD 1999).

Riparian Condition

Heavy logging has occurred in the Meadow Creek watershed, resulting in loss of riparian shade, and an associated increase in water temperature. Although habitat conditions are generally good in Meadow Creek, the high water temperatures may have resulted in the stream being unsuitable to bull trout. Water temperatures may be improving with the regrowth of riparian vegetation. Logging has occurred in the Cold Creek watershed, but the riparian area adjacent to the stream remains generally intact (Renfrow).

Water Quality

Gold Creek and Meadow Creek are on the CWA 303(d) impaired water quality list for water temperature. Additional water quality sampling in the early 1970s in tributaries to Lake Keechelus found problems in Hyak and Gold creeks (KCCD 1999). Some of the problems in Hyak Creek may have been associated with discharges from the Snoqualmie Pass Sewer District treatment facility; discharges to the stream from this facility were eliminated in 1982.

Heavy logging has occurred in the Meadow Creek watershed, resulting in loss of riparian shade, and an associated increase in water temperature (Renfrow, Teske). Although habitat conditions are generally good in Meadow Creek, the high water temperatures may have resulted in the stream being unsuitable to bull trout. Water temperatures may be improving with the regrowth of riparian vegetation.

Water Quantity

The following description of water quantity concerns in Gold Creek is taken directly from BOR (2000):

> "General development has affected Gold Creek above the maximum lake elevation, resulting in elevated stream temperatures, unstable channel conditions, decreased cover, and increased sediment loads (WDFW 1998). Channel habitats and hydrology have been altered by land use practices, including road construction (Wissmar and Craig 1998). Recent studies and observations have shown that channel dewatering in Gold Creek, upstream of the Keechelus Lake maximum water elevation, is likely one source of ongoing stress to the current population (Wissmar and Craig 1998). Channel dewatering appears to be related to low rainfall, Gold Creek Pond, timber harvest patterns, and road and residential developments (Wissmar and Craig 1998). A subsurface infiltration gallery that supplies a 30,000-gallon reservoir tank (Washington Dept. of Ecology, Water Well Report) is located near the area that typically dewaters. Dewatering of the main channel of Gold Creek occurred in 1993, 1994, 1995, 1996, 1998, and 1999 (Wissmar and Craig; Craig, personal communication 1998; James, personal communication 2000). Dewatering of the channel isolates upstream migrating bull trout from the spawning areas, and also strands fish, which can result in direct mortality. For example, Wissmar and Craig (1998) estimated that 63% (1993) and 24% (1994) of the adult bull trout died in Gold Creek; mortality occurred as the fish swam downstream after spawning and before these fish reached Lake Keechelus."

Cold Creek has substantial instream flows of cold water, likely suitable for bull trout if they were able to access the stream above the barrier culvert at the Milwaukee Railroad grade. Meadow Creek also has substantial instream flow, and may be suitable for bull trout once riparian regrowth reduces water temperatures (Renfrow).

Lakes

Keechelus Reservoir is the smallest of the three major Yakima Project reservoirs in Kittitas County. The lake is approximately 5.5 miles long, has an active storage volume of 157,800 acre-feet, with a surface area of 2526 acres when full. The dam is 128 feet high, and was originally constructed in 1917.

Lake level fluctuation and drawdown of Lake Keechelus likely reduces production of phytoplankton, zooplankton, and aquatic insects (BOR 2000), which reduces the food web base for kokanee and bull trout residing in the reservoir. Productivity in Lake Keechelus is likely limited by factors similar to those identified in Cle Elum Lake (loss of nutrients provided by anadromous fish passage, hypolimnetic discharge, and fluctuating lake levels). Please refer to the "Lakes" element in the Cle Elum River section of this chapter for a discussion of these factors.

Action Recommendations

The following ranked salmonid habitat restoration actions are recommended for the watershed upstream of Keechelus Dam:

- **Develop and implement a plan to ensure unobstructed bull trout migration from Lake Keechelus into Gold Creek** (this plan should address problems within the reservoir inundation zone as well as problems between the reservoir and the upper watershed)
- **Restore fish passage at Keechelus Dam**
- **Reduce bed instability and bank erosion in Gold Creek, possibly through restoration of LWD presence**
- **Correct fish passage barrier on Cold Creek at RM 0.5**
- **Stabilize Cold Creek channel downstream of culvert at RM 1.5**
- **Minimize dispersed recreation impacts in Meadow Creek watershed**
- **Assess, prioritize, and correct fish passage barriers**
- **Work with WSDOT to address water quality impacts to Coal Creek** (road runoff, traction sand, deicer)

ASSESSMENT OF LIMITING FACTORS

The intent of HB 2496 and watershed restoration is to determine what stream restoration actions are appropriate to provide healthy, productive populations of salmon that will support sport, commercial, and tribal fisheries, and salmon for future generations. This goal requires a higher standard of habitat protection than what would be necessary to just ensure continued existence of the species. Although there remains some debate on specific habitat thresholds necessary for productive salmon habitat, there is broad consensus that salmon require:

- cool, clean, well-oxygenated water,
- instream flows that mimic the natural hydrology of the watershed, maintaining adequate flows during low flow periods and minimizing the frequency and magnitude of peak flows (stormwater),
- clean spawning gravels not clogged with fine sediment or toxic materials,
- presence of instream pools that will support juvenile rearing and resting areas for returning adults,
- abundance of instream large woody debris, particularly large key pieces, that provide cover, create pools, and provide habitat diversity,
- free, unobstructed migration for juveniles and adults to and from the stream of origin,
- broad, dense riparian stands of native mature trees (particularly conifer, where applicable) that provides cover, shade, LWD recruitment, etc., and
- estuarine conditions that provide nearshore migration corridors and support production of prey organisms for juvenile outmigrants, as well as for juvenile salmonid rearing and for returning adults (this element is certainly applicable to all Columbia basin tributaries, including the Yakima River, but is not discussed within this report).

A more detailed discussion of the role of healthy habitat is included in a previous chapter of this report.

Salmonid Habitat Concerns

The Yakima River watershed supports anadromous stocks of spring chinook, Fall chinook, coho, and summer steelhead. Sockeye were historically present in the watershed, but have been extirpated. The watershed also supports bull trout and other resident salmonids. There are an estimated 1380 miles of anadromous salmonid habitat (combined known, presumed, and historic use, as estimated using GIS for summer steelhead) in the Yakima River watershed. Utilization of this habitat has been impaired to varying extents, depending on species. Much of the difference between current and historic use is due to impaired fish access, mostly associated with irrigation diversions and irrigation water storage throughout the watershed. The occurrence and severity of habitat limiting factors varies between streams and reaches within individual subwatersheds. The extent and quality of current salmonid utilization is impaired to varying degrees throughout the watershed by loss of floodplain function (including loss of side-channel habitats within the floodplain), loss of in-channel habitat diversity, loss of channel and bank stability, increased presence of fines in the substrate that impairs spawning and rearing success and benthic invertebrate productivity, impaired riparian function, water quality impacts from agricultural runoff, and perhaps most importantly, altered hydrology throughout much of the watershed due to land use and irrigation water delivery.

Combined, these limiting factors significantly reduce the salmonid productivity potential of the Yakima watershed. Initial significant impacts date back to early European settlement (mid- to late-1800s), with significant agriculture/irrigation, logging, and mining impacts prior to 1900.

Subsequent land use modifications (including increased irrigation storage and delivery, and channel encroachment and floodplain confinement and alteration associated with road construction and conversion to urban/suburban development) have adversely impacted the quantity and quality of salmonid habitat, and accessibility to habitat in these streams. Current habitat conditions have even been compromised by past well-intended actions to restore habitat, such as removal of log jams to ensure fish passage, that are now known to have been very detrimental to habitat quality and diversity.

Productivity potential is further compromised by the severe decline in numbers of adult salmonids that return to these streams to spawn, whose carcasses provide the marine nutrient base that serves as the foundation of the food web for juvenile salmonids and other stream associated invertebrates, fish, and wildlife. The loss of marine nutrients is particularly critical in the high elevation oligotrophic streams and lakes within the watershed, where carcasses appear to have provided a key source of nitrogen and phosphorous (see discussion for Cle Elum River in Habitat Limiting Factors by Subbasin chapter). Loss of adult salmonid spawning also has an effect on the nature of channel substrate and shape. Large numbers of spawning salmonids modify riverine habitat in ways beneficial to future generations of salmonids; loss of these geomorphic functions, which salmon perform, results in further habitat degradation. Changes in salmonid abundance, and relative abundance between different species can change the fundamental predator/prey relationships, which developed between salmonid populations over thousands of years. This loss of ecosystem function also causes reduced productivity of the ecosystems which salmonids inhabit.

Habitat Condition Rating

As noted above, there is often significant variability in the status of specific habitat elements between different reaches of a stream. In the Habitat Limiting Factors by Sub-Basin chapter, stream or reach-specific information is provided, where available. Composite habitat condition ratings (Good, Fair, and Poor) are summarized for major mainstem reaches and tributaries in Table 39 (at the end of this chapter), for each of the identified habitat elements in the previous chapter of this report. The habitat condition ratings in Table 39 reflect ratings from other watershed reports and from TAG professional expertise, and are generally consistent with, but may differ somewhat from the Salmonid Habitat Condition Rating Standards included for reference in Appendix C. Differences from the Rating Standards in Appendix C are often the result of stated ratings in reports that are comparing habitat evaluations with Forest Service Standards, Federal Watershed Analysis standards, etc., and where numerical data were not presented to allow comparison with the Rating Standards in Appendix C. The ratings generally represent the composite habitat condition for a stream; some reaches of the stream may be better or worse. A range of habitat condition ratings is presented where habitat quality differs between reaches within a watershed. Many of the habitat condition ratings for these streams are based on qualitative observations and experience of the TAG participants, due to the lack of quantitative habitat assessments for many of the streams in the Yakima watershed.

Action recommendations to address identified habitat limiting factors for each stream are included in the Habitat Limiting Factors by Subbasin chapter. However, the common thread between the action recommendations is restoration of stream and floodplain ecological function (represented by “good” habitat ratings for each of the specific habitat elements). These functions are not only critical to restoring salmonid populations in these watersheds, but are also critical to the overall watershed function and quality of life in the Yakima Basin (including factors such as prevention of flooding impacts, maintaining water quality for instream and domestic use, etc.).

Table 39 also identifies those streams/habitat elements for which insufficient information is available to make a habitat condition assessment. These are noted in the table as Data Gaps (DG). The absence of a stream in the list does not necessarily imply that the stream is in good health. Some streams may not be listed because they have not been visited, or no information is available. Others may show more impacts because they are easily accessible and have been the focus of more extensive scientific observations and study.

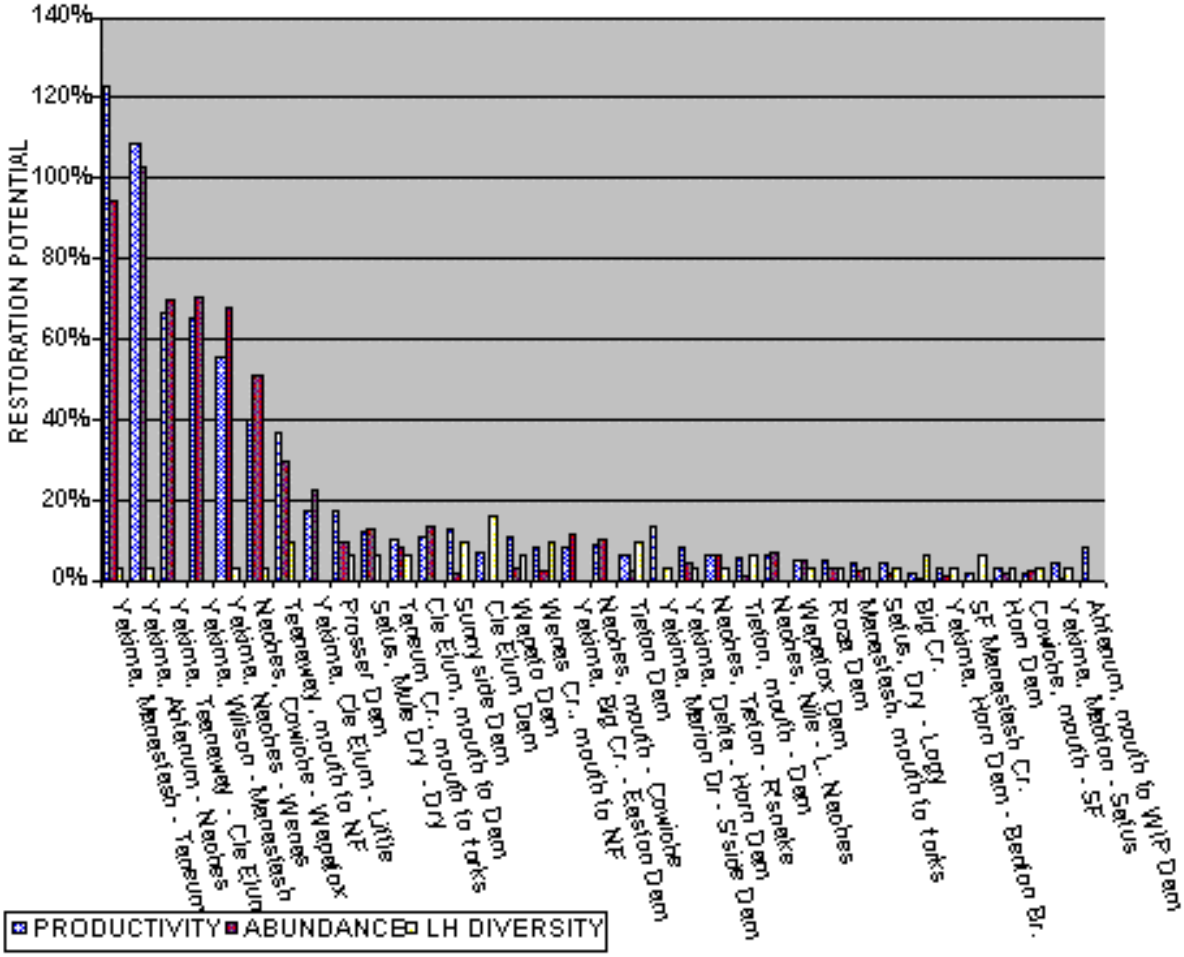
The purpose of Table 39 is to provide a quick visual reference to indicate the relative health of salmonid habitat base of individual mainstem reaches or subwatersheds within the Yakima watershed, and to provide a relative comparison of habitat condition within and between streams. The summary information in the table is useful as a general guide to healthy habitats warranting special protection, habitat problem "hot spots" that warrant restoration consideration, or additional assessment data collection to guide habitat restoration. However, the Habitat Limiting Factors by Subbasin chapter should be consulted for specific stream information and action recommendations on which to base specific salmonid habitat restoration proposals. Some streams may have current habitat conditions that are highly altered, but may have excellent habitat restoration potential. In other cases, the potential benefit of proposed habitat restoration actions may be limited due to the number of habitat problems in a stream, higher priority limiting factors that should be addressed first, sequencing of projects to ensure effectiveness, etc. Each habitat project (protection, restoration, or assessment) should be considered on its own merits, based on anticipated benefits to salmonid restoration.

Habitat Restoration Potential

Despite the extensive impacts that have occurred to fresh and marine water habitats, and the number of "fair" or "poor" habitat ratings that exist throughout the area, there are a number of reasons to be optimistic regarding the future of salmonid habitat and productivity in the Yakima watershed. Although adult salmonid returns to the Yakima are still but a fraction of historic run size, they have increased significantly in the last few years, partially in response to restoration and supplementation efforts that have already been implemented in the basin.

Ecosystem Diagnosis and Treatment (EDT) simulations have been used to identify the spring chinook restoration potential for each of 142 reach designations in the Yakima Watershed. Similar efforts are currently underway for summer steelhead. Simulations are yet to be undertaken for fall chinook, coho, or bulltrout. EDT estimates current productivity levels of salmonid habitat in the watershed, compares that with historic condition, and estimates productivity with anticipated habitat restoration. The spring chinook simulations have indicated that contribution to restoration potential within the Yakima watershed is unequally distributed across reaches (YSS 2000 DRAFT). Of the 35 reaches that total 90% of the restoration potential, the top eight reaches comprise 60% of the overall watershed-wide restoration potential (Figure 61). The top eight reaches include all but one of the major alluvial, anastomosing reaches in the basin. This is expected, given the contribution of these reaches to productivity, carrying capacity, and biodiversity of fish, wildlife, and benthic invertebrates, and the extensive habitat alteration of these areas that has occurred over the last 150 years. The other major alluvial, anastomosing reach (Ahtanum Creek to Toppenish Creek) is also important overall, as it was the major spawning area for summer and fall chinook. It is, however, qualitatively different for spring chinook, with water temperatures excessive for spring chinook spawning, but not for other species which spawn later when water temperatures have decreased.

Figure 61: EDT evaluation of the relative contributions of the 35 Yakima Basin reaches providing 90% of spring chinook estimated mean restoration potential (from YSS 2001 DRAFT).



Restoration projects in the Yakima watershed should be considered in relation to the production potential of the stream and the anticipated benefits of the restoration project. Several of the streams have areas where habitat is currently in relatively good condition, and these areas should be protected (see Habitat In Need Of Protection chapter of this report). In other streams, substantial amounts of habitat exists upstream of passage barriers (culverts, irrigation diversions, etc.), where access could be effectively restored. Although most of the large irrigation diversions have been screened to avoid entrainment of juvenile salmonids, many unscreened diversions remain on the tributaries. Other degraded habitats have potential to provide excellent habitat and warrant special consideration. However, the habitat in some mainstem reaches and tributaries has been so extensively altered that habitat restoration would be very difficult, complex, and expensive, with lower certainty of success. Habitat protection, restoration, and assessment efforts should be prioritized to place emphasis on those efforts and areas that are likely to provide the greatest restoration benefit to salmonids.

Table 39: Salmonid habitat condition ratings for mainstem reaches and tributaries in the Yakima watershed

				Channel Conditions				Water Quality		Hydrology	
Stream Name	**Stream#**	**Fish Access**	**Floodplain Connectivity**	**LWD**	**Pools**	**Substrate**	**Riparian Conditions**	**Temp /DO**	**Toxics**	**Peak Flow**	**Low Flow**
Yakima River (Mouth to Prosser Dam)	37.0002	P	F	P	G	F	P-F	P	P	P	P
Yakima River (Prosser to Granger)	37.0002	F	F	G	G	P	F	P	P	P	F
Yakima River (Granger to Union Gap)	37.0002	F	F-G	G	G	G	F	P	P	P	F
Yakima River (Union Gap to Selah Gap)	37.0002	G	F	P	P	G	P-F	F	F	F	G
Yakima River (Selah Gap to Wilson Cr.)	37.0002	G	P-F	F	G	F	P-F	G	F	F	G
Yakima River (Wilson Cr. to Thorp)	37.0002	G	P-F	P-F	DG	G	F	G	G	F	F
Yakima River (Thorp to Teanaway R.)	37.0002	G	G	F-P	DG	G	F-G	G	G	F	F
Yakima River (Teanaway R. to Cle Elum R.)	37.0002	G	F	P-F	G	G	F-G	G	G	F	F
Yakima River (Cle Elum R. to Easton Dam)	37.0002	G	F	P-F	G	G	F-G	F-G	G	F	F
Yakima River (Easton to Keechelus Dam)	37.0002	F	G	P-F	G	G	G	F-G	G	F	P-F
Amon Creek		P	?	?	?	?	P-F	?	?	F	G
Corral Canyon Cr.	37.0205	F	P	P	F	P	G	G	G	G	F
Snipes Cr.	37.0332	P	G	F	G	P-F	P-F	P	P	???	P
Spring Cr.	37.0333	P	P	F	P	F-P	P-F	DG	P	F	P
Sulphur Cr.	37.0453	P	NA	P	P	P	P	P	P	P	P
Mabton Drain		DG	DG	DG	DG	DG	DG	DG	P	DG	DG
Drain 301		DG	DG	DG	DG	DG	DG	DG	P	DG	DG
South Drain	37.0478	DG	DG	DG	DG	DG	DG	DG	P	DG	DG
Satus Cr.	37.0482	G	F	P	DG	P-F	P-G	P-G	F	F	F
Toppenish Cr. (below WIP diversion @ RM 44.2)	37.1308	P	P	P	P	P	P	P	P	P	P
Toppenish Cr. (above WIP diversion @ RM 44.2)	37.1308	F	G	G	G	G	G	G	G	G	G
Simcoe Cr.	37.1289	P	P	DG	DG	P-G	P-F	DG	DG	DG	P
Marion Drain		F	NA	DG	DG	DG	DG	P	DG	G	G

				Channel Conditions				Water Quality		Hydrology	
Stream Name	**Stream#**	**Fish Access**	**Floodplain Connectivity**	**LWD**	**Pools**	**Substrate**	**Riparian Conditions**	**Temp /DO**	**Toxics**	**Peak Flow**	**Low Flow**
Wanity Slough		P	P	DG	DG	DG	P	P	P	G	G
Harrah Drain		DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Granger Drain		G	P	DG	P	P	P	P	P	NA	P
Moxee Drain		P	P	P	F	P	P	P	P	F	G
Ahtanum Cr.	37. 1382	P	P	P	P	P	P-F,DG	P-G,DG	G,DG	G	P-G
Wide Hollow Cr.	37.1400	P	P	P	G	F	P-F	P	P	G	G
Naches River (below Tieton)	38.0003	F	P-F	P	F	P	F	G	G	P	P
Naches River (above Tieton)	38.0003	G	F-G	P	G	F	P-F	F	G	G	G
Cowiche Cr.	38.0005	P	F	G	G	G	P-G	P	DG	F	F
NF Cowiche Cr.		P	F	DG	DG	F	DG	P	DG	P	G
SF Cowiche Cr.		P	F-G	G	G	G	F	P	DG	F	G
Tieton R. (below dam)	38.0166	P	P-F	P	P	P	P-F	P	G	P	P
Tieton R. (above dam) inc.tribs.	38.0166	P	P-G	G	G	F	F-G	P	G	G	G
Oak Cr.	38.0169	F	P	F	F	DG	P-F	F	G	F	G
Wildcat Cr.	38.0270	F	DG	DG	DG	G	DG	DG	DG	DG	DG
Rattlesnake Cr.	38.0518	G	P	P-G	F	F	P-G	P-G	G	F	G
L. Rattlesnake Cr.	38.0519	G	G	G	P	G	G	G	G	F	G
NF Rattlesnake		G	G	G	F	G	G	G	G	F	G
Nile Cr.	38.0692	DG	P	G	G	F-G	G	P	G	G	G
Rock Cr.	38.0754	G	G	G	DG	F	DG	DG	DG	DG	DG
Lost Cr.	38.0790	DG	DG	DG	DG	DG	DG	DG	DG	DG	DG
Gold Cr.		P	DG	DG	DG	DG	P	P	DG	DG	DG
Swamp Cr.		F	DG	DG	DG	DG	DG	DG	DG	DG	DG
Milk Cr.		P	DG	DG	DG	P	DG	DG	DG	DG	DG
Bumping R. (below dam)	38.0998	G	F-G	G	F	F	G	P	G	G	G

				Channel Conditions				Water Quality		Hydrology	
Stream Name	**Stream#**	**Fish Access**	**Floodplain Connectivity**	**LWD**	**Pools**	**Substrate**	**Riparian Conditions**	**Temp /DO**	**Toxics**	**Peak Flow**	**Low Flow**
Bumping R. (above dam)	38.0998	P	G	G	F	G	G	G	G	G	G
American R.	38.1000	G	G	G	F	G	G	???	G	G	G
L. Naches R.	38.0852	G	P-G	P	P-G	P-F	P-G	G	G	F	F
Wenas Cr.	39.0032	P	P	P	P	P	P-G,DG	P	DG	G	P
Roza Cr.		F	P-F	G	G	DG	P-F	DG	DG	DG	G
Lmmuma Cr.		G	G	DG	DG	P,DG	P-F	P-F	DG	DG	F
Umtanum Cr.	39.0553	P-F	P-G	DG	DG	G	P-G	F	G	DG	P-F
Manastash Cr.	39.0988	P	F	P-F	P-F	P-F	F-G	F	G	G	P
Wilson/Cherry	39.0604	P	P	P	P	P-F	P-F	P	F	F	G
Reecer Cr.	39.0968	P	P	P	P	DG	P-G	P	DG	G	P
Dry Cr.	39.1049	P	P	P	P	DG	P-G	DG	DG	F	P-F
Taneum Cr.	39.1081	P-F	F-G	F	F	P-F	P-G	F	DG	G	P
Swauk Cr.	39.1157	P	P	P	P	P-F	P	P	DG	P	P
Teanaway Cr.	39.1236	F	P-F	P-F	G	F-G	F-G	P-F	P	P	P
Cle Elum R. (below dam)	39.1434	G	F-G	DG	DG	F-G	G	G	G	P	P
Cle Elum R. (above lake) inc. tribs	39.1434	P	G	G	F	G	G	DG	G	G	G
Little Cr.	39.1674	P,DG	P	P-G	P-F	P	F	DG	DG	DG	DG
Big Cr.	39.1687	P	P	P-G	P	P	P-G	F	DG	G	P
Tucker Cr.	39.1709	P	P,DG	DG	DG	DG	DG	DG	DG	DG	P-F
Cabin Cr.	39.1798	P	P	P	P	P	P-F	P-F	DG	P	G
Kachess R. (below dam)	39.1739	G	F	DG	DG	DG	F	F	G	P	P
Kachess R. (above dam) inc. tribs.		P	F	P	P	F	F	F	G	G	G
Tribs. upstream of Keechelus Dam		P	P-G	P	P	P-G	P-G	F-G	DG	G	P-G

HABITAT NEEDING PROTECTION

Previous chapters in this report identify salmonid habitat throughout the Yakima watershed that has been adversely impacted by the broad suite of land uses that exist in the watershed, and which would benefit from habitat restoration projects. However, there are a number of habitat areas that remain in relatively good condition, where existing habitat functions should be protected, or where acquisition/easement is considered critical to future restoration success. These areas serve as the foundation upon which habitat restoration and salmonid recovery efforts are most effectively built. Protection of functional salmonid habitat is typically always more cost effective and provides greater certainty of long-term success than restoration of degraded habitat. Habitat protection can be provided through acquisition, conservation easement, or specific protection under critical area ordinances or other regulatory processes administered by local land use managers.

It is not practicable to prioritize areas recommended for acquisition or conservation easement, as opportunities often only arise as willing sellers surface, and there is typically a very limited timeframe in which to respond. The following stream reaches and/or protection strategies are identified as important to ensure continued function of high quality salmonid habitat, or areas that are critical to restoration of natural floodplain function:

Key Mainstem Floodplain Reaches

Floodplain reaches that appear to be crucial to the long-term survival and recovery of salmon in the Yakima watershed have been evaluated and ranked based on natural habitat heterogeneity, productivity, current and historic use by anadromous salmonids, and restoration potential (Snyder and Stanford 2000 DRAFT). The Yakima watershed reaches identified for conservation actions, listed in order of priority are:

- Upper Yakima-Teanaway – From upstream of the Cle Elum confluence downstream to about halfway between the Teanaway River and Swauk Creek, including the lower ~km of the Teanaway. This is a very complex floodplain, with the primary zone of upwelling and braiding around the Teanaway-Yakima confluence, including the lower ~1 km of the Teanaway. Although much of this reach is significantly altered and disconnected (the river is channelized and constricted between the railroad and I-90, there are several gravel pits within the floodplain, the river is generally a flume in the vicinity of the hatchery, and the floodplain is significantly altered downstream of the crossing below Cle Elum), a substantial portion of this floodplain reach remains connected and has little development (Eric Snyder, pers. comm.).This floodplain reach is also influenced by regulated flows, abstraction via Easton Diversion, several diversions on the Teanaway. The Teanaway-Yakima confluence area has substantial restoration potential because the land is not heavily developed and because the remnant backwaters and spring brooks are present in spite of the road berms and bridge revetments.
- Kittitas Valley – From the Taneum Creek confluence downstream to the upper end of the Yakima Canyon. Much of this floodplain reach is disconnected from the river by I-90 and other road berms, and it is influenced by flow regulation from the headwater reservoirs and diversions. Riparian encroachment by new homes is also a big problem. The Cascade, Ellensburg Water Company (Town Ditch), and other smaller diversions are within this reach, although all are smaller than the major irrigation diversions in the lower watershed. The lower 5-8 km of the reach is a very complex upwelling system with substantial intact riparian forest and minimal housing encroachment.

- Yakima City – From the Naches River confluence downstream to Union Gap. This floodplain reach has extensive floodplain urbanization encroachment and revetment. The lower 5 km has extensive upwelling, with a fair amount of interconnected floodplain habitat.
- Upper and Lower Naches - The upper Naches reach is in the Nile Valley of the Naches River, extending 3 km upstream and downstream of the confluence of Rattlesnake Creek. The lower Naches reach extends from the Naches Canal Diversion (RM 18.4) downstream to near the confluence with the Yakima. This floodplain reach is reasonably intact, but is influenced by regulated flows from Bumping Reservoir. The lower Naches valley floodplain is large and extensively braided, with the lower 8 km being an extensive upwelling zone with several large springbrooks, substantial fish habitat, and minimal housing encroachment.
- Wapato – From Union Gap downstream ~35 km to near the confluence of Satus Creek. This floodplain reach is largely intact, with an extensive cottonwood riparian forest. However, the reach is influenced by Sunnyside Dam and other upstream diversions and irrigation returns via numerous drains. The floodplain habitats are most complex from the Wapato Bridge downstream to the upper end of the meander zone (near the mouth of Satus Creek), with extensive riparian wetlands associated with upwelling from the alluvial aquifer system. This reach is of likely major importance as rearing habitat for juvenile salmon and steelhead.
- Selah – From the downstream end of the Yakima Canyon downstream to Selah Gap (~8 km). This floodplain reach is substantially modified by gravel mining, but has a nice upwelling zone at its lower end that probably could be rehabilitated by normative flows if gravel mining ceased. In addition, an old side-channel (Taylor Ditch) has been maintained for irrigation delivery on the outer edge of this floodplain reach, and restoration of access into this side channel may increase floodplain habitat and function through this reach (TAG).
- Yakima River Mouth – Including the lower portion of the Yakima River that is inundated by McNary pool (~3 km). This floodplain likely was very extensive and complex prior to the construction of McNary Dam on the Columbia River. Remnant riparian forests remain on exposed portions of the extensive alluvial delta (most of the original delta is submerged). The reach is substantially modified by inundation and erosion associated with McNary pool, but a substantial expanse of wetlands exists on the fringes. Surface and groundwater interactions appear to be dominated by infiltration of McNary pool water, which probably maintains the fringing wetlands.
- Ahtanum Creek - The middle portion of Ahtanum Creek, from the confluence of the NF and MF to ~10 km downstream. This floodplain reach has channel features that suggest extensive alluviation and a variety of springbrooks are present in the lower portion. However, riparian condition is poor, and further inspection is needed before it can be considered a key restoration site.

A key uncertainty in the ranking above is the relative importance of the meandering reach from the lower end of the Wapato floodplain reach (priority 5) and Prosser. The reach appears to have considerable habitat complexity, but no information was found describing the ecology or specific salmon use (Snyder and Stanford 2000DRAFT).

Prioritization of these floodplain reaches for conservation does not mean that the rest of the river corridor does not require restoration of normative conditions (Snyder and Stanford 2000 DRAFT). The premise is that if the most aggraded reaches are naturalized, the more constrained reaches (where change in river stage likely has relatively less spatial influence) will also be enhanced.

Tributary Habitats

There are several tributaries, or reaches of tributaries, within the Yakima watershed where habitat conditions are good and warrant special consideration for protection, through acquisition, conservation easement, voluntary measures, or land use regulation. There have also been active programs through WDFW and BOR to acquire critical parcels for long-term protection, such as the recent acquisition of the Heart-K ranch on Taneum Creek, and current attempts to acquire key Yakima River floodplain habitat. The TAG identified the following areas as the highest priority for protection, at least in the near-term:

- Bumping River and American River watersheds – The entirety of these watersheds warrants protection to protect ecological function. Habitat conditions are generally good, and the majority of these watersheds are in USFS ownership. The spring chinook stock in the American River is genetically distinct from the stock in the Bumping River. The American River is the most productive spring chinook spawning reach in the Naches watershed, and also has the highest density of fluvial bull trout redds in all of the Yakima watershed, particularly around and upstream of Union Creek (WDFW 1998). The kokanee population in Bumping Lake is naturally reproducing, with no supplementation. Bumping Lake may also offer the best opportunity for anadromous sockeye reintroduction in the Yakima watershed.
- Rattlesnake Creek upstream of the mouth of the NF – Habitat upstream of the mouth of the NF is generally in good condition, with good abundance of LWD and pools, providing excellent habitat for summer steelhead and bull trout spawning.
- SF and NF Tieton, Indian Creek – Although anadromous salmonids are not able to access upstream of Tieton Dam, the habitat in these tributaries upstream of the dam remains in good condition, and provides spawning and rearing habitat for bull trout and kokanee residing in Rimrock Lake. If anadromous access is restored upstream of Tieton Dam, the majority of salmonid production in the Tieton would likely come from these tributaries upstream of the lake.
- Big Creek upstream of the diversion at RM 2.1 – There is high quality habitat upstream of the currently impassable barrier at the diversion at RM 2.1, which will be accessible once the barrier is corrected.
- Swauk Creek downstream of Lauderdale Junction – Although habitat function in this reach is currently not high quality, the floodplain remains generally intact and would likely naturally restore if given the opportunity.
- Lower Lmmuma Creek – While there is likely little spawning that occurs in Lmmuma Creek, it provides key off-channel rearing habitat in the Yakima Canyon, where off-channel habitat is very limited. There are good stands of riparian cottonwoods in the lower portion of the creek, and all of the land is within a single ownership, offering unique opportunities to protect this important habitat.

This list of habitats in need of protection is only a partial list. There are numerous other tributary reaches that also warrant special consideration for protection. The list above represents those areas where special efforts should be made to ensure that critical ecological functions are protected. However, opportunities for acquisition of key habitats should be evaluated and exercised where warranted; ownership offers greater potential for protection and restoration than might otherwise be possible.

All salmonid habitats should be included within local critical areas ordinances, and those ordinances should be reviewed and revised as necessary to ensure no further degradation of salmonid habitat, and to restore habitat function where possible. Protecting habitat function is far

more cost effective and provides greater certainty than attempting to restore habitat function that has been lost.

DATA GAPS

Despite the extensive amount of research, and salmonid stock interaction and habitat evaluations that have been done in the Yakima watershed, there are a number of key data gaps remaining to be filled. These include some fundamental understanding of species distribution and habitat utilization and preferences, and understanding of the implications of land use actions and flow regulation on habitat forming processes in the watershed.

Salmonid Species Utilization

Knowledge of Yakima watershed fall chinook is almost totally restricted to the population spawning upstream of Prosser Dam, with very limited knowledge even here. Little is known regarding the effects of high water temperature and low dissolved oxygen on pre-spawning mortality; and lack of ability to assess the population (number of spawners, age and sex composition, fecundity) downstream of Prosser have limited the ability to effectively estimate egg-smolt survival (CBSP 1990). In addition, although spawning concentrations of fall chinook are known in the Yakima River near Granger, in Marion Drain, and in the vicinity of Horn Rapids Dam, the relative magnitude of spawning at those and other areas has yet to be determined. Previous estimates indicated 70% of the spawning occurred downstream of Prosser Dam and 30% upstream, but more recent estimates indicate the split may be closer to 50-50.

The lower Naches River is thought to have been an important summer-early fall rearing area, particularly for summer steelhead. Flip-flop flow management has significantly altered the natural hydrology in the lower Naches River, ranging from very low flows in mid-late summer, to very high flows during the month of September. Rearing through the low flow period is likely severely impacted by the lack of wetted floodplain, and it is unknown to what extent the peak flows in September displace juvenile salmonids (particularly steelhead) from the preferred rearing area of the lower Naches, or strand them on the floodplain once flip-flop flows are reduced.

Review of Flip-Flop Flow Management

The flip-flop flow management scheme was implemented in the early 1980s, designed specifically to provide stable flows for spring chinook spawning and incubation in the Yakima River upstream of Easton. Flip-flop was implemented with little consideration or understanding of the implications to other species, particularly the potential implications to summer steelhead in the Naches watershed. Implementation has resulted in a number of unintended consequences, particularly the loss of virtually all of the production potential of the Tieton River, and potential negative impacts to steelhead juveniles rearing in the lower Naches River. Scientists now have a better understanding of the associated adverse impacts to other stocks/species and to habitat conditions elsewhere in the watershed. After 20 years of experience with flip-flop, it is time to comprehensively review flip-flop and modify the scheme as necessary, considering benefits and implications to all salmonid stocks/species.

Water Budget

A water budget that allows BOR to accurately predict the effects of conservation and allocation scenarios is essential (Snyder and Stanford 2000 DRAFT). For example, we need to know precisely how much instream flows can be increased by various conservation techniques. This involves monitoring discharge in withdrawals and returns. The information is vital for making sound ecological decisions. Also, we need to be able to accurately assess the condition and

accessibility of backwater habitats, which are critical for juvenile rearing (Pearsons et al. 1996). A rigorous water budget provides the tools necessary for predicting water elevation in these habitats throughout the basin. Finally, the water budget needs to be peer-reviewed; a process that provides credibility to decisions made using the water budget as a tool.

Identification of Instream Flows Necessary to Support Normative Ecosystem Function

Many of the impairments to salmonid productivity and to habitat function in the Yakima watershed are associated with alterations to the natural hydrologic regime. Whereas instream flows have been established by court order for some reaches (Title XII flows, flip-flop), there is a lack of agreement on instream flow needs for most of the watershed. The need to establish and implement flows to support normative ecosystem function has been identified by SOAC (1999) and Snyder and Stanford (2000 DRAFT). In addition, Jeff Braatne has identified the need to return to a more normal flow pattern in order to improve riparian composition and health. Species interaction studies (Phinney 1999) have shown a relationship between instream flows and avian predation on salmonid smolts, but this information has yet to be incorporated into a revised flow regime. Another element that is poorly understood is the effect of operational spills (from the major irrigation canals) on false attraction of adults, stranding of juveniles, and the adverse effects to salmonid habitat conditions in the drainages into which the operational spills are made.

The infrastructure that has been implemented for irrigation operational spills, irrigation return flows, and agricultural drains has significantly interrupted floodplain ecological function on the mainstem Yakima, as well as on many of the tributaries. Restoration of flow per se may not provide the desired benefits in terms of allowing completion of life history, or maximizing ecosystem function (Freudenthal). In many cases, the drainage network of the basin has been simplified or “short circuited”, decreasing the residence time of water within the watershed and dramatically altering floodplain, riparian and watershed function. Removal of the “short circuits” may not result in increased flow per se, but it will result in predictably improved ecological function and process. Water which has passed through the thermal sink of the alluvial floodplain is very precious indeed, particularly in the lower river. Instream flow studies need to recognize not only biologically-based objective, but the underlying processes which sustained biological productivity prior to alteration of the watershed since the early 1800s.

Sediment Budget

Rates of sediment supply and delivery are a key factor determining the spawning and rearing success of anadromous salmonids and steelhead (Snyder and Stanford 2000 DRAFT). This applies not only to the sources and transport of spawning gravel, but also to the flux of finer-grained transported material that can smother redds and bury spawning gravels. Recently, much emphasis has been placed on the detrimental impacts of gravel extraction within the floodplain. Potential restoration or mitigation strategies will very likely involve a complete understanding of sediment flux in various reaches, particularly between Roza Dam and Union Gap. Because of flip-flop, sediment dynamics in the Naches River are likely severely altered, and quantitative information needs to be gathered to understand this process. Finally, are the various reaches degrading or downcutting due to lack of gravel caused by revetment and flow regulation? This is a highly relevant question that has not been investigated at all in the Yakima basin.

There are recent efforts to significantly reduce the fine sediment delivery from irrigation drains and return flows. There is ongoing monitoring of the reductions in fine sediment delivery from most of the tributaries, but no current monitoring on substrate conditions in the Yakima River, or

strategic planning to determine what management actions should be taken to restore productivity in mainstem reaches where substrate has been adversely impacted by past fine sediment delivery. Another substrate-related data gap is the lack of understanding of the effects of revetments on channel characteristics, substrate quality, and sediment transport.

Temperature Budget

We do not know the extent to which river temperatures in the lower Yakima are influenced by surface water vs. groundwater (Snyder and Stanford 2000 DRAFT). Historically, spring flooding provided an annual source of cool water to the groundwater system. Throughout the summer, this cool groundwater reserve would recharge into the river, maintaining lower instream temperatures. Also, winter stream temperatures would be warmer given increased groundwater inflow. Currently, up to 80% of the instream flow in the lower Yakima comes from irrigation and municipal returns. This water is not only warm, but is loaded with suspended sediment, which has been positively correlated with concentrations of DDT derivatives, both in sediment and fish tissue.

Food Web Structure and Function

There is a lack of information on food web structure, primary and secondary productivity (Snyder and Stanford 2000 DRAFT). This type of analysis is critical if limiting variables are to be identified. For example, the potentially synergistic interaction of habitat limitation and flood limitation is unknown. This type of analysis ideally should be done with all salmonid species of concern and at different life stages.

Juvenile Salmonid Ecology

Current research indicates that juvenile salmonids utilize backwater habitat extensively in the upper Yakima (Pearsons et al. 1994, 1996). Estimates need to be made examining the degree to which these habitats have changed over the past 100 years (this analysis is currently being undertaken for some river reaches)(Snyder and Stanford 2000 DRAFT).

Groundwater/Surface Water Interactions

In naturally functioning river ecosystems, the interface between surface and ground waters is most prevalent in the riparian zone, which acts as a landscape filter (Snyder and Stanford 2000 DRAFT). The zone is characterized by high retention and heterotrophic transformation of organic material and inorganic nutrients , and removal of nitrogen and phosphorous through denitrification and adsorption (Pusch et al. 1998). In large alluvial rivers, such as the Yakima, the riparian zone must be serimposed over an extensive floodplain that, at least historically, was temporally and spatially heterogeneous. The structure and function of the riparian zone is mediated by geomorphic and hydrologic variables, such as precipitation patterns, which determine flow regime (Stanford 1998). Also, there has been no rigorous analysis examining the historic vs. contemporary extent of the floodplain and riparian zone. This analysis is currently being conducted (Uebelacker 1986).

Catchment Level Controls

There have been no measurements or estimates of the effects of regulation and modification on nutrient cycling, energy metabolism, trophic structure and function, and decomposition rates

(Snyder and Stanford 2000 DRAFT). These types of analyses require measurements of algal and macroinvertebrate standing stocks (for measurements made in autumn; see Leland 1995) and Cuffney et al. 1997), solar radiation, and nutrient flux throughout the year. There is a need to incorporate the natural disturbance regime into past and ongoing research activities. Historically, annual spring flooding provided a predictable disturbance event and one of the major components of the habitat template (Southwood 1977) for the Yakima River. We know that salmonid fish populations in the basin are spatially and temporally variable (Pearsons et al. 1994), a response likely linked to abiotic factors, such as disturbance regime.

Marine Derived Nutrients

Historically, salmonid carcasses provided a significant source of nutrients, particularly nitrogen and phosphorous, to the streams and lakes in the Yakima basin. The reduction in numbers of returning spawners from 300-800 thousand to <10,000 represents a significant decrease in nutrients, particularly to oligotrophic headwater streams where nutrient input is naturally limited. A significant difference in nitrogen and phosphorous was detected in Cle Elum Lake sediments pre- and post-1906, when returning salmonids were likely blocked by dam construction (Mongillo and Faulconer 1982). Water quality sampling has generally considered low nutrient levels to represent good water quality, and has not recognized the importance of nitrogen and phosphorous to food web support and salmonid productivity. Although the loss of marine derived nutrient to stream in the Yakima basin can clearly be shown, there is very limited understanding of the extent to which this loss has affected salmonid productivity in the basin.

Role and Importance of Beaver in the Yakima Basin

Beaver presence has been eradicated or severely reduced throughout much of the Yakima Basin. Beaver trapping was common during early European settlement in the mid-1800s, and continues at significantly reduced levels today. Subsequent land use actions, such as dewatering of stream reaches, channelization, and removal of riparian vegetation have decreased habitat suitability for beaver. Historic beaver presence is identified as a potential key to providing habitat complexity, stream stability, floodplain water storage, and stream baseflows in several watersheds (e.g., Teanaway and Swauk creeks). However, the specific role and importance of beaver reestablishment to habitat and salmon restoration is not well understood, and warrants further study. In addition, it is important to better understand how many beavers are enough to achieve the desired salmonid habitat targets, and to be able to identify locations where presence of beavers is most practicable.

Riparian Role of Historic Riparian Zone Characteristics and Disturbance Patterns

Based on the information cited in Stanford and Snyder regarding the pre-disturbance riparian zone, it is apparent that Ponderosa Pine is no longer present in any significant numbers in the riparian zone of the lower Yakima River from Granger to the Canyon mouth (Freudenthal). Other historical records from the Yakima Valley Museum and Arboretum suggest that much of the current Selah, Yakima, and Ahtanum valleys were forested with Pondersa pine. Serious consideration should be given to reintroduction of Ponderosa Pine in these environments due to its ecological benefits, including importance to avian wildlife for food and for nesting and roosting, its high shade value, relatively low water use (in comparison with Cottonwood), and structural longevity as a contributor to in-stream habitat diversity. This last function is especially important given the loss of in-stream connectivity and recruitment of upstream LWD to the Wapato reach as a result of loss of upstream sources of LWD and multiple irrigation diversion

dams. Natural recolonization of Ponderosa Pine will likely take several centuries due to the difficulty of re-invading a long, linear structure isolated from adjacent seed sources. Re-introduction of Ponderosa Pine will also be difficult due to the unique environment (in terms of climate, moisture stress, fire frequency, etc.) of these riparian zones present for Ponderosa Pine. Ponderosa Pine is (like salmonids themselves) normally adapted to very site-specific conditions. There are available seed stocks for planting at elevations above 1500 feet MSL, but there does not currently exist a seed stock commercially available for use in restoring this element of the riparian zone. Based on examples of Ponderosa Pines which have been planted in the riparian zone in recent times, (mostly associated with DOT mitigation) the available cultivars of Ponderosa Pine do not grow as quickly or achieve the same growth form as the few native pines which are regenerating. A study of the habitat characteristics of the remaining low-elevation Ponderosa pine family groups should be undertaken, and conservation of the genetics of these few remaining families should be considered.

Loss of Ponderosa pine is but one example of the changes in the riparian communities of the lower Yakima River (Freudenthal). Examination of the 1927 aerial photos indicates a much less well developed riparian zone existed at that time in the Selah, Yakima, Lower Naches, and Wapato reaches. It is possible that these photos are a better representation of the 'template' condition for riparian zones in the lower Yakima, or that they were in the process of recovery from a major disturbance such as several decades of chronic de-watering of the lower reaches of the Yakima as documented in the opening chapters of this document. In addition, current riparian condition in the Lower Naches is undoubtedly affected by the relatively long time period in which the Wapatox and other diversions have dramatically altered the flow and groundwater relationships in this portion of the river, as well as the more recent changes in flow as a result of "flip-flop". Improvement of floodplain function should include restoration of the natural vegetative characteristics of the riparian zone as plant communities have dominant roles in determining floodplain and in-channel roughness and energy dissipation, as well as bank resistance to erosion and rates of channel movement and meander translation.

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The summary of Literature Cited in this report represents only those reports that were directly referenced. Several of these citations represent other similar Yakima watershed synthesis reports that have been recently completed, such as the Yakima Subbasin Summary (YSS 2001 DRAFT), and Snyder and Stanford (2000 and 2001). Many of the cited references in the report are secondary references, representing conclusions that these authors cited from other reports; these secondary references are not included in the list above. An extensive Yakima Project Working Bibliography is being developed and maintained as part of the "Yakima Reaches Study"; the bibliography can be accessed at the Flathead Biological Research Station website at http://www.umt.edu/biology/flbs/yakima/Biblio.htm.

APPENDICES

APPENDIX A

Yakima River Watershed (WRIAs 37-39) Salmonid Distribution

The following streams in the Yakima River watershed (WRIAs 37-39) are identified as having anadromous salmonid presence. Bull trout distribution (as provided by WDFW and Streamnet) is identified in a separate table in this appendix. Dist. for anadromous salmonids is based primarily on input of Technical Advisory Group (TAG) participants, with additional consideration of other sources.

Known distribution (code=1 in species column) in these streams represents current knowledge, which is limited to those only streams/locations where observations have been made at the appropriate time of year, and may be significantly different than historic distribution, with current distribution likely being more limited. Reasons for more restricted current distribution include habitat conditions that no longer support salmonids; presence of barriers that preclude salmonid access to productive habitats; extirpation of species; and reduced spawner populations that tend to narrow the distribution extent, limit the ability of the fish to maintain suitable substrate conditions, and limit the return of marine nutrients from carcass decomposition that support the instream food web for subsequent juvenile salmonid production. Due to the difficulties of surveying for spawning summer steelhead during spring runoff, steelhead that are identified as known are actually a combination of known/presumed.

Presumed species distribution (code=2 in species column) is also identified for a number of streams and species. Potential/historic distribution (code=3 in species column) is identified where historic distribution is known/presumed to have been more extensive based on watershed literature, personal knowledge, or presence of suitable salmonid habitat upstream of anthropogenic fish passage barriers. Potential salmonid distribution is likely greater than represented. Habitat use (spawning (S), rearing (R)) is also identified for species records in the distribution table, where known.

Coho were extirpated from the Yakima River watershed, and a reintroduction project is currently underway to attempt to reestablish sustainable natural adult coho returns. Due to the lack of knowledge on areas historically used by coho, historic coho distribution has been assumed to extent of known or historic summer steelhead distribution, whichever is higher. Where upstream migration is blocked by a barrier, such as a falls, historic coho distribution likely extended to the same point. Where upstream summer steelhead distribution is limited by increasing stream gradient, it is possible that historic coho presence may not have extended quite as far upstream, as steelhead are known to utilize slightly higher stream gradients than coho.

See Yakima River watershed anadromous species distribution maps for a visual representation of the following data.

			Species						
GIS #	**Stream Name**	**Stream #**	**Spring Chinook**	**Fall Chinook**	**Summer Steelhead**	**Coho**	**Upper Extent (RM)**	**Source**	**Comments**
11	Yakima River	37.0002		1(S,R)			127.9	1,2,5,6,7	Upper dist. based on observed chinook passing Roza Dam in October
75			1(S,R)		1		214.50	1,2,5	Dist. to Keechelus Dam, spring chinook rearing only in WRIA 37 mainstem Yakima
232						1(S,R)	202.50	7C	Distribution to Easton Dam
234	Amon Creek		1(R, S?)			1 (R,S?)	1.0	3H	Juveniles sampled ~0.25 miles upstream of SR 240
236			2(R, S?)			2(R,S?)	4.9	3H	Presumed distribution to wetlands just downstream of I-82
235	EF Amon Cr.		2(R,S?)			2(R,S?)	1.1	3H	Presumed distribution to railroad crossing (dependent on presence of flow)
1	Corral Canyon Cr.	37.0205		2(S?,R?)		2(S?,R?)	1.50	7G	Dist. to beaver dams and barrier caused by past instream work. Estimated additional .75 miles of habitat upstream. Primarily rearing, although coho redd observed near mouth in 2000 (Cummins)
82					1(S,R)		3.4	1	Summer steelhead identified to Katie Fleck Spring (RM 3.4) by YKFP staff. No historic summer steelhead or coho dist. noted due to assumed lack of instream flow prior to irrigation.
3	Snipes Cr.	37.0332		1(S?,R?)		1(S,R)	3.30	7B,3D	Dist. to SVID Canal
12			1(R)				0.50	25	
83					1(S,R)		3.60	1,7	Dist. to Roza Canal. No historic summer steelhead or coho dist. noted due to assumed lack of instream flow prior to irrigation.
2	Spring Cr.	37.0333	1(R)	1(S?,R?)	1(S,R)	1(S,R)	1.00	1,3D,5,3A,3E,21,25,7B	Few fish are able to pass culvert at Hess Rd.; carcasses seen to or just upstream of culvert. No historic distribution noted due to likely lack of flow prior to irrigation return flows.

GIS #	Stream Name	Stream #	Species: Spring Chinook	Species: Fall Chinook	Species: Summer Steelhead	Species: Coho	Upper Extent (RM)	Source	Comments
13	Sulphur Cr.	37.0453	1(R)				6.00	25	Dist. to 2nd BN RR crossing.
4			1(S?,R?)	1(S?,R?)	1(S,R)	1(S,R)	7.20	1,7,7B, 3D	Dist. to Sheller Rd. Adult spring chinook observed downstream of barrier at Sheller Rd. on May 14, 2001. No historic summer steelhead or coho dist.noted due to assumed lack of instream flow prior to irrigation
86	Unnamed RB at 2.5				1(S,R)		1.60	25	Dist. to Midvale Rd. No historic summer steelhead or coho dist. noted due to assumed lack of instream flow prior to irrigation
85	Unnamed RB at 0.1				1(S,R)		0.50	25	Dist. to Midvale Rd. No historic summer steelhead or coho dist. noted due to assumed lack of instream flow prior to irrigation
87	Mabton Drain				1		1.30	7	Dist. To BN RR crossing. No historic summer steelhead or coho dist. noted due to assumed lack of instream flow prior to irrigation.
88	Drain 301				1		0.90	7	Dist. To BN RR crossing. No historic summer steelhead or coho dist. noted due to assumed lack of instream flow prior to irrigation.
89	South Drain				1		1.70	7	Dist. To BN RR crossing. No historic summer steelhead or coho dist. noted due to assumed lack of instream flow prior to irrigation.
5	Satus Cr.	37.0478	1(S?,R)	2(R)			3.60	3B,5,7	Dist. to BN RR crossing
175						1(S,R)	22.70	7, 7B	Screw trap juvenile coho recoveries; likely the result of upstream production
NA			2(S?,R)						Dist. to mouth of Logy Cr.
90					1(S,R)	3(S,R)	49.10	7	Dist. to impassable falls
96	Mule Dry Cr.	37.0482			1(S,R)	3(S,R)	17.20	7	Dist. to Lucy Canyon
95	Dry Creek	37.0650			1(S,R)	3(S,R)	25.40	1,5	Dist. to gradient break 0.2 mi. upstream of MF Dry Cr.
14	Logy Cr.	37.0849	2(S?,R)				3.50	7	Dist. to unnamed RB trib @ RM 3.5

GIS #	Stream Name	Stream #	Species: Spring Chinook	Species: Fall Chinook	Species: Summer Steelhead	Species: Coho	Upper Extent (RM)	Source	Comments
16			3(S,R)				8	20	Dist. to impassable fall @RM 8.0
94					1(S,R)	3(S,R)	12.30	1,5	Dist. to gradient break above confluence w/Yakama Cr.
93	Highbridge Spring				1(S,R)	3(S,R)	1.20	1,5,7	Dist. to gradient break at Unnamed LB trib. @ RM 1.3
92	Bull Cr.				1(S,R)	3(S,R)	3.00	1,5,7	Dist. to gradient break at Unnamed RB trib. @ RM 3.2
163	Kusshi Cr.				1(S,R)	3(S,R)	6.30	1,5	Dist. to gradient break at Unnamed LB trib. @ RM 6.3
91	Wilson Charlie Cr.				1(S,R)	3(S,R)	1.60	1,5	Dist. to gradient break at Unnamed LB trib. @ RM 1.7
161	Subdrain 35				1(R)		1.60	7	No historic summer steelhead or coho dist. noted due to assumed lack of instream flow prior to irrigation. Dist. to Parton Dr.
162	E. Toppenish Drain				1(R)		2.80	7	No historic summer steelhead or coho dist. noted due to assumed lack of instream flow prior to irrigation. End of drain near Myers Rd.
6	Toppenish Cr.	37.1178	1(S,R)	2(R)			4.80	3B,5,20	Dist. to Taner Gate
181						1(S,R)	9.10	7,7B	
100			3(S,R)		1(S,R)		66.60	1,5,20	Dist. to mouth of Panther Creek
101					3(S,R)	3(S,R)	71.30	7	Dist. to headwaters
164	Snake Cr.				1	3(S,R)	3.60	1,5,7	
97	NF Toppenish Cr.	37.1308			1(S,R)		4.90	1,5,7	Dist. to confluence of Unnamed RB trib. @ RM 4.9
98					3(S,R)	3(S,R)	9.00	20	
102	SF Toppenish Cr.				1(S,R)	3(S,R)	5.10	1,5,7	Dist. to confluence of Unnamed LB trib. @ RM 5.1
99	Panther Cr.				3(S,R)	3(S,R)	5.00	20	
	Simcoe Cr.	37.1289							

GIS #	Stream Name	Stream #	Species: Spring Chinook	Species: Fall Chinook	Species: Summer Steelhead	Species: Coho	Upper Extent (RM)	Source	Comments
110	S. Medicine Cr.				1(S,R)	3(S,R)	10.60	1,5,7	Dist. to headwaters
105	Agency Cr.	37.1295			1(S,R)	3(S,R)	12.30	1,5,7	Dist. to confluence of Unnamed RB trib. @ RM 12.3
103	Wahtum Cr.				1(S,R)	3(S,R)	5.00	20	
104	Yesmowit Cr.				1(S,R)	3(S,R)	3.60	7	Dist. to confluence of Unnamed RB trib. @ RM 3.6
106	SF Simcoe Cr.				1(S,R)		4.00	20	
107					3(S,R)	3(S,R)	10.00	1,5,7	Dist. to confluence of Unnamed LB trib. @ RM 10.0
108	NF Simcoe Cr.				1(S,R)		4.00	20	
109					3(S,R)	3(S,R)	9.30	1,5,7	Dist. to confluence of Unnamed LB trib. @ RM 9.3
8	Marion Drain			1(S,R)	1(S)	1(S,R)	17.80	1,5,6,20,7B	Dist. to confluence w/Harrah Drain. No historic distribution, as channel is artificial
7	Wanity Slough			2(R)	1(S,R)	1(S,R)	14.50	1,5,20,7B	Dist. to Lateral #3. Coho dist. throughout accessible area
9	Harrah Drain			1(S,R)	1(S)		23.10	20	Dist. to BN RR Crossing (town of Harrah). No historic distribution, as channel is artificial
18	Ahtanum Cr.	37.1382	1(R)				8.00	20,25	Dist. to lower WIP Diversion at ~RM 8. Fall chinook use (current or historic) is unknown.
177						1(S,R)	7.60	7B	Dist. to lower end of Bachelor Cr.
15	Bachelor Cr.		3(S,R)		1(S,R)	3(S,R)	14.90	1,3B,5,7A	Dist. throughout historic natural side channel

GIS #	Stream Name	Stream #	Species: Spring Chinook	Species: Fall Chinook	Species: Summer Steelhead	Species: Coho	Upper Extent (RM)	Source	Comments
17	Hatton Cr.		3(S,R)		1(S,R)	3(S,R)	8.80	1,3B,5, 7A	Dist. throughout historic natural side channel
19	SF Ahtanum Cr.		3(S,R)				1.00	5,11,7 A	Dist. to ~RM1
111					1(S,R)	3(S,R)	6.30	1,3B	Dist. to confluence of Unnamed LB trib. @ RM 6.3
112	MF Ahtanum Cr.				1(S,R)	3(S,R)	0.90	1,3B	Dist. to confluence of Unnamed LB trib. @ RM 0.9
20	NF Ahtanum Cr.		3(S,R)				1.00	5,11,7 A	Dist. to ~RM1
229					1(S,R)		14.50	26	
113						3(S,R)	13.10	1,3B	Dist. to McLaine Canyon
115	Nasty Cr.				1(S,R)		3.70	26	
230						3(S,R)	1.60	26	
114	Foundation Cr.				1(S,R)	3(S,R)	0.80		
239	Moxee Drain		2(R?)		1(R)	1(R)	1.9	3G	Distribution to barrier near Birchfield Road based on access and water quantity through the winter. Historic distribution extent unknown.
159	Wide Hollow Cr.	37.1400	1(R)	1(R)			0.25	1,3B	Dist. to impassable Mill Dam
176						1(S,R)	5.8	7C, 3F	Dist. to 64th Street; planted coho juveniles use rearing habitat to 80th St., but adults are not able to pass upstream of 64th St.
116					1(S,R)	3(S,R)	10.40	1,3B,7	Dist. to Dazet Rd.
10	Naches River	38.0003		2(S,R)		1(S,R)	18.00	7B	Dist. to confluence of Tieton R.
NA			1(S,R)		1(S,R)	3(S,R)		1,2,5	Dist. to mouth of Bumping R.
168	Buckskin Slough				1(S,R)	1(S,R)	5.50	7A	Dist. throughout historic side channel of Naches
21	Cowiche Cr.	38.0005	2(R)			1(S,R)	7.30	1,5,7,7	Dist. to confluence of NF and SF

GIS #	Stream Name	Stream #	Species: Spring Chinook	Species: Fall Chinook	Species: Summer Steelhead	Species: Coho	Upper Extent (RM)	Source	Comments
								B	
169	NF Cowiche				3(S,R)	3(S,R)	3.30	20	Dist. upstream to forested area
117	SF Cowiche Cr.	38.0031			1(S,R)	3(S,R)	17.50		Dist. to confluence of Unnamed RB trib @ RM 17.5
118	Reynolds Cr.				1(S,R)	3(S,R)	5.00		
182	S. Naches Channel		1(S,R)		1(S,R)	3(S,R)	4.20	7B	Distribution throughout historic side channel of Naches R.
22	Tieton R.	38.0166	1(S,R)		1(S,R)		21.30	1,2,5	Dist. to Tieton Dam
121	Oak Cr.	38.0169			1(S,R)	3(S,R)	3.20	1,3E	
165	Wildcat Cr.	38.0270	1(S,R)				0.1	1,9	Dist. to SR 12 crossing
120					1(S,R)	3(S,R)	1.70	1,9A	Dist. to1362 Road Culvert @ RM 1.7
23	SF Tieton	38.0374	3(S,R)				12		
119					3(S,R)	3(S,R)	14.00		Dist. to barrier falls @ RM 14.0
24	NF Tieton	38.0291	3(S,R)		3(S,R)	3(S,R)	17.40		Distribution to toe of alluvial fan @RM 17.4
25	Clear Cr.		3(S,R)		3(S,R)	3(S,R)	4.00	3B	Dist. to ~RM 4
26	Indian Cr.		3(S,R)		3(S,R)	3(S,R)	5.10		Dist. to barrier falls @ RM 5.1
27	Rattlesnake Cr.	38.0518	1(S,R)				17.50	3B	Dist. to north end of stream in S 26, T 15N, R 13E; no barrier to migration further upstream
123					1(S,R)	3(S,R)	20.20	1,5,20, 10	Dist. to confluence of L. Wildcat Cr.
28	L. Rattlesnake Cr.	38.0519	1(R)				2.60	1,3B,9 A	
29			2(R)				4.50	1,7,9A	Dist. to confluence with Unnamed RB trib. at RM 4.5
122					1(S,R)	3(S,R)	7.60	1,3C,5, 10	
125	NF Rattlesnake				1(S,R)	3(S,R)	3.00	1,9	Dist. to falls @ RM 3.0

GIS #	Stream Name	Stream #	Species: Spring Chinook	Species: Fall Chinook	Species: Summer Steelhead	Species: Coho	Upper Extent (RM)	Source	Comments
124	Hindoo Cr.	38.0618			1(S,R)	3(S,R)	0.80	1,9	Dist. to falls @ RM 0.8
30	Nile Cr.	38.0692	1(S?,R)				0.40	7	Dist. to road crossing at RM 0.4
31			3(S?,R)				5.80		Dist. to confluence with Orr Cr.
126					1(S,R)	3(S,R)	9.40	1,9	Dist. to falls @ RM 9.4
127	Rock Cr.	38.0754	2(R)		1(S,R)		0.40	1,3B	Dist. to SR 410 Road crossing
33			3(R)		3(S,R)	3(S,R)	1.50	1,3B	Dist. to confluence of forks
34	Lost Cr.	38.0790	2(R)		1(S,R)		0.20	1,9,20	Dist. to road @ RM 0.2
35			3(R)		3(S,R)	3(S,R)	1.00	20	Dist. to gradient break at RM 1.0
166	Gold Cr.		2(R)		1(S,R)		0.15	1,9,20	Dist. to SR 410 Road crossing
36			3(R)		3(S,R)	3(S,R)	0.35	20	Dist. to gradient break @ RM 0.35
237	Milk Creek	38.0828	1(R)		1(R,S?)		0.15	9B	Distribution to fish passage barrier culvert at SR 410
238			3(S?,R)		3(S?,R)	3(S?,R)	2.50	9B	Distribution to fish passage barrier culvert on FR 1707
37	Bumping R.	38.0998	1(S,R)		1(S,R)		15.70	1,5	Dist. to Bumping Dam
38			3(S,R)		3(S,R)	3(S,R)	22.30		Dist. to impassable Falls @ RM 22.3
192	Unnamed RB Trib.		2(S,R)		1(S,R)	3(S,R)	0.25	27	RB trib. ~.2 RM upstream of confluence w/ Fifes Cr. Dist. To estimated 12% gradient.
193	Unnamed RB Trib.		2(S,R)		1(S,R)	3(S,R)	0.05	27	RB trib. ~1 RM upstream of confluence w/ Fifes Cr. Dist. To estimated 12% gradient.
194	Unnamed LB Trib.		2(S,R)		1(S,R)	3(S,R)	0.10	27	LB trib. ~2 RM upstream of confluence w/ Fifes Cr. Dist. To estimated 12% gradient.
195	Unnamed LB Trib.		2(S,R)		1(S,R)	3(S,R)	0.20	27	LB trib. ~.7 RM downstream of Goat Cr. Dist. To estimated 12% gradient.
196	Goat Cr.		2(S,R)		1(S,R)	3(S,R)	0.30	27	Dist. To estimated 12% gradient.
197	Unnamed RB Trib.		2(S,R)		1(S,R)	3(S,R)	0.10	27	RB trib. ~.8 RM upstream of Goat Cr. Dist. To estimated 12% gradient.
198	Scab Cr.		2(S,R)		1(S,R)	3(S,R)	0.10	27	Dist. To estimated 12% gradient.
199	Unnamed LB Trib.		2(S,R)		1(S,R)	3(S,R)	0.15	27	LB trib. ~.5 RM downstream of Scab Cr. Dist. To estimated 12% gradient.

GIS #	Stream Name	Stream #	Species: Spring Chinook	Species: Fall Chinook	Species: Summer Steelhead	Species: Coho	Upper Extent (RM)	Source	Comments
200	Unnamed LB Trib.		2(S,R)		1(S,R)	3(S,R)	0.80	27	LB trib. ~.4 RM downstream of Sunrise Cr. Dist. To estimated 12% gradient.
201	Sunrise Cr.		2(S,R)		1(S,R)	3(S,R)	0.60	27	Dist. To estimated 12% gradient.
202	Unnamed RB Trib.		2(S,R)		1(S,R)	3(S,R)	0.60	27	RB trib. ~.8 RM downstream of Bumping Dam. Dist. To estimated 12% gradient.
203	Unnamed RB Trib.		2(S,R)		1(S,R)	3(S,R)	1.00	27	RB trib. ~.1 RM downstream of Bumping Dam. Dist. To estimated 12% gradient.
39	Deep Cr.		3(S,R)		3(S,R)	3(S,R)	5.20		Dist. to unnamed LB trib @ RM 5.2
40	American R.	38.1000	1(S,R)		1(S,R)		17.00	1,5	Dist. to confluence of Morse Cr.
128					3(S,R)	3(S,R)	22.00		
204	Pinus Cr.		1(S,R)		1(S,R)	3(S,R)	0.20	27	Dist. To estimated 12% gradient.
205	Wash Cr.		1(S,R)		1(S,R)	3(S,R)	0.30	27	Dist. To estimated 12% gradient.
206	Parker Cr.		1(S,R)		1(S,R)	3(S,R)	0.20	27	Dist. To estimated 12% gradient.
207	Unnamed RB trib.		1(S,R)		1(S,R)	3(S,R)	0.30	27	RB trib .2 RM upstream of Parker Cr. Dist. To estimated 12% gradient.
208	Miner Cr.		1(S,R)		1(S,R)	3(S,R)	0.50	27	Dist. To estimated 12% gradient.
209	Unnamed RB trib.		1(S,R)		1(S,R)	3(S,R)	0.20	27	RB trib. .7 RM downstream of Kettle Cr. Dist. To estimated 12% gradient.
210	Unnamed RB trib.		1(S,R)		1(S,R)	3(S,R)	0.40	27	RB trib. .3 RM downstream of Kettle Cr. Dist. To estimated 12% gradient.
211	Kettle Cr.		1(S,R)		1(S,R)	3(S,R)	0.40	27	Dist. To estimated 12% gradient.
212	Survey Cr.		1(S,R)		1(S,R)	3(S,R)	0.20	27	Dist. To estimated 12% gradient.
213	Unnamed LB trib.		1(S,R)		1(S,R)	3(S,R)	0.10	27	LB trib. .9 RM upstream of Survey Cr. Dist. To estimated 12% gradient.
214	Unnamed LB trib.		1(S,R)		1(S,R)	3(S,R)	0.20	27	LB trib. .5 RM downstream of Union Cr. Dist. To estimated 12% gradient.
215	Unnamed RB trib.		1(S,R)		1(S,R)	3(S,R)	1.10	27	RB trib. .8 RM downstream of Union Cr. Dist. To estimated 12% gradient.

GIS #	Stream Name	Stream #	Species: Spring Chinook	Species: Fall Chinook	Species: Summer Steelhead	Species: Coho	Upper Extent (RM)	Source	Comments
216	Unnamed RB trib.		1(S,R)		1(S,R)	3(S,R)	0.30	27	RB trib. 1.0 RM downstream of Timber Cr. Dist. To estimated 12% gradient.
217	Timber Cr.		1(S,R)		1(S,R)	3(S,R)	0.20	27	Dist. To estimated 12% gradient.
218	Unnamed LB trib.		1(S,R)		1(S,R)	3(S,R)	0.30	27	LB trib. .6 RM downstream of Morse Cr. Dist. To estimated 12% gradient.
219	Morse Cr.		1(S,R)		1(S,R)		0.30	3B,3E, 20,27	Dist. To estimated 12% gradient.
220	Morse Cr.		1(S,R)		1(S,R)		0.10	3B,3E, 20,27	Old Morse Creek channel - now side channel to Morse Cr.; dist. to estimated 12% gradient.
130	Morse Cr.				3(S,R)	3(S,R)	3.00	3B,3E, 22	Dist. to RM 3
170	Union Cr.				3(S,R)	3(S,R)	1.00	3B,3E, 20	Dist. to Union Creek Falls
32	Mesatchee Cr.				3(S,R)	3(S,R)	2.00	3B,3E, 21	
129	Rainier Fork				3(S,R)	3(S,R)	2.00	3B,3E, 23	Dist. to RM 2
43	L. Naches R.	38.0852	1(S,R)				13.10	1,5	Dist. to confluence of NF and MF
41	Crow Cr.		1(S?,R)		1(S,R)	3(S,R)	9.80	1,3B,9 A, 20	Dist. to Falls Cr. slide
134	Quartz Cr.				1(S,R)	3(S,R)	3.70	3B,20	
133	Matthew Cr.				1(S,R)	3(S,R)	3.50	3B,20	
42	SF L. Naches		2(R?)				1.80	1,3B,2 0	Dist. to Unnamed RB trib at RM 1.8
131					1(S,R)	3(S,R)	4.00	3B,20	Dist. to impassable falls at ~RM 4.0
44	Bear Cr.		2		1	3(S,R)	0.50	3B,20	
132	MF L. Naches				1(S,R)	3(S,R)	1.70	1,9A	Dist. to falls at RM 2.5
45	NF L. Naches		2(S?,R)				2.30	9A	Dist. to gradient break @ RM 2.3

GIS #	Stream Name	Stream #	Species: Spring Chinook	Species: Fall Chinook	Species: Summer Steelhead	Species: Coho	Upper Extent (RM)	Source	Comments
135					1(S,R)	3(S,R)	6.00	9A,22	Dist. to confluence of Pyramid Cr.
46	Blowout Cr.		2(S?,R)		1(S,R)	3(S,R)	0.60	9A	Distribution to road crossing @ RM 0.6
47	Wenas Cr.	39.0032	3(S,R)		1(R)		1.40	1	Dist. to confluence of Cottonwood Cr @ RM 1.4
136	SF Wenas Cr.				3(S,R)	3(S,R)	3.00	20	
137	NF Wenas Cr.				3(S,R)	3(S,R)	8.00	20	Dist. to impassable falls
228	Roza Cr.		?		3(S,R)	?	2.00	3A, 7A,2A	Potential use based on good beaver pond habitat in lower 2 miles, may extend further upstream; surface water connection with Yakima R. likely only during spring runoff flows or winter storm peak flows
NA	Lmmuma Cr.		?		?	?		3A, 7A,2A	Potential use based on presence of substantial flow in lower portion, particularly during spring when steelhead spawning occurs
48	Umtanum Cr.	39.0553	1(R)			1(S,R)	0.50	2A,7B	Dist. in lower ~0.5 mile
49			3(S,R)		1(S,R)	3(S,R)	7.80	2,3B	Dist. to impassable falls @RM 7.8
50	Manastash Cr.	39.0988			1(S,R)		1.60	1,2,3C	Distribution documented to Brown Road (Pearson) and likely extends upstream to barrier at West Side Canal, although athletic steelhead may be able to pass into the headwaters on high spring flows (Renfrow)
233			1(S,R)				1.40	2A, 3A	Distribution documented to Brown Road (Pearson) and likely extends upstream to Barnes Road, which is typically a barrier at fall flows
171	NF Manastash		3(S,R)		3(S,R)	3(S,R)	10.40	3A	Dist. to USFS boundary; may extend higher into drainage
139	SF Manastash		3(S,R)		3(S,R)	3(S,R)	13.10	3A,20	Dist. to Buck Meadows
226	Wilson Cr.	39.0604	3(S,R)				20		Estimated historic spring chinook distribution to upper edge of valley floor; distribution may have extended higher to a gradient break
191					3(S,R)	3(S,R)	22.20	2A,27	Dist. to est. 12% gradient barrier and presence of viable rainbow presence

GIS #	Stream Name	Stream #	Species: Spring Chinook	Species: Fall Chinook	Species: Summer Steelhead	Species: Coho	Upper Extent (RM)	Source	Comments
78	E. Branch Wilson		1(S,R)		1(S,R)			1,2,7A	Dist. to irrigation diversion barrier
79	W. Branch Wilson		1(S,R)		1(S,R)			1,2,7A	Dist. to irrigation diversion barrier
189	Mercer Cr		1(S,R)		1(S,R)	3(S,R)	1.10	7A	Dist. to irrigation diversion barrier
190	Whiskey Cr.		1(S,R)		1(S,R)	3(S,R)	2.10	7A	Dist. to irrigation diversion barrier
77	Cherry Cr.		1(S,R)		1(S,R)		1.30	7A	Dist. to irrigation diversion barrier
183	Badger Cr.		1(S,R)		1(S,R)		0.70	2,3C,7A	Dist. to irrigation diversion barrier
184			3(S,R)		3(S,R)	3(S,R)	10.50	2A,27	Dist. to est. 12% gradient barrier and presence of viable rainbow presence; lack of natural summer/early-fall flows may have precluded access to fall returning adult salmonids
221	Park Cr.		3(S,R)				11		Estimated historic spring chinook distribution to upper edge of valley floor; distribution may have extended higher to a gradient break; lack of natural summer/early-fall flows may have precluded access to fall returning adult salmonids
185					3(S,R)	3(S,R)	12.20	2A,27	Dist. to est. 12% gradient barrier and extent of viable rainbow presence; lack of natural summer/early-fall flows may have precluded access to fall returning adult salmonids
222	Caribou Cr.		3(S,R)				13.8		Estimated historic spring chinook distribution to upper edge of valley floor; distribution may have extended higher to a gradient break; lack of natural summer/early-fall flows may have precluded access to fall returning adult salmonids
186					3(S,R)	3(S,R)	17.90	2A,27	Dist. to est. 12% gradient barrier and extent of viable rainbow presence; lack of natural summer/early-fall flows may have precluded access to fall returning adult

GIS #	Stream Name	Stream #	Species: Spring Chinook	Species: Fall Chinook	Species: Summer Steelhead	Species: Coho	Upper Extent (RM)	Source	Comments
									salmonids
223	Cooke Cr.		3(S,R)				15.20		Estimated historic spring chinook distribution to upper edge of valley floor; distribution may have extended higher to a gradient break; lack of natural summer/early-fall flows may have precluded access to fall returning adult salmonids
187					3(S,R)	3(S,R)	19.50	2A,27	Dist. to est. 12% gradient barrier and extent of viable rainbow presence; lack of natural summer/early-fall flows may have precluded access to fall returning adult salmonids
80	Naneum Cr.		1(S,R)		1(S,R)		1.90	2,3C,7A	Dist. to irrigation diversion barrier
225			3(S,R)				15.40		Estimated historic spring chinook distribution to upper edge of valley floor; distribution may have extended higher to a gradient break
138					3(S,R)	3(S,R)	24.40	2A,27	Dist. to est. 12% gradient barrier and presence of viable rainbow presence
81	Coleman Cr.		1(S,R)		1(S,R)		0.50	2,3B,3C, 7A	Dist. to irrigation diversion barrier
224			3(S,R)				13.20		Estimated historic spring chinook distribution to upper edge of valley floor; distribution may have extended higher to a gradient break
188					3(S,R)	3(S,R)	16.70	2A,27	Distribution to Coleman Falls
NA	Pearson Cr.		3?		3?	3?		2A	Likely, but unknown, historic presence based on flow and gradient
51	Reecer Cr.	39.0968	1(R)		1(S,R)		0.02	2,3A	Dist. in lower 100 feet of stream

GIS #	Stream Name	Stream #	Species: Spring Chinook	Species: Fall Chinook	Species: Summer Steelhead	Species: Coho	Upper Extent (RM)	Source	Comments
NA	Currier Cr.		3?		3?	3?		2A	Likely, but unknown, historic upstream presence based on flow and gradient
52	Dry Cr.	39.1049	1(R)		1(S,R)		0.60	2,3A	Known/presumed Dist. to McManamee Rd.; to Diversion near BN RR crossing
NA			3?		3?	3?		2A	Likely, but unknown, historic upstream presence based on flow and gradient
53	Taneum Cr.	39.1081	1(S,R)				2.00	1,2	Dist. to Bruton Diversion
54			3(S?,R)				12.70	20,25	Dist. to confluence NF and SF
140	SF Taneum Cr.				1(S,R)	3(S,R)	2.30	20	Dist. to confluence w/Case Knife Cr.
141	NF Taneum Cr.				1(S,R)	3(S,R)	5.70	20	Dist. to Fishhook Flats
227	Swauk Cr.	39.1157	1(R)				8.80	2A	Electroshocking recoveries at Swauk-2 sampling site for Yakima Species Interaction Study; actual distribution likely extends higher in the watershed
157	Williams Cr.				1(S,R)	3(S,R)	2.80	3B	Dist. to Cougar Gulch
158	Iron Cr.				1(S,R)	3(S,R)	2.00	2,3B	
55	Teanaway Cr.	39.1236				1(S,R)	10.90	7B	To confluence of forks
167	Mason Cr.		3(S,R)				0.60	2	Dist. to gradient break at R 0.6
155					1(S,R)	3(S,R)	2.50	3B,13	Dist. to confluence w/Unnamed RB trib @ RM 2.5
178	WF Teanaway		1(R)				2.95	2A	
147					1(S,R)	3(S,R)	8.80	20	Dist. to impassable falls at RM 7.3
56	MF Teanaway	39.1351	1(R)				2.45	2A	
148					1(S,R)	3(S,R)	11.20	1,9	Dist. to confluence w/ Jolly Cr.
57	NF Teanaway	39.1260	1(S,R)				7.70	1,2,9	Dist. to 0.5 mi. upstream of Jungle Cr.
60			2(S,R)				10.40	2A	Dist. to confluence of Beverly Cr.
151					1(S,R)		11.40	1,9	Dist. to 1/2 mi. upstream of confl. with Johnson Cr
152					3(S,R)	3(S,R)	15.30	20	Dist. to confluence with DeRoux Cr.
150	Lick Cr.		3(S?,R)		3(S,R)	3(S,R)	1.50	2A	
172	Middle Cr.		3(S?,R)		1(S,R)	3(S,R)	1.40	2A	

GIS #	Stream Name	Stream #	Species: Spring Chinook	Species: Fall Chinook	Species: Summer Steelhead	Species: Coho	Upper Extent (RM)	Source	Comments
173	Indian Cr.		3(S?,R)		1(S,R)	3(S,R)	2.80	2A	
174	Jack Cr.		3(S?,R)		1(S,R)	3(S,R)	2.10	2A	Potential barrier culvert at FR 9737 crossing
NA	Camp Cr.		3(S?,R)		1(S?,R)	3(S?,R)		2A	Likely presence in lower portion of stream based on similar habitat characteristics to other nearby drainages where presence is known
NA	Jungle Cr.		3(S?,R)		1(S?,R)	3(S?,R)		2A	Likely presence in lower portion of stream based on similar habitat characteristics to other nearby drainages where presence is known
NA	Beverly Cr.		3(S?,R)		1(S?,R)	3(S?,R)		2A	Likely presence in lower portion of stream based on similar habitat characteristics to other nearby drainages where presence is known
NA	Middle Cr.		3(S?,R)		1(S?,R)	3(S?,R)		2A	Likely presence in lower portion of stream based on similar habitat characteristics to other nearby drainages where presence is known
NA	Dickey Cr.		3(S?,R)		1(S?,R)	3(S?,R)		2A	Likely presence in lower portion of stream based on similar habitat characteristics to other nearby drainages where presence is known
NA	Stafford Cr.		3(S?,R)		1(S,R)	3(S,R)		1,9,11	Dist. to confluence of Bear Cr.
154					3(S,R)	3(S,R)	6.00	20	
58	Standup Cr.		3(S,R)				0.50	2A	Dist. in lower 0.5 mile
156					3(S,R)	3(S,R)	2.00	20	
59	Bear Cr.		3(S,R)		1(S,R)		0.50	1,9	Dist. to falls
149					3(S,R)	3(S,R)	2.00	20	
NA	Beverly Cr.		3(S?,R)		1(S?,R)	3(S?,R)		2A	Likely presence in lower portion of stream based on similar habitat characteristics to other nearby drainages where presence is known
NA	DeRoux Cr.		3(S?,R)		1(S?,R)	3(S?,R)		2A	Likely presence in lower portion of stream based on similar habitat characteristics to other nearby drainages where presence is known

GIS #	Stream Name	Stream #	Species: Spring Chinook	Species: Fall Chinook	Species: Summer Steelhead	Species: Coho	Upper Extent (RM)	Source	Comments
NA	Johnson Cr.		3(S?,R)		1(S?,R)	3(S?,R)		2A	Likely presence in lower portion of stream based on similar habitat characteristics to other nearby drainages where presence is known
180	Cle Elum Hatchery Slough					1(S,R)	0.60	7B	Adult returns to coho acclimation release site
61	Tillman Cr.		2(R)		1(S?,R)	3(S,R)	1.30	3A	Dist. to KRD Canal
62	Cle Elum R.	39.1434	1(S,R)		1(S,R)		8.10	1,2,5	Dist. to Cle Elum Dam
63			3(S,R)		3(S,R)	3(S,R)	36.6	20,21	Dist. to Hyas Lake
144	French Cabin Cr.				3(S,R)	3(S,R)	0.50	23	Dist. to gradient break
145	Howson Cr.				3(S,R)	3(S,R)	0.30	23	Dist. to gradient break
146	L. Salmon La Sac				3(S,R)	3(S,R)	0.30	23	Dist. to gradient break
64	Cooper Cr.		3		3(S,R)	3(S,R)	3.20	21	Dist. to gradient break
65	Waptus Cr.		3		3(S,R)	3(S,R)	3.50	20,21	Dist. to gradient barrier upstream of Hour Cr.
66	Peterson Cr.		2(R)		1(S?,R)	3(S,R)	0.6	3A	Dist. to confluence with Fowler Cr.
67	Little Cr.	39.1674	1(R)		1(S?,R)		0.90	3A,3B, 20	Dist. to subdivision
68			3(S?,R)				3.60		Dist. to gradient break at RM 3.6
142					3(S,R)	3(S,R)	5.00		
69	Big Cr.	39.1687	1(R)		1(S?,R)		2.10	3A,3B	Dist. to KRD canal barrier
70			3(S?,R)				4.80	20	
143					3(S,R)	3(S,R)	12.00	20	
71	Tucker Cr.	39.1709	1(S,R)		1(S?,R)		0.90	7	Dist. to KRD siphon barrier
231			3(S,R)		3(S,R)	3(S,R)	2.40	7D	Approximately 1.5 miles of suitable habitat upstream of the KRD siphon barrier
72	Cabin Cr.	39.1798	2(S,R)		1(S?,R)	3(S,R)	3.10	1,2	Dist. to impassable falls at RM 3.1
73	Kachess R.	39.1739	1(S,R)		1(S,R)		1.50	3B	Dist. to Kachess Dam
160					3(S,R)	3(S,R)	13.00	1	Dist. to confluence with Mineral Creek

			Species						
GIS #	**Stream Name**	**Stream #**	**Spring Chinook**	**Fall Chinook**	**Summer Steelhead**	**Coho**	**Upper Extent (RM)**	**Source**	**Comments**
74	Box Canyon Cr.		3(S,R)		3(S,R)	3(S,R)	1.40	20,21	Dist. to impassable falls
76	Gold Cr.		3(S,R)		3(S,R)	3(S,R)	4.00	10,20	

Sources Referenced in Yakima Salmonid Distribution Table (Appendix A)

1 WDFW - Streamnet/WARIS/PHS Database
2 WDFW - Yakima Species Interaction Study
  a- Todd Pearson
3 WDFW Staff:
  a - Brent Renfrow, Area Habitat Biologist
  b - Eric Anderson, Area Fish Biologist
  c - John Easterbrooks, Fish Program Manager
  d - Rick Watson, Area Fish Biologist
  e - Jim Cummins, Area Fish Biologist
  f - Richard Visser
  g - Perry Harvester
  h - Paul LaRiviere
4 WDFW - Salmonid Stock Inventory: Bull Trout/Dolly Varden (1998)
5 NWPPC Sub-Basin Plan (1990)
6 YN - Spawning Ground Survey
7 YN - YKFP Survey
  a- Scott Nicolai
  b-Jim Dunnigan
  c-Mark Johnston
  d-Henry Fraser
8 USFWS Observation
9 USFS Staff:
  a - Scott Hoefer, District Biologist
  b - Karen Lindhorst, District Biologist
10 USFS Watershed Analysis
11 Bryant and Parkhurst, 1950 (USFWS Spec. Sci. Rep. 37)
11 WDFW - Yakima River Wild Trout Survey (J. Johnston, 1980)
12 WDFW - Rattlesnake Creek Survey (1975)
13 Wild Trout Database (Larry Brown, 1986)
14 WDFW - Tony DeLatorre
15 YN - Spring Chinook Enhancement Study (1984)
16 WDFW - Jim Shannon
17 CWU - Paul James, Dept. of Biol. Sciences
18 Gale Bloomstrom
19 WDFW - Paul Mongillo
20 Bruce Watson
21 Yakama Subdivision Report
22 Bill Wasserman
23 Cle Elum Watershed Analysis
24 Bureau of Reclamation Biological Analysis
25 Pat Monk
26 Dominguez, L. 1997. Ahtanum Watershed Analysis
27 Kevin Lautz
28 North Yakima Conservation District

APPENDIX B

Bull Trout Distribution Reference Data

This appendix presents bull trout survey data, on which the bull trout distribution map (Map 6 in the separate Maps file included with this report) was based. The distribution data and map coverages were provided by Dick O'Connor at WDFW. The data in the table are excerpted from the statewide bull trout survey database, were sorted from database by HUC, and may include some records for streams located outside of the Yakima River watershed (WRIAs 37-39).

A summary of bull trout surveys for the period 1984-2000, bull trout surveys in 2000, and a table that indicates the most recent surveys and bull trout detections in the subwatersheds in the Yakima Basin are located in the bull trout discussion in the Stock Distribution and Condition chapter of this report (tables provided by Eric Anderson/Jim Cummins WDFW).

The bull trout distribution metadata components are different from those for the other mapped salmonid species distributions, and are presented differently from the other species in the fish distribution maps. Please contact WDFW to obtain bull trout metadata, if desired.

Bull trout distribution data (courtesy of WDFW and Streamnet)

LLID	BEG MEAS	END MEAS	LENGTH	PRES CODE	KNOWN SPAWN	PIONEER SPAWN	KNOWN REAR	STREAM NAME	HUC	REV DATE	REV_WHO
1192269462537	0	662197.6	662197.6	1	0	0	0	Yakima River	17020011	08-21-00	Eric Andersen,WDFW
1192269462537	662197.6	790539.4	128341.8	1	0	0	0	Yakima River	17020011	08-21-00	Eric Andersen,WDFW
1192269462537	790539.4	828917.2	38377.8	1	0	0	0	Yakima River	17020011	08-21-00	Eric Andersen,WDFW
1192269462537	828917.2	888017.6	59100.4	1	0	0	0	Yakima River	17020011	08-21-00	Eric Andersen,WDFW
1192269462537	888017.6	941084.8	53067.2	1	0	0	0	Yakima River	17020011	08-21-00	Eric Andersen,WDFW
1192269462537	941084.8	991087.1	50002.3	1	0	0	0	Yakima River	17020011	08-21-00	Eric Andersen,WDFW
1192269462537	991087.1	1036213	45125.9	1	0	0	0	Yakima River	17020011	08-21-00	Eric Andersen,WDFW
1192269462537	1036213	1042202	5989	1	0	0	0	Yakima River	17020011	08-21-00	Eric Andersen,WDFW
1192269462537	1042202	1081055	38853	1	0	0	0	Yakima River	17020011	08-21-00	Eric Andersen,WDFW
1192269462537	1081055	1123344	42289	1	0	0	0	Yakima River	17020011	08-21-00	Eric Andersen,WDFW
1192269462537	1123344	1130968	7624	1	1	0	0	Yakima River	17020011	08-21-00	Eric Andersen,WDFW
1192269462537	1130968	1138547	7579	1	0	0	0	Yakima River	17020011	08-21-00	Eric Andersen,WDFW
1192269462537	1138547	1166463	27916	1	0	0	0	Yakima River	17020011	08-21-00	Eric Andersen,WDFW
1192269462537	0	175206.1	175206.1	5	0	0	0	Yakima River	17020011	08-18-00	Eric Andersen, WDFW
1192269462537	175206.1	178167.5	2961.4	1	0	0	0	Yakima River	17020011	08-18-00	Eric Andersen, WDFW
1192269462537	178167.5	250310.8	72143.3	5	0	0	0	Yakima River	17020011	08-18-00	Eric Andersen, WDFW
1192269462537	250310.8	579737.8	329427	3	0	0	0	Yakima River	17020011	08-18-00	Eric Andersen, WDFW
1192269462537	579737.8	630594.1	50856.3	2	0	0	0	Yakima River	17020011	08-18-00	Eric Andersen, WDFW
1194328463776	169994.8	173089.5	3094.7	4	0	0	0	Cold Creek	17020011	08-18-00	Eric Andersen, WDFW
1195384462779	0	16287.1	16287.1	5	0	0	0	Corral Creek	17020011	08-18-00	Eric Andersen, WDFW
1196681458779	7788.46	12365.67	4577.21	5	0	0	0	Glade Creek	17020011	09-06-00	Eric Andersen, WDFW
1196750462324	0	19081.12	19081.12	5	0	0	0	Snipes Creek	17020011	08-18-00	Eric Andersen, WDFW
1196766462331	0	35560.41	35560.41	5	0	0	0	Spring Creek	17020011	08-18-00	Eric Andersen, WDFW
1204591469529	0	27807.69	27807.69	5	0	0	0	Caribou Creek	17030001	08-21-00	Eric Andersen,WDFW
1204693465374	41278.85	53823.63	12544.78	5	0	0	0		17030001	08-18-00	Eric Andersen, WDFW
1204721465289	398.18	91790.14	91391.96	3	0	0	0	Ahtanum Creek	17030001	08-18-00	Eric Andersen, WDFW
1204721465289	91790.14	115769.9	23979.76	1	0	0	0	Ahtanum Creek	17030001	08-18-00	Eric Andersen, WDFW
1204747469396	52228.18	56842.7	4614.52	5	0	0	0	Park Creek	17030001	08-21-00	Eric Andersen,WDFW
1204830468552	565.99	5152.63	4586.64	5	0	0	0	Umtanum Creek	17030001	08-21-00	Eric Andersen,WDFW

LLID	BEG MEAS	END MEAS	LENGTH	PRES CODE	KNOWN SPAWN	PIONEER SPAWN	KNOWN REAR	STREAM NAME	HUC	REV DATE	REV_WHO
1204830468552	10050.45	16162.05	6111.6	5	0	0	0	Umtanum Creek	17030001	08-21-00	Eric Andersen,WDFW
1204830468552	22618.14	25023.51	2405.37	5	0	0	0	Umtanum Creek	17030001	08-21-00	Eric Andersen,WDFW
1204907466951	0	71502.54	71502.54	5	0	0	0	Wenas Creek	17030001	08-21-00	Eric Andersen,WDFW
1204907466951	78086.7	87073.26	8986.56	5	0	0	0	Wenas Creek	17030001	08-21-00	Eric Andersen,WDFW
1204966469272	0	33174.91	33174.91	5	0	0	0		17030001	08-21-00	Eric Andersen,WDFW
1204991469477	0	129033.9	129033.9	6	0	0	0	Coleman Creek	17030001	08-21-00	Eric Andersen,WDFW
1204996469262	0	31499.61	31499.61	5	0	0	0	Wilson Creek	17030001	08-21-00	Eric Andersen,WDFW
1204996469262	31499.61	74865.91	43366.3	5	0	0	0	Wilson Creek	17030001	08-21-00	Eric Andersen,WDFW
1204996469262	74865.91	84526.78	9660.87	5	0	0	0	Wilson Creek	17030001	08-21-00	Eric Andersen,WDFW
1205030469443	2080.68	57084.53	55003.85	5	0	0	0	Naneum Creek	17030001	08-21-00	Eric Andersen,WDFW
1205030469443	57084.53	64053.45	6968.92	5	0	0	0	Naneum Creek	17030001	08-21-00	Eric Andersen,WDFW
1205030469443	64053.45	111992.8	47939.35	5	0	0	0	Naneum Creek	17030001	08-21-00	Eric Andersen,WDFW
1205084469164	5725.64	20484.42	14758.78	5	0	0	0	Cherry Creek	17030001	08-21-00	Eric Andersen,WDFW
1205138466304	0	14371.52	14371.52	1	0	0	0	Naches River	17030001	08-16-00	Eric Andersen, WDFW
1205138466304	14371.52	150023.2	135651.7	1	0	0	0	Naches River	17030001	08-16-00	Eric Andersen, WDFW
1205138466304	150023.2	233171	83147.8	1	0	0	0	Naches River	17030001	08-16-00	Eric Andersen, WDFW
1205138466304	233171	235492.9	2321.9	1	0	0	0	Naches River	17030001	08-16-00	Eric Andersen, WDFW
1205291465639	66956.68	70126.86	3170.18	3	0	0	0		17030001	08-18-00	Eric Andersen, WDFW
1205393478272	0	8613.33	8613.33	1	0	0	0	Cougar Creek	17030001	06-05-01	Eric Andersen, WDFW
1205793469945	0	44517.05	44517.05	3	0	0	0	Manastash Creek	17030001	08-21-00	Eric Andersen,WDFW
1205793469955	0	66220.67	66220.67	5	0	0	0	Reecer Creek	17030001	08-21-00	Eric Andersen,WDFW
1205940473269	0	5474.6	5474.6	3	0	0	0		17030001	08-21-00	Eric Andersen,WDFW
1206033473306	0	144.96	144.96	5	0	0	0		17030001	08-21-00	Eric Andersen,WDFW
1206808466469	0	98574.3	98574.3	3	0	0	0	NF Cowiche Creek	17030001	08-16-00	Eric Andersen, WDFW
1206808466479	0	90000.77	90000.77	3	0	0	0	SF Cowiche Creek	17030001	08-16-00	Eric Andersen, WDFW
1206892473189	0	2230.3	2230.3	5	0	0	0	West Fork Creek	17030001	08-21-00	Eric Andersen,WDFW
1206925473321	0	2111.87	2111.87	3	0	0	0	Iron Creek	17030001	08-21-00	Eric Andersen,WDFW
1206925473321	2111.87	5282.88	3171.01	5	0	0	0	Iron Creek	17030001	08-21-00	Eric Andersen,WDFW
1206925473321	5282.88	9644.96	4362.08	3	0	0	0	Iron Creek	17030001	08-21-00	Eric Andersen,WDFW
1206925473321	9644.96	12710.07	3065.11	5	0	0	0	Iron Creek	17030001	08-21-00	Eric Andersen,WDFW
1206938472455	0	5945.75	5945.75	4	0	0	0	Mill Creek	17030001	08-21-00	Eric Andersen,WDFW

LLID	BEG MEAS	END MEAS	LENGTH	PRES CODE	KNOWN SPAWN	PIONEER SPAWN	KNOWN REAR	STREAM NAME	HUC	REV DATE	REV_WHO
1206954472430	0	1413.43	1413.43	3	0	0	0	Williams Creek	17030001	08-21-00	Eric Andersen,WDFW
1206954472430	1413.43	4892.5	3479.07	5	0	0	0	Williams Creek	17030001	08-21-00	Eric Andersen,WDFW
1206954472430	4892.5	18154.7	13262.2	5	0	0	0	Williams Creek	17030001	08-21-00	Eric Andersen,WDFW
1206954472430	18154.7	20521	2366.3	3	0	0	0	Williams Creek	17030001	08-21-00	Eric Andersen,WDFW
1206954472430	20521	22599.79	2078.79	5	0	0	0	Williams Creek	17030001	08-21-00	Eric Andersen,WDFW
1206960472615	0	813.81	813.81	3	0	0	0	Baker Creek	17030001	08-21-00	Eric Andersen,WDFW
1207081470923	0	31988.92	31988.92	3	0	0	0	Taneum Creek	17030001	08-21-00	Eric Andersen,WDFW
1207081470923	31988.92	40430.02	8441.1	5	0	0	0	Taneum Creek	17030001	08-21-00	Eric Andersen,WDFW
1207081470923	40430.02	66870.3	26440.28	3	0	0	0	Taneum Creek	17030001	08-21-00	Eric Andersen,WDFW
1207350469665	0	27294.18	27294.18	3	0	0	0	SF Manastash Creek	17030001	08-21-00	Eric Andersen,WDFW
1207350469665	27294.18	39157.61	11863.43	5	0	0	0	SF Manastash Creek	17030002	08-21-00	Eric Andersen,WDFW
1207350469665	39157.61	60087.59	20929.98	3	0	0	0	SF Manastash Creek	17030002	08-21-00	Eric Andersen,WDFW
1207350469665	60087.59	72919	12831.41	5	0	0	0	SF Manastash Creek	17030002	08-21-00	Eric Andersen,WDFW
1207350469665	72919	99947.77	27028.77	3	0	0	0	SF Manastash Creek	17030002	08-21-00	Eric Andersen,WDFW
1207370471233	0	4660.71	4660.71	1	0	0	0	Swauk Creek	17030002	08-21-00	Eric Andersen,WDFW
1207370471233	4660.71	16278.11	11617.4	3	0	0	0	Swauk Creek	17030002	08-21-00	Eric Andersen,WDFW
1207370471233	16278.11	21420.71	5142.6	3	0	0	0	Swauk Creek	17030002	08-21-00	Eric Andersen,WDFW
1207370471233	21420.71	24897.08	3476.37	5	0	0	0	Swauk Creek	17030002	08-21-00	Eric Andersen,WDFW
1207370471233	24897.08	34118.66	9221.58	3	0	0	0	Swauk Creek	17030002	08-21-00	Eric Andersen,WDFW
1207370471233	34118.66	37073.88	2955.22	5	0	0	0	Swauk Creek	17030002	08-21-00	Eric Andersen,WDFW
1207370471233	37073.88	41545.55	4471.67	3	0	0	0	Swauk Creek	17030002	08-21-00	Eric Andersen,WDFW
1207370471233	41545.55	45547.46	4001.91	5	0	0	0	Swauk Creek	17030002	08-21-00	Eric Andersen,WDFW
1207370471233	45547.46	74065.13	28517.67	5	0	0	0	Swauk Creek	17030002	08-21-00	Eric Andersen,WDFW
1207370471233	74065.13	79844.72	5779.59	3	0	0	0	Swauk Creek	17030002	08-21-00	Eric Andersen,WDFW
1207370471233	79844.72	89094.52	9249.8	3	0	0	0	Swauk Creek	17030002	08-21-00	Eric Andersen,WDFW
1207370471233	89094.52	90758.55	1664.03	5	0	0	0	Swauk Creek	17030002	08-21-00	Eric Andersen,WDFW
1207370471233	90758.55	101655.4	10896.85	3	0	0	0	Swauk Creek	17030002	08-21-00	Eric Andersen,WDFW
1207370471233	101655.4	106906.7	5251.3	5	0	0	0	Swauk Creek	17030002	08-21-00	Eric Andersen,WDFW
1207681468637	0	15203.42	15203.42	5	0	0	0	NF Wenas Creek	17030002	08-21-00	Eric Andersen,WDFW
1207857467464	0	108659	108659	1	0	0	0	Teiton River	17030002	08-16-00	Eric Andersen, WDFW
1207857467464	108659	121723.5	13064.5	1	0	0	0	Teiton River	17030002	08-16-00	Eric Andersen, WDFW

LLID	BEG MEAS	END MEAS	LENGTH	PRES CODE	KNOWN SPAWN	PIONEER SPAWN	KNOWN REAR	STREAM NAME	HUC	REV DATE	REV_WHO
1207857467464	121723.5	126622	4898.5	1	0	0	0	Teiton River	17030002	08-16-00	Eric Andersen, WDFW
1207939468845	8367.83	13581.99	5214.16	5	0	0	0	Dipping Vat Canyon	17030002	08-21-00	Eric Andersen,WDFW
1208014473653	0	3833.32	3833.32	3	0	0	0	Bear Creek	17030002	03-26-01	Eric Andersen,WDFW
1208121467235	0	16855.14	16855.14	1	0	0	0	Oak Creek	17030002	08-16-00	Eric Andersen, WDFW
1208121467235	16855.14	44252.05	27396.91	5	0	0	0	Oak Creek	17030002	08-16-00	Eric Andersen, WDFW
1208336471670	0	57936.61	57936.61	1	0	0	0	Teanaway River	17030002	08-21-00	Eric Andersen,WDFW
1208336471670	57936.61	63703.13	5766.52	3	0	0	0	Teanaway River	17030002	08-21-00	Eric Andersen,WDFW
1208336473546	0	14409.42	14409.42	3	0	0	0	Standup Creek	17030002	03-26-01	Eric Andersen,WDFW
1208479473474	0	25164.81	25164.81	3	0	0	0	Stafford Creek	17030002	03-26-01	Eric Andersen,WDFW
1208534465232	0	10499.45	10499.45	1	0	0	0	NF Ahtanum Creek	17030002	08-18-00	Eric Andersen, WDFW
1208534465232	10499.45	48928.07	38428.62	1	0	0	0	NF Ahtanum Creek	17030002	08-18-00	Eric Andersen, WDFW
1208534465232	48928.07	55673.89	6745.82	1	0	0	0	NF Ahtanum Creek	17030002	08-18-00	Eric Andersen, WDFW
1208534465232	55673.89	64259.22	8585.33	1	0	0	1	NF Ahtanum Creek	17030002	08-18-00	Eric Andersen, WDFW
1208534465232	64259.22	94461.11	30201.89	1	1	0	1	NF Ahtanum Creek	17030002	08-18-00	Eric Andersen, WDFW
1208534465232	94461.11	102850.8	8389.69	1	0	0	1	NF Ahtanum Creek	17030002	08-18-00	Eric Andersen, WDFW
1208534465242	0	45637.75	45637.75	1	0	0	0	SF Ahtanum Creek	17030002	08-18-00	Eric Andersen, WDFW
1208534465242	45637.75	53338.64	7700.89	1	0	0	1	SF Ahtanum Creek	17030002	08-18-00	Eric Andersen, WDFW
1208534465242	53338.64	69837.48	16498.84	1	1	0	1	SF Ahtanum Creek	17030002	08-18-00	Eric Andersen, WDFW
1208547473188	0	4185.83	4185.83	1	0	0	0	Jack Creek	17030002	08-21-00	Eric Andersen,WDFW
1208547473188	4185.83	10991.39	6805.56	3	0	0	0	Jack Creek	17030002	03-26-01	Eric Andersen,WDFW
1208551473329	0	11432.84	11432.84	1	0	0	0	Jungle Creek	17030002	08-21-00	Eric Andersen,WDFW
1208554472950	0	9573.31	9573.31	3	0	0	0	Middle Creek	17030002	03-26-01	Eric Andersen,WDFW
1208578472984	0	13310.09	13310.09	3	0	0	0	Indian Creek	17030002	03-26-01	Eric Andersen,WDFW
1208763473720	0	18505.43	18505.43	3	0	0	0	Beverly Creek	17030002	03-26-01	Eric Andersen,WDFW
1208768472513	0	82959.94	82959.94	1	0	0	1	NF Teanaway River	17030002	08-21-00	Eric Andersen,WDFW
1208814466193	0	30861.58	30861.58	3	0	0	0	Reynolds Creek	17030002	08-16-00	Eric Andersen, WDFW
1208824466827	0	14087.89	14087.89	3	0	0	0	Weddle Canyon	17030002	08-16-00	Eric Andersen, WDFW
1208968472571	0	1646.45	1646.45	4	0	0	0	MF Teanaway River	17030002	08-21-00	Eric Andersen,WDFW
1208968472571	1646.45	11743.23	10096.78	3	0	0	0	MF Teanaway River	17030002	08-21-00	Eric Andersen,WDFW
1208968472571	11743.23	13505.07	1761.84	4	0	0	0	MF Teanaway River	17030002	08-21-00	Eric Andersen,WDFW
1208968472571	13505.07	22655.4	9150.33	3	0	0	0	MF Teanaway River	17030002	08-21-00	Eric Andersen,WDFW

LLID	BEG MEAS	END MEAS	LENGTH	PRES CODE	KNOWN SPAWN	PIONEER SPAWN	KNOWN REAR	STREAM NAME	HUC	REV DATE	REV_WHO
1208968472571	24810.71	27140.48	2329.77	4	0	0	0	MF Teanaway River	17030002	08-21-00	Eric Andersen,WDFW
1208968472571	27140.48	66750.86	39610.38	3	0	0	0	MF Teanaway River	17030002	08-21-00	Eric Andersen,WDFW
1208968472581	0	1789.29	1789.29	4	0	0	0	WF Teanaway River	17030002	08-21-00	Eric Andersen,WDFW
1208968472581	1789.29	10151.73	8362.44	3	0	0	0	WF Teanaway River	17030002	08-21-00	Eric Andersen,WDFW
1208968472581	10151.73	13168.51	3016.78	4	0	0	0	WF Teanaway River	17030002	08-21-00	Eric Andersen,WDFW
1208968472581	13168.51	31493.92	18325.41	3	0	0	0	WF Teanaway River	17030002	08-21-00	Eric Andersen,WDFW
1208968472581	31493.92	38825.26	7331.34	5	0	0	0	WF Teanaway River	17030002	08-21-00	Eric Andersen,WDFW
1208968472581	38825.26	73362.59	34537.33	3	0	0	0	WF Teanaway River	17030002	08-21-00	Eric Andersen,WDFW
1209222467350	0	17828.11	17828.11	5	0	0	0	NF Oak Creek	17030002	08-16-00	Eric Andersen, WDFW
1209291468203	0	111987.9	111987.9	1	1	0	1	Rattlesnake Creek	17030002	08-16-00	Eric Andersen, WDFW
1209321471120	0	39754.45	39754.45	3	0	0	0	NF Taneum Creek	17030002	08-21-00	Eric Andersen,WDFW
1209321471120	39754.45	42627.28	2872.83	5	0	0	0	NF Taneum Creek	17030002	08-21-00	Eric Andersen,WDFW
1209321471120	42627.28	47541.82	4914.54	3	0	0	0	NF Taneum Creek	17030002	08-21-00	Eric Andersen,WDFW
1209321471120	47541.82	50538.3	2996.48	5	0	0	0	NF Taneum Creek	17030002	08-21-00	Eric Andersen,WDFW
1209321471120	50538.3	55054.49	4516.19	3	0	0	0	NF Taneum Creek	17030002	08-21-00	Eric Andersen,WDFW
1209321471130	0	20944.57	20944.57	3	0	0	0	SF Taneum Creek	17030002	08-21-00	Eric Andersen,WDFW
1209321471130	20944.57	26322.58	5378.01	5	0	0	0	SF Taneum Creek	17030002	08-21-00	Eric Andersen,WDFW
1209321471130	26322.58	39604.82	13282.24	3	0	0	0	SF Taneum Creek	17030002	08-21-00	Eric Andersen,WDFW
1209353467292	0	14640.77	14640.77	5	0	0	0	SF Oak Creek	17030002	08-16-00	Eric Andersen, WDFW
1209389468300	0	16057.44	16057.44	5	0	0	0	Nile Creek	17030002	08-16-00	Eric Andersen, WDFW
1209389468300	16057.44	22611.53	6554.09	2	0	0	0	Nile Creek	17030002	08-16-00	Eric Andersen, WDFW
1209389468300	22611.53	30684.3	8072.77	5	0	0	0	Nile Creek	17030003	08-16-00	Eric Andersen, WDFW
1209389468300	30684.3	37114.29	6429.99	2	0	0	0	Nile Creek	17030003	08-16-00	Eric Andersen, WDFW
1209398474206	0	2531.81	2531.81	1	0	0	0		17030003	08-21-00	Eric Andersen,WDFW
1209400474192	0	2057.27	2057.27	1	1	0	1	DeRoux Creek	17030003	08-21-00	Eric Andersen,WDFW
1209479468144	0	106.67	106.67	1	0	0	0	Little Rattlesnake Creek	17030003	08-16-00	Eric Andersen, WDFW
1209479468144	106.67	23131.91	23025.24	5	0	0	0	Little Rattlesnake Creek	17030003	08-16-00	Eric Andersen, WDFW
1209901471771	0	42800.81	42800.81	2	0	0	0	Cle Elum River	17030003	08-21-00	Eric Andersen,WDFW
1209901471771	42800.81	83606.37	40805.56	1	0	0	0	Cle Elum River	17030003	08-21-00	Eric Andersen,WDFW

LLID	BEG MEAS	END MEAS	LENGTH	PRES CODE	KNOWN SPAWN	PIONEER SPAWN	KNOWN REAR	STREAM NAME	HUC	REV DATE	REV_WHO
1209901471771	83606.37	100900	17293.63	1	0	0	0	Cle Elum River	17030003	08-21-00	Eric Andersen,WDFW
1209901471771	103382.5	105789.9	2407.4	4	0	0	0	Cle Elum River	17030003	08-21-00	Eric Andersen,WDFW
1209901471771	108932.5	110280	1347.5	4	0	0	0	Cle Elum River	17030003	08-21-00	Eric Andersen,WDFW
1209901471771	110280	116812.3	6532.3	2	0	0	0	Cle Elum River	17030003	08-21-00	Eric Andersen,WDFW
1209901471771	116812.3	121124	4311.7	1	0	0	0	Cle Elum River	17030003	08-21-00	Eric Andersen,WDFW
1209901471771	121124	173139.5	52015.5	1	0	0	0	Cle Elum River	17030003	03-26-01	Eric Andersen,WDFW
1209901471771	173139.5	178478.1	5338.6	1	1	0	0	Cle Elum River	17030003	03-26-01	Eric Andersen,WDFW
1209901471771	178478.1	196344.1	17866	2	0	0	0	Cle Elum River	17030003	08-21-00	Eric Andersen,WDFW
1209968465319	0	11404.36	11404.36	3	0	0	0	Foundation Creek	17030003	08-18-00	Eric Andersen, WDFW
1210097468504	0	11966.6	11966.6	2	0	0	0	NF Nile Creek	17030003	08-16-00	Eric Andersen, WDFW
1210141465182	0	4616.32	4616.32	1	1	0	1	MF Ahtanum Creek	17030003	08-18-00	Eric Andersen, WDFW
1210141465182	4616.32	28601.66	23985.34	1	0	0	1	MF Ahtanum Creek	17030003	08-18-00	Eric Andersen, WDFW
1210141465182	28601.66	35774.1	7172.44	1	1	0	1	MF Ahtanum Creek	17030003	08-18-00	Eric Andersen, WDFW
1210232470880	0	6274.64	6274.64	3	0	0	0		17060103	08-21-00	Eric Andersen,WDFW
1210330464663	0	19054.27	19054.27	3	0	0	0	Reservation Creek	17060103	08-18-00	Eric Andersen, WDFW
1210383468581	0	18053.99	18053.99	2	0	0	0	Orr Creek	17060103	08-16-00	Eric Andersen, WDFW
1210401465313	0	22849.96	22849.96	3	0	0	0	NF Foundation Creek	17060103	08-18-00	Eric Andersen, WDFW
1210401465323	0	13071.74	13071.74	3	0	0	0	SF Foundation Creek	17060103	08-18-00	Eric Andersen, WDFW
1210459474775	0	11718.12	11718.12	1	0	0	0	Fortune Creek	17060103	03-26-01	Eric Andersen,WDFW
1210567472344	0	167.12	167.12	2	0	0	0	Domerie Creek	17060103	08-21-00	Eric Andersen,WDFW
1210567472344	167.12	5627.1	5459.98	5	0	0	0	Domerie Creek	17060103	08-21-00	Eric Andersen,WDFW
1210667468101	0	31328.4	31328.4	3	0	0	0	NF Rattlesnake Creek	17060106	08-16-00	Eric Andersen, WDFW
1210761472100	0	8195.14	8195.14	5	0	0	0	Little Creek	17060106	08-21-00	Eric Andersen,WDFW
1210761472100	41700.93	48054.39	6353.46	5	0	0	0	Little Creek	17060106	08-21-00	Eric Andersen,WDFW
1210863474194	0	40796.51	40796.51	2	0	0	0	Waptus River	17060106	08-21-00	Eric Andersen,WDFW
1210863474194	40796.51	50265.73	9469.22	1	0	0	0	Waptus River	17060106	08-21-00	Eric Andersen,WDFW
1210863474194	50265.73	63139.49	12873.76	2	0	0	0	Waptus River	17060106	08-21-00	Eric Andersen,WDFW
1210863474194	63139.49	67790.8	4651.31	5	0	0	0	Waptus River	17060106	08-21-00	Eric Andersen,WDFW
1210935469888	0	108468	108468	1	0	0	0	Bumping River	17060106	08-16-00	Eric Andersen, WDFW
1210935469898	0	119.01	119.01	1	0	0	0	Little Naches River	17060106	08-16-00	Eric Andersen, WDFW
1210935469898	119.01	16515.72	16396.71	1	0	0	0	Little Naches River	17060106	08-16-00	Eric Andersen, WDFW

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1210935469898	16515.72	34556.05	18040.33	2	0	0	0	Little Naches River	17060106	08-16-00	Eric Andersen, WDFW
1210935469898	34556.05	69220.78	34664.73	2	0	0	0	Little Naches River	17060106	08-16-00	Eric Andersen, WDFW
1210946469837	0	4492.49	4492.49	1	0	0	0	Milk Creek	17060107	08-16-00	Eric Andersen, WDFW
1210946469837	4492.49	20112.49	15620	2	0	0	0	Milk Creek	17060107	08-16-00	Eric Andersen, WDFW
1210966472175	0	24581.21	24581.21	3	0	0	0	Big Creek	17060107	08-21-00	Eric Andersen,WDFW
1210976471171	0	1341.82	1341.82	3	0	0	0	Lookout Creek	17060107	08-21-00	Eric Andersen,WDFW
1210976471171	1341.82	3039.66	1697.84	5	0	0	0	Lookout Creek	17060107	08-21-00	Eric Andersen,WDFW
1210983473905	0	47692.9	47692.9	3	0	0	0	Cooper River	17060107	08-21-00	Eric Andersen,WDFW
1211037471086	0	3844.02	3844.02	3	0	0	0		17060107	08-21-00	Eric Andersen,WDFW
1211120473489	573.24	4270.08	3696.84	5	0	0	0	French Cabin Creek	17060107	08-21-00	Eric Andersen,WDFW
1211220466649	0	3236.35	3236.35	2	0	0	0	Wildcat Creek	17060107	08-16-00	Eric Andersen, WDFW
1211220466649	3236.35	9351.71	6115.36	5	0	0	0	Wildcat Creek	17060107	08-16-00	Eric Andersen, WDFW
1211220466649	9351.71	32569.7	23217.99	2	0	0	0	Wildcat Creek	17060107	08-16-00	Eric Andersen, WDFW
1211330470152	0	23859.17	23859.17	1	0	0	1	Crow Creek	17060107	08-16-00	Eric Andersen, WDFW
1211330470152	23859.17	47562.2	23703.03	1	1	0	1	Crow Creek	17060107	08-16-00	Eric Andersen, WDFW
1211339470167	0	2844.64	2844.64	1	0	0	0	Quartz Creek	17060107	08-16-00	Eric Andersen, WDFW
1211339470167	2844.64	15402.3	12557.66	2	0	0	0	Quartz Creek	17060107	08-16-00	Eric Andersen, WDFW
1211430466725	0	17144.54	17144.54	2	0	0	0	Thunder Creek	17060107	08-16-00	Eric Andersen, WDFW
1211490466169	0	2081.79	2081.79	1	0	0	1	Short And Dirty Creek	17060110	08-16-00	Eric Andersen, WDFW
1211490466169	9849.79	18660.65	8810.86	5	0	0	0	Short And Dirty Creek	17070101	08-16-00	Eric Andersen, WDFW
1211509466120	2397.64	16024.85	13627.21	5	0	0	0	EF Short And Dirty	17070101	08-16-00	Eric Andersen, WDFW
1211528466383	0	8882.14	8882.14	1	0	0	0	SF Tieton River	17070102	08-16-00	Eric Andersen, WDFW
1211528466383	8882.14	38851.32	29969.18	1	0	0	1	SF Tieton River	17070102	08-16-00	Eric Andersen, WDFW
1211528466383	38851.32	74019.63	35168.31	1	1	0	1	SF Tieton River	17070102	08-16-00	Eric Andersen, WDFW
1211547474938	1164.9	4529.4	3364.5	5	0	0	0	Spinola Creek	17070102	08-21-00	Eric Andersen,WDFW
1211569469758	0	53299.97	53299.97	1	0	0	0	American River	17070102	08-16-00	Eric Andersen, WDFW
1211569469758	53299.97	62714.89	9414.92	1	1	0	1	American River	17070102	08-16-00	Eric Andersen, WDFW
1211569469758	62714.89	75068.39	12353.5	1	0	0	1	American River	17070102	08-16-00	Eric Andersen, WDFW
1211569469758	75068.39	88404.56	13336.17	1	1	0	1	American River	17070102	08-16-00	Eric Andersen, WDFW
1211577465308	0	5228.76	5228.76	1	1	0	1	Shellneck Creek	17070102	08-18-00	Eric Andersen, WDFW
1211629467850	0	121.93	121.93	1	0	0	0	Hindoo Creek	17070102	08-16-00	Eric Andersen, WDFW

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1211629467850	121.93	5789.53	5667.6	1	0	0	1	Hindoo Creek	17070102	08-16-00	Eric Andersen, WDFW
1211675467868	0	3659.56	3659.56	1	1	0	1	Dog Creek	17070102	08-16-00	Eric Andersen, WDFW
1211714466430	0	19265.64	19265.64	1	0	0	0	NF Tieton River	17070102	08-16-00	Eric Andersen, WDFW
1211714466430	19265.64	43314.28	24048.64	2	0	0	0	NF Tieton River	17070102	08-16-00	Eric Andersen, WDFW
1211714466430	43314.28	47991.71	4677.43	2	0	0	0	NF Tieton River	17070102	08-16-00	Eric Andersen, WDFW
1211714466430	47991.71	61271.63	13279.92	2	0	0	0	NF Tieton River	17070102	08-16-00	Eric Andersen, WDFW
1211714466430	61271.63	64043.17	2771.54	2	0	0	0	NF Tieton River	17070102	08-16-00	Eric Andersen, WDFW
1211714466430	64043.17	68287.61	4244.44	1	0	0	0	NF Tieton River	17070102	08-16-00	Eric Andersen, WDFW
1211714466430	68287.61	96052.3	27764.69	2	0	0	0	NF Tieton River	17070102	08-16-00	Eric Andersen, WDFW
1211816470449	0	10212.11	10212.11	2	0	0	0	Pileup Creek	17070102	08-16-00	Eric Andersen, WDFW
1211984475153	9471.07	12980	3508.93	5	0	0	0	Spade Creek	17070102	08-21-00	Eric Andersen,WDFW
1211984475153	15074.06	17272.83	2198.77	5	0	0	0	Spade Creek	17070102	08-21-00	Eric Andersen,WDFW
1212002472513	0	8743.18	8743.18	2	0	0	0	Kachess River	17070102	08-21-00	Eric Andersen,WDFW
1212002472513	8743.18	59796.64	51053.46	1	0	0	0	Kachess River	17070102	08-21-00	Eric Andersen,WDFW
1212002472513	59796.64	62644.22	2847.58	1	1	0	0	Kachess River	17070102	08-21-00	Eric Andersen,WDFW
1212002472513	62644.22	74811.17	12166.95	1	1	0	1	Kachess River	17070102	08-21-00	Eric Andersen,WDFW
1212133474564	0	17112.42	17112.42	3	0	0	0	Lemah Creek	17070102	08-21-00	Eric Andersen,WDFW
1212161475217	0	3187.46	3187.46	2	0	0	0	Shovel Creek	17070102	08-21-00	Eric Andersen,WDFW
1212161475217	6775.41	8281.78	1506.37	5	0	0	0	Shovel Creek	17070102	08-21-00	Eric Andersen,WDFW
1212161475217	15134.76	15544.35	409.59	5	0	0	0	Shovel Creek	17070102	08-21-00	Eric Andersen,WDFW
1212161475217	17125.34	18884.17	1758.83	5	0	0	0	Shovel Creek	17070102	08-21-00	Eric Andersen,WDFW
1212182465906	0	3220.34	3220.34	1	1	0	1	Spruce Creek	17070102	08-16-00	Eric Andersen, WDFW
1212220465915	0	1652.82	1652.82	1	1	0	1	Grey Creek	17070102	08-16-00	Eric Andersen, WDFW
1212253470660	0	18748.94	18748.94	2	0	0	0	SF Little Naches River	17070102	08-16-00	Eric Andersen, WDFW
1212253470660	18748.94	32627.68	13878.74	5	0	0	0	SF Little Naches River	17070102	08-16-00	Eric Andersen, WDFW
1212262472481	1095.72	25965.04	24869.32	3	0	0	0	Cabin Creek	17070102	08-21-00	Eric Andersen,WDFW
1212262472481	40979.05	44551.2	3572.15	5	0	0	0	Cabin Creek	17070102	08-21-00	Eric Andersen,WDFW
1212345467314	0	6506	6506	1	1	0	1	Little Wildcat Creek	17070105	08-16-00	Eric Andersen, WDFW
1212378473609	0	1254.08	1254.08	1	0	0	0	Box Canyon Creek	17070105	08-21-00	Eric Andersen,WDFW
1212378473609	1254.08	5462.23	4208.15	1	1	0	1	Box Canyon Creek	17070105	08-21-00	Eric Andersen,WDFW
1212397474197	0	5563.81	5563.81	1	0	0	1	Mineral Creek	17070105	08-21-00	Eric Andersen,WDFW

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1212410470734	0	10538.64	10538.64	2	0	0	0	Bear Creek	17070105	08-16-00	Eric Andersen, WDFW
1212419470803	0	10095.22	10095.22	2	0	0	0	West Fork Bear Creek	17070105	08-16-00	Eric Andersen, WDFW
1212453473445	1785.72	4441.17	2655.45	5	0	0	0	Thetis Creek	17070105	08-21-00	Eric Andersen,WDFW
1212474466391	0	27862.86	27862.86	1	1	0	1	Indian Creek	17070105	08-16-00	Eric Andersen, WDFW
1212477465615	0	3540.57	3540.57	1	1	0	1	Corral Creek	17070105	08-16-00	Eric Andersen, WDFW
1212520474767	0	12748.76	12748.76	3	0	0	0		17070105	08-21-00	Eric Andersen,WDFW
1212594465385	0	5997.08	5997.08	1	1	0	1	Bear Creek	17070105	08-16-00	Eric Andersen, WDFW
1212594465385	5997.08	16551.88	10554.8	5	0	0	0	Bear Creek	17070105	08-16-00	Eric Andersen, WDFW
1212782466282	0	21359.48	21359.48	5	0	0	0	Clear Creek	17070106	08-16-00	Eric Andersen, WDFW
1212803470890	0	25027.99	25027.99	2	0	0	0	MF Little Naches Rive	17070106	08-16-00	Eric Andersen, WDFW
1212803470900	0	32360.67	32360.67	2	0	0	0	NF Little Naches River	17070106	08-16-00	Eric Andersen, WDFW

APPENDIX C

SALMONID HABITAT CONDITION RATING STANDARDS FOR IDENTIFYING LIMITING FACTORS

Under the Salmon Recovery Act (passed by the legislature as House Bill 2496, and later revised by Senate Bill 5595), the Washington Conservation Commission (WCC) is charged with identifying the habitat factors limiting the production of salmonids throughout most of the state. This information should guide lead entity groups and the Salmon Recovery Funding Board in prioritizing salmonid habitat restoration and protection projects seeking state and federal funds. Identifying habitat limiting factors requires a set of standards that can be used to compare the significance of different factors and consistently evaluate habitat conditions in each WRIA throughout the state.

In order to develop a set of standards to rate salmonid habitat conditions, several tribal, state, and federal documents that use some type of habitat rating system (Table 1) were reviewed. The goal was to identify appropriate rating standards for as many types of habitat limiting factors as possible, with an emphasis on those that could be applied to readily available data. Based on the review, it was decided to rate habitat conditions into three categories: Good, Fair, and Poor. For habitat factors that had wide agreement on how to rate habitat condition, the accepted standard was adopted by the WCC. For factors that had a range of standards, one or more of them were adopted. Where no standard could be found, a default rating standard was developed, with the expectation that it will be modified or replaced as better data become available.

Table 1 - Source documents

Code	Document	Organization
Hood Canal	Hood Canal/Eastern Strait of Juan de Fuca Summer Chum Habitat Recovery Plan, Final Draft (1999)	Point No Point Treaty Council, Skokomish Tribe, Port Gamble S'Klallam Tribe, Jamestown S'Klallam Tribe, and Washington Department of Fish and Wildlife
ManTech	An Ecosystem Approach to Salmonid Conservation, vol. 1 (1995)	ManTech Environmental Research Services for the National Marine Fisheries Service, the US Environmental Protection Agency, and the US Fish and Wildlife Service
NMFS	Coastal Salmon Conservation: Working Guidance for Comprehensive Salmon Restoration Initiatives on the Pacific Coast (1996)	National Marine Fisheries Service
PHS	Priority Habitat Management Recommendations: Riparian (1995)	Washington Department of Fish and Wildlife
Skagit	Skagit Watershed Council Habitat Protection and Restoration Strategy (1998)	Skagit Watershed Council
WSA	Watershed Analysis Manual, v4.0 (1997)	Washington Forest Practices Board
WSP	Wild Salmonid Policy (1997)	Washington Department of Fish and Wildlife

The ratings adopted by the WCC are presented in Table 2. These ratings are not intended to be used as thresholds for regulatory purposes, but as a coarse screen to identify the most significant habitat limiting factors in a WRIA. They also will hopefully provide a level of consistency between WRIAs that allows habitat conditions to be compared across the state. However, for many habitat factors, there may not be sufficient data available to use a rating standard or there may be data on habitat parameters where no rating standard is provided. For these factors, the professional judgment of the TAG should be used to assign the appropriate ratings. A set of narrative standards will be developed in the near future to provide guidance in this situation.

In some cases there may be local conditions that warrant deviation from the rating standards presented here. This is acceptable as long as the justification and a description of the procedures that were followed are clearly documented in the limiting factors report. Habitat condition ratings specific to streams draining east of the Cascade crest were included where they could be found, but for many parameters they were not. Additional rating standards will be included as they become available. In the meantime, TAGs in these areas will need to work with the standards presented here or develop alternatives based on local conditions. Again, if deviating from these standards, the procedures followed should be clearly documented in the limiting factors report.

Table 2 - WCC salmonid habitat condition ratings

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Access and Passage						
Artificial Barriers	% known/potential habitat blocked by artificial barriers	All	>20%	10-20%	<10%	WCC
Floodplains						
Floodplain Connectivity	Stream and off-channel habitat length with lost floodplain connectivity due to incision, roads, dikes, flood protection, or other	<1% gradient	>50%	10-50%	<10%	WCC
Loss of Floodplain Habitat	Lost wetted area	<1% gradient	>66%	33-66%	<33%	WCC
Channel Conditions						
Fine Sediment	Fines < 0.85 mm in spawning gravel	All – Westside	>17%	11-17%	≤11%	WSP/WSA/ NMFS/Hood Canal
	Fines < 0.85 mm in spawning gravel	All – Eastside	>20%	11-20%	≤11%	NMFS

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Large Woody Debris	pieces/m channel length	≤4% gradient, <15 m wide (Westside only)	<0.2	0.2-0.4	>0.4	Hood Canal/Skagit
	or use Watershed Analysis piece and key piece standards listed below when data are available					
	pieces/channel width	<20 m wide	<1	1-2	2-4	WSP/WSA
	key pieces/channel width*	<10 m wide (Westside only)	<0.15	0.15-0.30	>0.30	WSP/WSA
	key pieces/channel width*	10-20 m wide (Westside only)	<0.20	0.20-0.50	>0.50	WSP/WSA
	* Minimum size to qualify as a key piece:	BFW (m) / Diameter (m) / Length (m) 0-5 / 0.4 / 8 6-10 / 0.55 / 10 11-15 / 0.65 / 18 16-20 / 0.7 / 24				
Percent Pool	% pool, by surface area	<2% gradient, <15 m wide	<40%	40-55%	>55%	WSP/WSA
	% pool, by surface area	2-5% gradient, <15 m wide	<30%	30-40%	>40%	WSP/WSA
	% pool, by surface area	>5% gradient, <15 m wide	<20%	20-30%	>30%	WSP/WSA
	% pool, by surface area	>15 m	<35%	35-50%	>50%	Hood Canal

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Pool Frequency	Channel widths per pool	<15 m	>4	2-4	<2	WSP/WSA
	Channel widths per pool	>15 m	-	-	chann width / pools/ mile / cw/ pool 50' / 26 / 4.1 75' / 23 / 3.1 100' / 18 / 2.9	NMFS
Pool Quality	pools >1 m deep with good cover and cool water	All	No deep pools and inadequate cover or temperature, major reduction of pool volume by sediment	Few deep pools or inadequate cover or temperature, moderate reduction of pool volume by sediment	Sufficient deep pools	NMFS/WSP /WSA
Streambank Stability	% of banks not actively eroding	All	<80% stable	80-90% stable	>90% stable	NMFS/WSP
Sediment Input						
Sediment Supply	$m^3/km^2/yr$	All	> 100 or exceeds natural rate*	-	< 100 or does not exceed natural rate*	Skagit
	* Note: this rate is highly variable in natural conditions					
Mass Wasting		All	Significant increase over natural levels for mass wasting events that deliver to stream	-	No increase over natural levels for mass wasting events that deliver to stream	WSA
Road Density	mi/mi^2	All	>3 with many valley bottom roads	2-3 with some valley bottom roads	<2 with no valley bottom roads	NMFS
	or use results from Watershed Analysis where available					

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Riparian Zones						
Riparian Condition	• riparian buffer width (measured out horizontally from the channel migration zone on each side of the stream) • riparian composition	Type 1-3 and untyped salmonid streams >5' wide	<75' or <50% of site potential tree height (whichever is greater) OR • Dominated by hardwoods, shrubs, or non-native species (<30% conifer) unless these species were dominant historically.	• 75'-150' or 50-100% of site potential tree height (whichever is greater) AND • Dominated by conifers or a mix of conifers and hardwoods (≥30% conifer) of any age unless hardwoods were dominant historically.	• >150' or site potential tree height (whichever is greater) AND • Dominated by mature conifers (≥70% conifer) unless hardwoods were dominant historically	WCC/WSP
	• buffer width • riparian composition	Type 4 and untyped perennial streams <5' wide	<50' with same composition as above	50'-100' with same composition as above	>100' with same composition as above	WCC/WSP
	• buffer width • riparian composition	Type 5 and all other untyped streams	<25' with same composition as above	25'-50' with same composition as above	>50' with same composition as above	WCC/WSP

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Water Quality						
Temperature	degrees Celsius	All	>15.6° C (spawning) >17.8° C (migration and rearing)	14-15.6° C (spawning) 14-17.8° C (migration and rearing)	10-14° C	NMFS
Dissolved Oxygen	mg/L	All	<6	6-8	>8	ManTech
Hydrology						
Flow	hydrologic maturity	All	<60% of watershed with forest stands aged 25 years or more	-	>60% of watershed with forest stands aged 25 years or more	WSP/Hood Canal
		or use results from Watershed Analysis where available				
	% impervious surface	Lowland basins	>10%	3-10%	≤3%	Skagit
Biological Processes						
Nutrients (Carcasses)	Number of stocks meeting escapement goals	All Anadromous	Most stocks do not reach escapement goals each year	Approximately half the stocks reach escapement goals each year	Most stocks reach escapement goals each year	WCC
Lakes (further work needed)						
Estuaries (further work needed)						