SECTION 30 – Table of Contents

30 Upper Columbia Subbasin Assessment – Aquatic

30.1 Species Characterization and Status

Prior to hydroelectric development, species that historically ascended into the upper Columbia River included Chinook salmon *Oncorhynchus tshawytscha*, sockeye *O. nerka*, coho salmon *O. kisutch,* pink salmon *O. gorbuscha*, chum salmon *O. keta,* steelhead *O. mykiss* (Ray 1954)*,* and Pacific lamprey *Lampetra tridentatus.* Scholz et al. (1985) estimated total salmon and steelhead escapement above the current Grand Coulee Dam location was between 1.1 and 1.9 million fish annually, three times the average total return for the entire Columbia River Basin above Bonneville Dam (578,683) over the last 10 years (USACOE, Columbia River DART website).

Fish species known or presumed to be present within the Upper Columbia Subbasin are listed in Table 1. The fish community encompasses a variety of native and introduced species that may be encountered in various habitats within the Subbasin. All anadromous salmon and steelhead, as well as Pacific lamprey have been extirpated from the region. Species listed as native to Washington and had ranges that occurred within the Upper Columbia Subbasin, but have not been recorded as present are listed as “within range.” The remaining native species that have been observed above Grand Coulee Dam are listed as “known.”

Table 30.1. Fish species occurring within the Upper Columbia Subbasin

Species	Common Name	Origin	Status
Lampetra tridentata	Pacific lamprey	native	within range[5]- extirpated
Acipenser transmontanus	white sturgeon	native	known[1]
Coregonus clupeaformis	lake whitefish	introduced	known[2]
Prosopium williamsoni	mountain whitefish	native	known[2]
Oncorhynchus clarki	cutthroat trout	native	known[3]
Oncorhynchus mykiss	rainbow trout	native	known[2]
Oncorhynchus tshawytscha	Chinook salmon	native	known[4] - extirpated
Oncorhynchus gorbuscha	pink salmon	native	within range[5]- extirpated
Oncorhynchus kisutch	coho salmon	native	within range[5]- extirpated
Oncorhynchus keta	chum salmon	native	within range[5]- extirpated
Oncorhynchus nerka	sockeye salmon	native	known[4] - extirpated
Oncorhynchus nerka	kokanee salmon	native	known[2]
Salmo trutta	brown trout	introduced	known[2]
Salvelinus fontinalis	brook trout	introduced	known[2]
Salvelinus confluentus	bull trout	native	known[3]
Acrocheilus alutaceus	chiselmouth	native	known[2]
Couesius plumbeus	lake chub	native	within range[5]
Cyprinus carpio	common carp	introduced	known[2]
Mylocheilus caurinus	peamouth	native	known[2]
Ptychocheilus oregonensis	northern pikeminnow	native	known[2]
Rhinichthys cataractae	longnose dace	native	known[2]
Rhinichthys falcatus	leopard dace	native	within range[5]
Rhinichthys osculus	speckled dace	native	known[2]

Species	Common Name	Origin	Status
Richardsonius balteatus	redside shiner	native	known[2]
Tinca tinca	tench	introduced	known[2]
Catostomus catostomus	longnose sucker	native	known[2]
Catostomus columbianus	bridgelip sucker	native	known[2]
Catostomus macrocheilus	largescale sucker	native	known[2]
Catostomus platyrhynchus	mountain sucker	native	within range[5]
Ictalurus nebulosus	brown bullhead	introduced	known[6]
Percopsis transmontanus	sandroller	native	within range[5]
Lota lota	burbot	native	known[2]
Gasterosteus aculeatus	three-spine stickleback	native	within range[5]
Micropterus dolomieui	smallmouth bass	introduced	known[2]
Micropterus salmoides	largemouth bass	introduced	known[2]
Lepomis macrochirus	bluegill	introduced	known[6]
Lepomis gibbosus	pumpkinseed	introduced	known[6]
Pomoxis annularis	white crappie	introduced	known[2]
Pomoxis nigromaculatus	black crappie	introduced	known[2]
Perca flavescens	yellow perch	introduced	known[2]
Sander vitreus	walleye	introduced	known[2]
Cottus bairdi	mottled sculpin	native	known[2]
Cottus beldingi	piute sculpin	native	known[2]
Cottus cognatus	slimy sculpin	native	within range[5]
Cottus confusus	shorthead sculpin	native	within range[5]
Cottus rhotheus	torrent sculpin	native	within range[5]
Cottus asper	prickly sculpin	native	known[6]

[1]Anders and Powell 1999
[2]Griffith and McDowell 1996
[3]Tom Shuhda, Fish Biologist, USFS, personal communication
[4]Fish and Hanavan 1948
[5]Wydoski and Whitney 1979
[6]Washington Department of Fish and Wildlife Species Composition Data for Moses Lake, Washington

30.1.1 Lake Roosevelt

Based on 1997 to 1999 sampling (McLellan et al. 2003; Spotts et al. 2002; Cichosz et al. 1999), more than 25 fish species are known to occur throughout Lake Roosevelt. In 1999, rainbow trout and walleye comprised >99 percent of the harvested fish in the reservoir, while all other species combined to comprise <1 percent of the harvest (McLellan et al. 2003). In all, the Lake Roosevelt fishery accounts for 140,000 to 600,000 angler trips annually and has an annual economic worth of between $5 and $20 million (McLellan et al. 2003; Spotts et al. 2002; Cichosz et al. 1999; Underwood and Shields 1995).

Stomach content analysis of 16 different fish species residing in Lake Roosevelt were conducted by McLellan et al. (2003). Results indicated that eleven of the examined species had substantial diet overlap (>0.70) with at least one other species. Substantial diet overlap values were observed between the following species: eastern brook trout with kokanee salmon, brown trout, rainbow trout and smallmouth bass; rainbow trout with kokanee salmon and lake whitefish; tench with bridgelip sucker, longnose sucker and northern pikeminnow; and largescale sucker with bridgelip sucker, longnose sucker, and lake whitefish. Black crappie, burbot, mountain whitefish, walleye, and yellow perch did not exhibit high diet overlap with any other species. Rainbow trout and kokanee salmon exhibited the highest dietary overlap among all species. Cladocera (34.63 percent) had the highest relative importance (Ri_a) among identified prey items across all fish species, followed by Osteichthyes (11.52 percent) and Diptera (9.89 percent). Across all species, Osteichthyes comprised the highest percent of the diet by dry weight (21.84 percent), followed by Cladocera (13.5 percent). Cladocera were consumed in the highest numbers, making up 96.0 percent of the total items consumed. Fish had the highest relative importance in the diets of both burbot and walleye, and were also important in the diets of rainbow trout, eastern brook trout, brown trout, northern pikeminnow, smallmouth bass, and yellow perch. Results suggested that zooplankton populations in Lake Roosevelt were substantially utilized by fishes as evidenced by relative importance of zooplankton in their diets (McLellan et al. 2003).

Despite the healthy zooplankton population, benthic macroinvertebrates in Lake Roosevelt are limited due to annual changes in lake elevation, minimal macrophyte production, and substrate types. As a result, the secondary trophic level of Lake Roosevelt consists mostly of zooplankton (Peone et al. 1989).

30.1.2 Kettle River

The salmonid fish assemblage in the Kettle River watershed mainly consists of native redband trout and mountain whitefish populations, as well as a nonnative brown trout population. See Section 30.4 for more detail about redband/rainbow trout.

30.1.3 Colville River

The sport fishery in the Colville River consists mainly of rainbow, brown trout, and brook trout; however, very little information is available (Curt Vail, Fish Biologist, WDFW, personal communication, 2003). Inventory projects in some of the tributaries reveal that native populations of westslope cutthroat trout are extremely limited and in many areas are not detectable. Substantial populations of introduced brook trout are present throughout the Colville River watershed and the Upper Columbia Subbasin.

30.1.4 Lakes

30.1.4.1 Curlew Lake

The sport fishery in Curlew Lake focused primarily on rainbow trout. Although largemouth bass are abundant, they provide a lesser fishery than trout. Historic reports indicate the presence of trout, grayling and other fish occupying Curlew Lake in the late nineteenth century (Juul 1989). In the early 1900s, bass and silver salmon (kokanee salmon) were reported to be very numerous. Kokanee spawning was last reported in the 1940s (Juul 1989), and today the lake is void of kokanee. Currently, the lake supports rainbow trout, largemouth bass, northern pike minnow, brook trout, chubs, suckers, and tiger muskellunge. The majority of the rainbow trout population is maintained with stocked hatchery and net pen reared fish and the tiger muskellunge population is supported through stocking of hatchery-reared fish. Although smaller in numbers than the stocked population, adfluvial redband/rainbow trout are present in Curlew Lake, which migrate into Trout Creek to spawn (Curt Vail and Sandy Lembcke, WDFW, personal communication, 2003).

30.1.4.2 Other Lakes

Many lakes within the Subbasin are located on the Colville Reservation and are managed by the Colville Confederated Tribes (CCT). Reservation lakes provide recreational fishing opportunities for both Tribal and non-Tribal members. Twin Lakes, which includes North Twin and South Twin lakes, are considered to provide most important recreational fishery (brook and rainbow trout) for Tribal and non-Tribal members. Round Lake is also an important recreational fishery for brook and rainbow trout and is stocked annually. Sugar and Nichols lakes are stocked annually with rainbow trout and Simpson Lake is stocked with brook trout. Bourgeau Lake is stocked annually with rainbow trout and also contains a self-sustaining population of largemouth bass that is not managed. Elbow Lake is sometimes referred to as "ghost" lake and is only stocked with rainbow trout after two above average annual snow events occur. Elbow Lake drains into a small fracture and is dependent on high precipitation to support a recreational fishery.

Lakes outside the Colville Reservation are managed by the Washington Department of Fish and Wildlife (WDFW). Although numerous fishing opportunities exist, some of the more popular lakes are Long, Swan, and Ferry. Long Lake is managed as a fly-fishing only lake and provides a high quality cutthroat trout fishery. Swan Lake is stocked with catchable rainbow trout, which are the main target species for anglers. In addition, Ferry Lake is managed as a rainbow trout fishery.

30.2 Focal Species Selection

Focal species selected in the Upper Columbia Subbasin include white sturgeon, redband/rainbow trout, kokanee salmon, Chinook salmon, Pacific lamprey, and burbot. The rationale for these selections, the historic and current status of the species, and current management are presented in sections 30.3 to 30.8. Although westslope cutthroat trout are not listed as a focal species in the Upper Columbia Subbasin, and were not analyzed using the QHA model, they are native to portions of the Subbasin and still occur in limited geographic areas. Westslope cutthroat trout are an important species in the Upper Columbia Subbasin from a native salmonid restoration and preservation view.

30.3 Focal Species – White Sturgeon

The white sturgeon was selected as a focal species due to its ecological significance, cultural importance to the Upper Columbia United Tribes, and the species economic value.

White sturgeon are found in marine waters and freshwater rivers along the Pacific Coast from California to Alaska (Wydoski and Whitney 2003). In the State of Washington, white sturgeon are found in the Columbia and Snake rivers, Grays Harbor, Willapa Bay, Puget Sound, and Lake Washington (Wydoski and Whitney 2003).

White sturgeon are the largest fish found in the freshwaters of North America, with specimens being reported to reach length of 20 ft and weights of 1, 800 pounds (Wydoski and Whitney 2003). Reproduction occurs at between 9 and 16 years of age and only a small percentage of adults may spawn in any given year. White sturgeon migrate great distances in unimpounded rivers and display both anadromous and resident life history forms.

White sturgeon in the Columbia River declined in numbers due numerous factors, including obstruction of migration by dams, altered stream flows, altered temperature regimes, reduced spawning habitats, and over-harvest (Wydoski and Whitney 2003).

30.3.1 Historic Status

Prior to hydroelectric development, white sturgeon within the Subbasin were likely to be exhibit both anadromous and resident life histories and may have migrated considerable distances between Subbasins within the Columbia River (Upper Columbia White Sturgeon Recovery Plan 2002). Recent genetic surveys indicate white sturgeon from Lake Roosevelt contain several diverse, maternal lineages. These results suggest pre-impoundment white sturgeon exhibited long migrations in the Columbia River (Anders 2002)

In general, white sturgeon are not known to display variable life history strategies other than occasional, facultative anadromy. Typical traits associated with benthic feeding white sturgeon include a long life span (>100 years), large size (682 kg is the largest on record), delayed maturation, spring spawning, and high fecundity (Upper Columbia White Sturgeon Recovery Plan 2002). However, survival from egg to adult is relatively low (Anders 2002).

White sturgeon have not historically been stocked within the Upper Columbia Subbasin.

30.3.2 Current Status

The current white sturgeon population estimate is 1,400 adults in the transboundary region of the Upper Columbia River basin (Upper Columbia White Sturgeon Recovery Plan 2002). Specific numbers for the Upper Columbia Subbasin are not known. Nonetheless, the population status is considerably less than the endangered status criteria of 2,500 adults determined by the World Conservation Union (Upper Columbia White Sturgeon Recovery Plan 2002). Although most of the upper-mainstem populations appear unstable, their genetic similarity to the stable lower Columbia River population has excluded them from consideration for listing under the federal Endangered Species Act, unlike the Kootenai River population.

White sturgeon are found in Lake Roosevelt and the Columbia River upstream of the reservoir. Any anadromous component to the life history of white sturgeon within the Subbasin has been lost. Genetic diversity of the samples collected is similar to the diversity observed elsewhere within the Columbia and Kootenai basins (Upper Columbia White Sturgeon Recovery Plan 2002).

In 1998, a stock-indexing project (Devore et al. 2000) found that only 1.5 percent of the captured white sturgeon were juveniles (<110 cm Fork Length), suggesting poor recruitment. Furthermore, of the 204 fish captured, only three were captured in experimental gill nets (deployed for the purpose of catching juvenile sturgeon) and length at age assignments revealed an age structure of 12- to 96-year-old fish (Devore et al. 2000), indicating that older fish dominate the population structure. The conclusion that there are severe recruitment limitations (Devore et al. 2000) supports conclusions of research conducted in the Canadian Reach of the Columbia River (R.L. & L. Environmental Services Ltd. 1996). In addition, Devore et al. (2000) found that the relative weight (Wr) of 91 percent of the white sturgeon collected from Lake Roosevelt was lower than other populations. To date, this is the lowest recorded Wr value recorded for any Columbia River Basin white sturgeon population. If this trend in poor recruitment and condition of white sturgeon continues, the population in Lake Roosevelt may be in jeopardy. If recruitment does not improve, the Upper Columbia River basin population is projected to decline 50 percent within 10 years and 75 percent within 20 years (Upper Columbia White Sturgeon Recovery Plan 2002).

Distribution of white sturgeon within the Upper Columbia Subbasin is dependent upon water condition and suitable habitat (Devore et al. 2000). Trends in abundance will likely show declines since there appear to be little or no juvenile recruitment within the stock (Anders, 2002; Devore et al. 2000). Carrying capacity within the Upper Columbia Subbasin is not known and needs to be further assessed. Current stocks are considered depressed but limiting factors are not completely known. Areas of successful spawning and recruitment are habitats to be identified, protected, and/or enhanced.

30.3.3 Current Management

In 2002, a recovery plan for the Upper Columbia white sturgeon was designed by a cooperative effort among Canadian and U.S. Federal, Provincial, State, First Nation and Tribal agencies. The basic components of the plan include short-, medium-, and long-term objectives. Assessment of the population status is the primary short-term objective. Determination of the limiting factors and feasible response measures are the medium-term objectives. Long-term objectives include re-establishing a self-sustaining population by increasing recruitment, re-establishing a natural age structure in the population, and meeting target abundance levels. If these objectives are met, and a healthy white sturgeon population is re-established, beneficial uses of white sturgeon would likely increase within the area (Upper Columbia White Sturgeon Recovery Plan 2002).

Harvest of white sturgeon is closed in all portions of the Columbia River upstream of Chief Joseph Dam (WDFW 2003). White sturgeon are not stocked nor do any captive breeding programs currently exist within Washington, however Canada has a conservation production facility for Upper Columbia River white sturgeon. These fish have been found to migrate into Lake Roosevelt (2002 Lake Roosevelt Sturgeon Recovery Project Report).

During February 2003, two thousand eight month-old juvenile white sturgeon were transported from the Kootenay Sturgeon Conservation Hatchery near Cranbrook, B.C. to the WDFW Columbia Basin Fish Hatchery at Moses Lake. The transplants are part of the Upper Columbia white sturgeon recovery plan and will be used to supplement the white sturgeon population in the Columbia River near the U.S.-Canadian border. Each young fish will be implanted with a small PIT (passive integrated transponder) tag, which will provide information on the background of individual fish for monitoring purposes. The juvenile white sturgeons will be released when they are one year in age.

Washington Department of Fish and Wildlife's Columbia Basin hatchery has the water-heating capability needed for the warmer water temperatures that sturgeon require. Improvements to the Colville fish hatchery will be an interim measure while the Canada-U.S. recovery team completes a feasibility study to determine the potential for a U.S. sturgeon broodstock holding facility and rearing hatchery dedicated for sturgeon aquaculture.

In 2002 and 2003, a combined total of nearly 20,000 juvenile sturgeon were released into the Columbia River north of the Canadian border. In addition, in May of 2004, 2,000 juvenile sturgeon from British Columbia and reared at WDFW's Columbia Basin Hatchery were pit tagged and released into Lake Roosevelt. In the years ahead, the U.S. and Canada will together release up to 12,000 juvenile sturgeon in the U.S. and Canadian portions of the Columbia River.

30.4 Focal Species – Redband/Rainbow Trout

Redband/rainbow trout were selected as a focal species due to their recreational importance as a sport fish, their subsistence value to Upper Columbia United Tribes, and their ecological significance within the watershed. Rainbow trout are stocked into Lake Roosevelt annually through a resident fish hatchery program established as partial-mitigation for losses of anadromous salmon and steelhead in the blocked area above Grand Coulee Dam.

Rainbow trout were historically distributed from northern Mexico to southeastern Alaska and inland in rivers that are free of natural obstructions from the Pacific Ocean (Behnke 1992). Rainbow trout exhibit both anadromous and non-anadromous life history strategies, with the anadromous form being referred to as steelhead. Three life history strategies are displayed by non-anadromous rainbow trout. Fluvial fish rear as adults in larger rivers and migrate to tributary streams to spawn, adfluvial fish rear as adults in lakes or reservoirs and migrate to tributaries to spawn, and resident fish spend their entire life cycle in tributary streams. The present distribution of rainbow trout and steelhead has been affected by both indiscriminate stocking practices and habitat alterations (Wydoski and Whitney 2003).

Rainbow trout are a cold-water salmonid that prefer water with temperatures below 70^{o} F and high amounts of dissolved oxygen (Wydoski and Whitney 2003). Rainbow trout typically mature between age 1 and age 5, depending on their growth rates (Wydoski and Whitney 2003). Rainbow trout spawn in the spring usually between February and June, depending on the temperature and location. Substrate composition, cover, water quality, and water quantity are important habitat elements for spawning rainbow trout (Bjornn and Reiser 1991). Juvenile rainbow trout typically prey on drifting organisms while residing in lotic systems and prey on a variety of planktonic, terrestrial, and bethic organisms when in lentic habitats. Adult rainbow trout are ominivorous and often feed on the most abundant prey resource at any given time. As rainbow trout grow in size, a proportion of their diet may be comprised of fish.

Rainbow trout have been transplanted to many temperate-zone waters in both the northern and southern hemispheres and have self-sustaining populations in many areas (Bjornn and Reiser 1991). Two subspecies of rainbow trout exist in the State of Washington, the coastal rainbow trout (*O. mykiss mykiss*) and the redband trout (*O. mykiss gairdneri*). Redband rainbow trout are native to the IMP and currently at risk in many areas due to introgression from transplanted coastal rainbow trout stocks. The extirpated steelhead runs within the IMP were of the redband subspecies (Behnke 1992), therefore conservation of current redband populations may have benefits for recovering steelhead runs within the IMP in the future with the possibility of fish passage at Chief Joseph and Grand Coulee dams.

30.4.1 Historic Status

The species *Oncorhynchus mykiss* was divided into two subspecies, *Oncorhynchus mykiss irideus* (rainbow trout) and *Oncorhynchus mykiss gairdneri* (redband trout) within the early twentieth century (Behnke 2002). Though these common names are often used interchangeably, only *O. m. gairdneri* were present in the Upper Columbia Subbasin historically (Behnke 1992; 2002). This subspecies exhibited three differing life history strategies including an anadromous form referred to as steelhead, a small-sized, stream resident form (fluvial) most often referred to as redband or redside trout and a large, lake adapted form. All steelhead within the IMP were summer-run fish that entered the system mainly from May through September. Historical accounts indicate as many as one million steelhead adults entered the Columbia River under optimal conditions before impacted by European settlement.

Development of the FCRPS adversely impacted the ability of native fluvial rainbow trout to sustain a viable population with a harvestable surplus. After the construction of Grand Coulee Dam stocking of hatchery-reared rainbow trout (*O. m. irideus*) into the Upper Columbia Subbasin commenced.

30.4.2 Current Status

Currently there are three life history strategies being expressed by redband trout in the Upper Columbia Subbasin, adfluvial, fluvial, and resident. It is believed that the adfluvial/fluvial forms of redband trout in this region have genetic material from remnant anadromous steelhead. The significance of maintaining these populations, aside from native species conservation is that these stocks may serve as native donor stocks for anadromous reintroduction.

Rainbow trout comprise an important part of the recreational fishery in Lake Roosevelt (Table 30.2). The rainbow trout population within Lake Roosevelt is generally strong with a significant amount of stocking from hatchery sources used to augment the fishery. In 1986, the Lake Roosevelt Development Association (LRDA) began a rainbow trout net pen program to supplement the rainbow trout fishery in Lake Roosevelt. Rainbow trout reared in WDFW hatcheries have been stocked every year since 1990 at an average of over 188,373 annually. In addition, during 1999 the Colville Tribes Emergency Fish Relocation Program planted over 100,000 triploid steelhead into Lake Roosevelt. The planting supported a winter fishery in the Kettle Falls area and these fish continue to contribute to the Lake Roosevelt fishery (Monte Miller, Fish Biologist, CCT, personal communication, 2004). Although wild rainbow are present in Lake Roosevelt, they comprise little of the total harvest.

Native redband trout dominate the fish community in the Kettle River watershed, but investigations in the early 1990s suggested a declining population of native redband trout throughout the system (Curt Vail, Fish Biologist, WDFW, personal communication, 2003). However, the population seems to be rebounding with current management strategies and as additional populations have been discovered in tributaries to the Kettle River.

As previously mentioned, rainbow trout are part of the sport fishery in the Colville River; however, little information is available of the current status of the population, but numbers are believed to be low (Curt Vail, Fish Biologist, WDFW, personal communication, 2003). Additional naturally self-sustaining populations of redband trout have been documented in Barnaby Creek on National Forest Lands and in Meadow, Jack and Bridge creeks on the Colville Indian Reservation.

Table 30.2. Summary of the economic value of the fishery, number of angler trips, number of fish caught, number of fish harvested and mean lengths of rainbow trout observed during creel surveys on Lake Roosevelt, WA (1990-1999)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Economic Value (millions)	$5.3	$12.8	$9.7	$20.7	$19.1	$8.7	$6.9	$5.8	$8.0
Angler Trips	171,725	398,408	291,380	594,508	469,998	232,202	176,769	146,264	196,775
No. Caught									
Rainbow trout	81,560	81,529	167,156	402,277	499,460	125,958	76,915	5,356	233,036
No. Harvested									
Rainbow trout	79,683	73,777	140,609	398,943	499,293	122,939	76,782	5,356	226,809
CPUE (per hr)									
Rainbow trout	0.13	0.20	0.22	0.17	0.21	0.08	0.10	0.01	0.18
HPUE (per hr)									
Rainbow trout	0.12	0.20	0.18	0.16	0.21	0.08	0.10	0.01	0.18
Mean Length (mm)									
Rainbow trout	346	348	422	471	473	410	363	395	364

30.4.3 Limiting Factors Redband/Rainbow Trout

Adfluvial and resident redband/rainbow trout were analyzed separately in the QHA due to their differing migratory life history strategies. Adfluvial redband/rainbow trout unlike resident redband/rainbow trout do not have access to all habitats. To examine all habitats for rainbow trout, resident life history strategies could be used, but the connectivity needed for adfluvial life histories would be lost in the assessment. In addition, differences in rearing location and behavior can be profound between these two life history forms. Therefore, it was important to assess habitat conditions for both life history types even if considerable overlap existed. The primary difference within the QHA assessment was not the physical habitat, but the habitat utilization hypothesis.

30.4.3.1 Resident Redband/Rainbow Trout

Historically, resident redband/rainbow trout were present in 72 of the 98 delineated reaches and watersheds in the Upper Columbia Subbasin. Cottonwood Creek (divided into two reaches) was included in the historic distribution, however resident redband/rainbow trout are no longer present there. Currently, resident redband/rainbow trout are distributed in 74 areas. Resident redband/rainbow trout have expanded into areas where they were not historically present, such as Upper Lynx and Deep creeks and the Lower Colville River. Genetically pure redband (resident redband/rainbow trout) populations within the Subbasin are listed in Table 30.3

Table 30.3. List of the twelve creeks on NFS lands and the Colville Reservation that support genetically pure redband populations

Creek Name
Nancy Creek
Barnaby Creek
Hall Creek
Deadman Creek
Lane and Canyon Creeks (tributaries to Sherman Creek)
Tonata Creek
Lone Ranch Creek
Trout Creek (tributary to Curlew Lake)
South Fork Chewelah Creek
Strauss Creek (a tributary of Mill Creek)
Lynx Creek

(*Source*: T. Shuhda and J. Arterburn personal communication, 2003)

The top five ranked reaches presented in Table 30.4 appear to have undergone severe habitat alterations compared to reference conditions negatively impacting riparian condition, habitat diversity, channel stability, and low flow regime. The most impacted streams appear to be Mill and lower Cottonwood creeks. Geographically the most altered habitats cover a variety of regions in the Subbasin including the northwestern corner

(Toroda, Myers, Mary Anne creeks), western section (Mill, Cottonwood creeks), and the reservoir to name a few (Table 30.4).

In general, the habitat attributes in the reaches and watersheds in the northern portion of the Subbasin are most similar to reference conditions and ranked highest for protection (Table 30.5). Some of these creeks include Boulder, Lone Ranch, Sheep, Deep, Nancy, and Deer creeks.

The tornado diagram (Table 30.6) and maps (Map UC-1, Map UC-2, located at the end of Section 30) represent the reach scores for both current habitat condition (ranging from zero to positive one, Map UC-1) and protection (ranging from zero to negative one, Map UC-2). Scores closest to positive one depict reaches with habitat conditions least similar to reference conditions. Confidence scores range from zero to one and are associated with the ratings assigned by local biologists based on documentation or their expert opinion regarding reference and current habitat attributes for each reach.

Table 30.4. Ranking of reaches with the largest deviation from the reference habitat conditions for resident redband/rainbow trout in the Upper Columbia Subbasin. A reach rank equal to 1 has the greatest deviation from reference condition in comparison to other reaches. Reach scores range from 0 to 1, with 1 having the greatest deviation from reference. Values associated with each habitat attribute range from 1 to 11, a value of 1 indicates a habitat attribute having the greatest deviation from reference compared to the other attributes within that reach. In some cases multiple habitat attributes have a value of 1 indicating all attributes equally deviate the most from the reference.

Sequence	Reach Name	Reach Rank	Reach Score	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
97	Toroda	1	0.7	1	1	1	7	11	1	1	8	8	10	6
96	Myers/Mary Anne	2	0.7	1	1	1	9	11	1	1	1	1	10	1
16	Mill/N Mill Ck	3	0.5	1	4	1	4	9	1	4	10	4	4	10
36	Middle Sherman Ck	4	0.4	1	1	3	3	7	3	10	10	3	9	7
1	Lower Cottonwood Ck	5	0.4	1	2	2	2	9	2	8	10	2	2	10
17	Middle and South Forks Mill Ck	6	0.4	3	3	1	2	9	7	3	10	7	3	10
75	Middle Hall Creek (Meadow)	7	0.3	2	3	6	5	9	8	10	7	4	10	1
90	Barnaby Creek to Colville River	8	0.3	7	2	1	2	8	8	2	8	6	2	8
91	Colville River To Kettle Falls	8	0.3	7	2	1	2	8	8	2	8	6	2	8
93	Ryan Narrows To Onion Creek	8	0.3	7	2	1	2	8	8	2	8	6	2	8
94	Onion Creek To Big Sheep Creek	8	0.3	7	2	1	2	8	8	2	8	6	2	8
95	Big Sheep Creek To Canada	8	0.3	7	2	1	2	8	8	2	8	6	2	8
9	Lower North Fork/S Fork Chewelah	13	0.3	1	1	1	1	9	7	7	11	9	6	1
14	Huckleberry Range	14	0.3	2	2	2	2	8	1	9	9	7	6	9

Sequence	Reach Name	Reach Rank	Reach Score	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
49	Grand Coulee Dam To San Poil Arm	14	0.3	7	2	1	2	8	8	2	8	5	6	8
50	San Poil Arm To Hawk Creek	14	0.3	7	2	1	2	8	8	2	8	5	6	8
51	Hawk Creek to Spokane Arm	14	0.3	7	2	1	2	8	8	2	8	5	6	8
52	Spokane Arm to Ninemile Creek	14	0.3	7	2	1	2	8	8	2	8	5	6	8
58	Ninemile Creek To Hunter Creek	14	0.3	7	2	1	2	8	8	2	8	5	6	8
64	Hunters Creek To Gifford's Landing	14	0.3	7	2	1	2	8	8	2	8	5	6	8
85	Gifford's Landing to Barnaby Creek	14	0.3	7	2	1	2	8	8	2	8	5	6	8
98	Hawk Creek	22	0.3	1	1	1	6	8	7	8	10	5	1	10
34	Deadman Ck	23	0.3	2	4	4	3	9	10	4	10	4	8	1
53	Lower Ninemile Creek (Lake to Falls)	23	0.3	3	5	1	4	10	7	9	6	7	11	1
12	LPO River	25	0.3	1	1	1	1	7	1	8	8	6	8	8
92	Kettle Falls To Ryan Narrows	25	0.3	7	2	1	2	8	8	2	8	6	2	11
2	Upper Cottonwood Ck	27	0.3	1	5	1	3	9	5	5	10	5	3	10
81	Sitdown Creek	28	0.3	3	2	3	3	8	6	11	6	9	10	1
67	Upper Stranger Creek	29	0.2	4	2	3	6	8	4	9	9	7	9	1
76	Onion Creek (No. Fork Hall Creek)	29	0.2	4	6	2	1	8	6	9	11	4	10	2
29	Lower Pierre Ck/TouLou Ck	31	0.2	1	5	1	4	8	1	9	9	5	7	9
55	Ninemile Creek 3 (Meadow reach)	32	0.2	2	2	5	4	10	7	8	8	5	11	1
46	Tonata Ck	33	0.2	1	4	4	2	9	4	4	9	4	2	9

Sequence	Reach Name	Reach Rank	Reach Score	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
72	Granite Creek	34	0.2	2	4	6	3	8	6	10	9	5	10	1
47	Upper Kettle River	35	0.2	2	3	1	6	8	3	8	8	3	6	8
59	Lower Wilmont Creek (Lake To falls)	36	0.2	3	9	2	5	8	4	10	7	6	10	1
65	Lower Stranger Creek (To Cornstalk)	37	0.2	2	1	3	4	8	7	10	9	6	10	4
62	Nez Perce Creek	38	0.2	2	6	2	5	8	6	9	11	2	9	1
74	Lower Hall Creek (Canyon)	39	0.2	3	7	3	2	8	6	10	9	1	10	3
10	Bayley Ck/Upper N Fk Chewelah	40	0.2	2	2	2	1	8	2	2	10	8	7	10
87	Lower Barnaby Creek (Reservation)	41	0.2	2	2	4	5	11	6	9	6	6	9	1
37	Upper Cherman Ck	42	0.2	1	3	3	2	7	8	8	8	3	6	8
38	S Fk Sherman Ck	42	0.2	1	3	3	1	6	7	7	7	3	7	7
73	Beaver Dam Creek	44	0.2	2	2	2	5	7	8	9	11	6	9	1
78	Middle Lynx Creek (Confined/Falls)	45	0.2	2	5	2	7	6	4	9	11	8	9	1
42	N and S Fks St Peters Ck	46	0.2	1	3	3	2	7	7	7	7	3	6	7
60	Middle Wilmont Creek (Unconfined)	47	0.1	3	3	3	1	7	2	8	8	6	8	8
68	Lower Cornstalk Creek	48	0.1	3	6	3	6	6	6	6	2	5	6	1
33	Boulder Ck	49	0.1	1	3	3	2	8	9	3	9	3	7	11
61	Upper Wilmont Creek (Higher Gradient)	50	0.1	2	5	5	2	7	4	10	8	8	10	1
57	Upper Ninemile Creek	51	0.1	4	7	4	2	9	7	10	6	3	11	1
35	Lower Sherman Ck	52	0.1	6	6	6	1	5	2	6	6	2	4	6

Sequence	Reach Name	Reach Rank	Reach Score	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
82	Stall Creek	53	0.1	4	6	3	2	9	6	10	5	8	10	1
22	Onion Ck	54	0.1	1	4	1	3	7	4	8	8	4	8	11
88	Upper Barnaby Creek (State)	55	0.1	1	2	4	3	7	5	9	7	5	9	9
77	Lower Lynx Creek (Unconfined)	56	0.1	4	1	1	6	7	1	8	4	8	8	8
26	Lower Deep Ck	57	0.1	1	4	1	3	4	4	4	4	4	4	4
56	South Fork Ninemile Creek	58	0.1	5	5	7	2	7	3	10	7	3	11	1
32	E Deer Ck	59	0.1	3	3	3	2	3	3	3	3	3	3	1
39	Nancy Ck	60	0.1	1	4	2	3	4	4	4	4	4	4	4
44	Long Alec/W Deer Cks	61	0.1	2	4	2	1	4	4	4	4	4	4	4
54	Ninemile Creek 2 (Confined reach)	62	0.1	1	2	2	2	8	5	7	9	5	10	11
84	North Fork Hall Creek	63	0.1	2	5	6	4	6	2	9	8	9	9	1
23	Lower Sheep Ck	64	0.1	4	4	1	3	4	4	4	4	1	4	4
24	Middle Sheep CK	64	0.1	1	4	1	3	4	4	4	4	4	4	4
25	Upper Sheep Ck	64	0.1	1	4	1	3	4	4	4	4	4	4	4
27	Middle Deep Creek	64	0.1	4	4	1	3	4	4	4	4	1	4	4
28	Upper Deep Ck	64	0.1	4	4	1	3	4	4	4	4	1	4	4
45	Lone Ranch Ck	69	0.0	3	4	1	2	4	4	4	4	4	4	4
80	Upper Hall Creek	70	0.0	2	7	4	6	3	8	10	9	4	10	1
83	West Fork Hall Creek	71	0.0	2	2	6	4	6	5	6	6	6	11	1

Sequence	Reach Name	Reach Rank	Reach Score	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
31	Little Boulder Ck	72	0.0	2	2	2	1	2	2	2	2	2	2	2

Table 30.5. Ranking of streams whose habitat is most similar to the reference condition for resident redband/rainbow trout in the Upper Columbia Subbasin in comparison to other reaches. A reach rank equal to 1 reveals the reach with current conditions most similar to reference conditions in comparison to other reaches. Reach score ranges from 0 to -1, with -1 having the least deviation from reference. Values associated with each habitat attribute range from 1 to 11, a value of 1 indicates a habitat attribute being most similar to the reference compared to the other attributes within that reach. In some cases multiple habitat attributes have a value of 1 indicating all attributes are equally the most similar to the reference.

Sequence	Reach Name	Reach Rank	Reach Score	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
31	Little Boulder Ck	1	-0.88	1	1	1	10	10	1	1	1	1	9	1
45	Lone Ranch Ck	2	-0.84	7	1	8	10	10	1	1	1	1	9	1
23	Lower Sheep Ck	3	-0.83	1	1	7	10	10	1	1	1	7	9	1
27	Middle Deep Creek	3	-0.83	7	1	7	10	10	1	1	1	1	9	1
28	Upper Deep Ck	3	-0.83	7	1	7	10	10	1	1	1	1	9	1
39	Nancy Ck	6	-0.82	10	1	7	9	10	1	1	1	1	8	1
44	Long Alec/W Deer Cks	6	-0.82	7	1	7	11	10	1	1	1	1	9	1
32	E Deer Ck	8	-0.81	1	1	1	9	9	1	1	1	1	8	11
26	Lower Deep Ck	9	-0.80	8	1	8	11	10	1	1	1	1	7	1
24	Middle Sheep CK	10	-0.74	1	1	6	9	9	1	1	1	6	8	11
25	Upper Sheep Ck	10	-0.74	1	1	6	9	9	1	1	1	6	8	11
42	N and S Fks St Peters Ck	12	-0.73	8	5	5	11	8	1	1	1	5	8	1
18	Rocky/MDW Cks	13	-0.72	4	4	4	11	10	4	4	1	1	9	1
37	Upper Cherman Ck	13	-0.72	8	5	5	11	10	1	1	1	5	8	1
38	S Fk Sherman Ck	13	-0.72	9	5	5	11	10	1	1	1	5	8	1

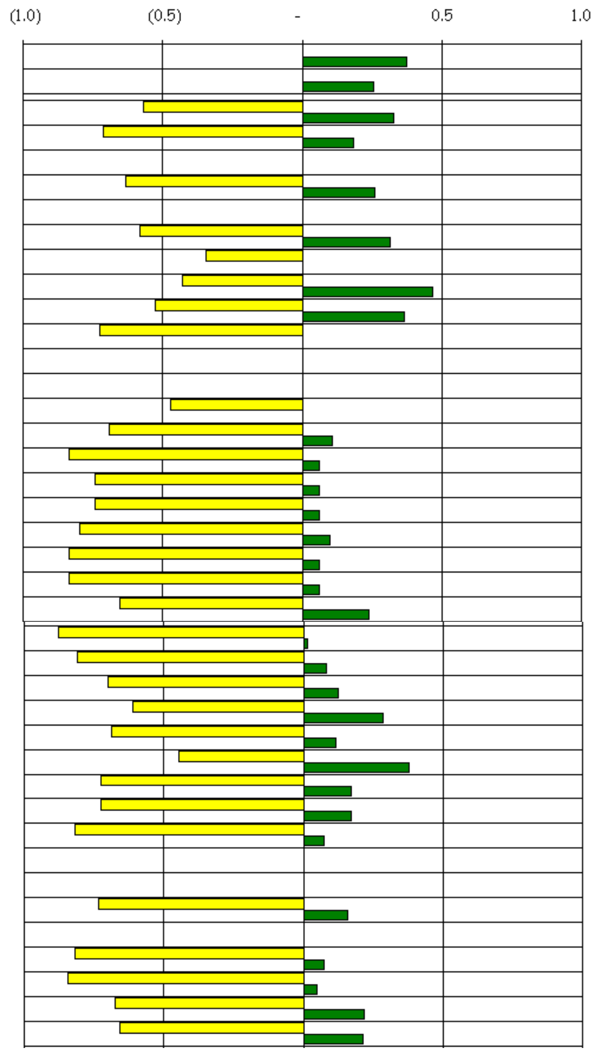
Sequence	Reach Name	Reach Rank	Reach Score	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
10	Bayley Ck/Upper N Fk Chewelah	**16**	-0.71	4	4	4	11	10	4	4	1	3	9	1
83	West Fork Hall Creek	**17**	-0.71	3	3	8	7	8	11	1	8	1	6	5
33	Boulder Ck	**18**	-0.70	8	4	4	11	10	1	4	1	4	8	1
22	Onion Ck	**19**	-0.69	8	4	8	11	10	4	1	1	4	7	1
35	Lower Sherman Ck	**20**	-0.69	1	1	1	10	9	6	1	1	6	8	11
46	Tonata Ck	**21**	-0.67	8	3	3	10	8	3	3	1	3	10	1
87	Lower Barnaby Creek (Reservation)	**22**	-0.66	4	4	3	9	10	6	1	6	2	8	11
47	Upper Kettle River	**23**	-0.66	7	4	11	9	7	4	1	1	4	9	1
29	Lower Pierre Ck/TouLou Ck	**24**	-0.66	6	4	6	11	10	6	1	1	4	6	1
54	Ninemile Creek 2 (Confined reach)	**25**	-0.65	7	4	4	10	9	7	1	2	2	6	10
78	Middle Lynx Creek (Confined/Falls)	**26**	-0.64	4	3	4	8	9	10	1	7	2	6	11
12	LPO River	**27**	-0.63	6	6	6	11	10	6	1	1	4	5	1
73	Beaver Dam Creek	**28**	-0.62	4	4	8	7	10	9	1	2	2	6	11
34	Deadman Ck	**29**	-0.61	7	3	3	10	9	1	3	1	3	7	11
79	Upper Lynx Creek	**30**	-0.60	2	3	8	6	10	9	1	6	4	5	11
59	Lower Wilmont Creek (Lake To falls)	**31**	-0.60	10	2	6	6	9	8	1	4	3	5	10
77	Lower Lynx Creek (Unconfined)	**32**	-0.59	5	3	7	6	10	11	1	9	1	4	7
62	Nez Perce Creek	**33**	-0.59	3	2	7	7	10	7	1	6	3	5	11
14	Huckleberry Range	**34**	-0.58	5	5	5	11	8	10	1	1	4	9	1
72	Granite Creek	**35**	-0.57	7	3	6	11	9	7	1	4	2	5	10

Sequence	Reach Name	Reach Rank	Reach Score	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
9	Lower North Fork/S Fork Chewelah	36	-0.57	5	5	5	11	9	3	3	1	2	10	5
49	Grand Coulee Dam To San Poil Arm	36	-0.57	4	6	11	10	6	1	6	1	5	9	1
50	San Poil Arm To Hawk Creek	36	-0.57	4	6	11	10	6	1	6	1	5	9	1
51	Hawk Creek to Spokane Arm	36	-0.57	4	6	11	10	6	1	6	1	5	9	1
52	Spokane Arm to Ninemile Creek	36	-0.57	4	6	11	10	6	1	6	1	5	9	1
58	Ninemile Creek To Hunter Creek	36	-0.57	4	6	11	10	6	1	6	1	5	9	1
64	Hunters Creek To Gifford's Landing	36	-0.57	4	6	11	10	6	1	6	1	5	9	1
85	Gifford's Landing to Barnaby Creek	36	-0.57	4	6	11	10	6	1	6	1	5	9	1
88	Upper Barnaby Creek (State)	44	-0.57	7	3	5	10	9	6	1	8	2	4	11
94	Onion Creek To Big Sheep Creek	45	-0.56	4	6	11	9	6	1	6	1	5	9	1
95	Big Sheep Creek To Canada	45	-0.56	4	6	11	9	6	1	6	1	5	9	1
67	Upper Stranger Creek	47	-0.56	3	7	5	8	9	10	1	3	2	6	11
90	Baraby Creek to Colville River	48	-0.56	4	6	11	9	6	1	6	1	5	9	1
91	Colville River To Kettle Falls	48	-0.56	4	6	11	9	6	1	6	1	5	9	1
92	Kettle Falls To Ryan Narrows	48	-0.56	4	6	11	9	6	1	6	1	5	9	1
93	Ryan Narrows To Onion Creek	48	-0.56	4	6	11	9	6	1	6	1	5	9	1
60	Middle Wilmont Creek (Unconfined)	52	-0.55	3	3	7	10	9	8	1	3	2	6	11
55	Ninemile Creek 3 (Meadow reach)	53	-0.55	9	6	6	11	8	5	1	2	2	4	10
81	Sitdown Creek	54	-0.54	7	4	3	10	9	5	1	5	2	8	11
74	Lower Hall Creek (Canyon)	55	-0.53	9	3	5	10	8	4	1	2	5	5	11

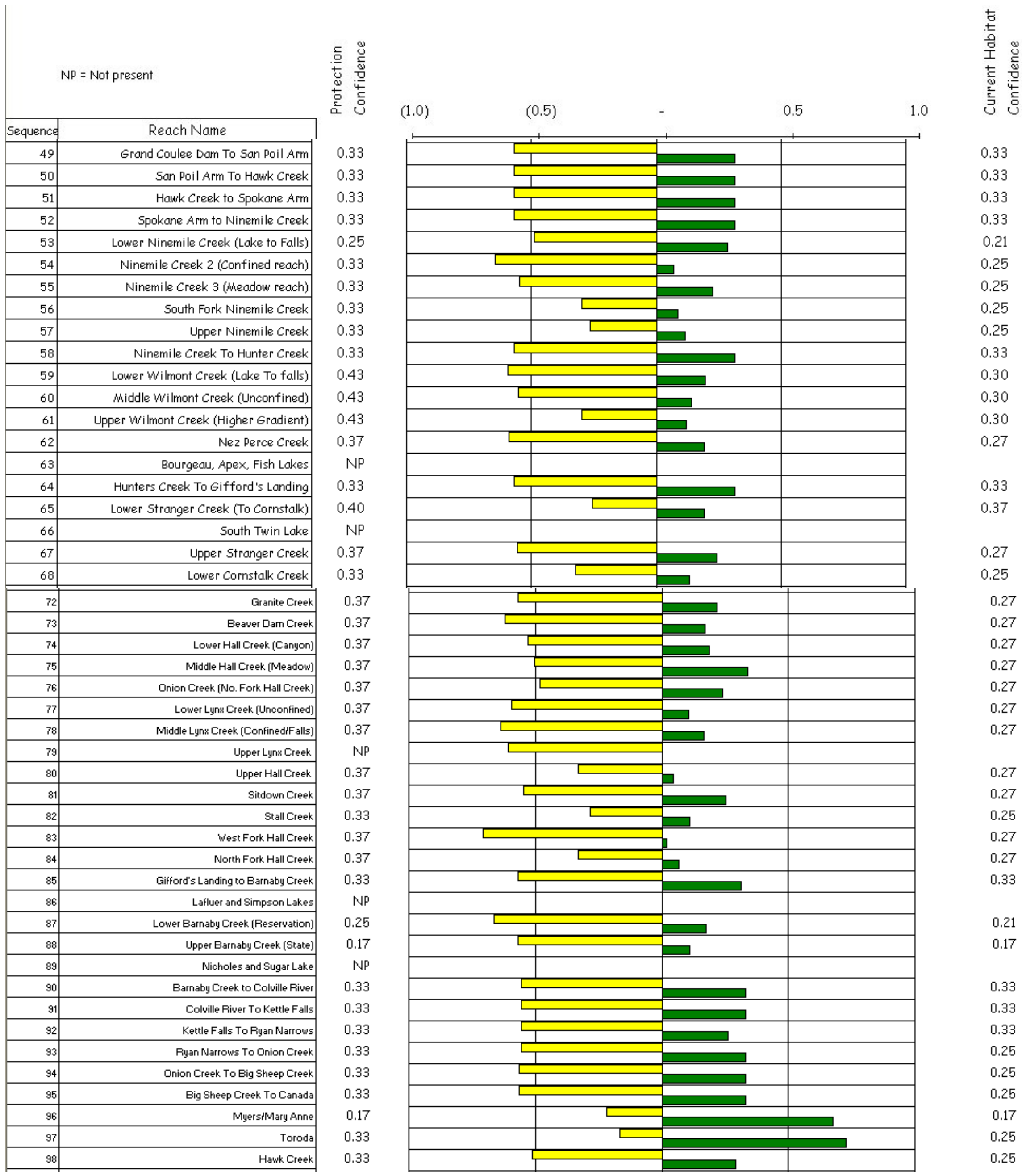
Sequence	Reach Name	Reach Rank	Reach Score	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
17	Middle and South Forks Mill Ck	**56**	-0.53	5	5	9	11	8	3	5	1	3	10	1
98	Hawk Creek	**57**	-0.51	5	5	5	9	8	3	2	1	4	10	11
75	Middle Hall Creek (Meadow)	**58**	-0.50	9	6	6	10	8	3	1	2	5	4	11
53	Lower Ninemile Creek (Lake to Falls)	**59**	-0.49	9	4	9	8	7	5	1	3	2	6	9
76	Onion Creek (No. Fork Hall Creek)	**60**	-0.48	6	2	9	10	8	6	1	2	5	4	10
21	Deep Ck	**61**	-0.47	8	4	4	10	7	4	2	1	2	10	8
36	Middle Sherman Ck	**62**	-0.45	7	7	3	10	7	3	1	1	3	3	11
16	Mill/N Mill Ck	**63**	-0.43	6	3	6	9	11	6	3	1	3	9	1
15	Lower Colville River	**64**	-0.34	9	5	9	9	8	5	3	1	3	7	1
80	Upper Hall Creek	**65**	-0.33	9	4	10	3	6	7	1	11	5	1	8
84	North Fork Hall Creek	**65**	-0.33	7	6	9	3	8	10	1	11	4	1	4
68	Lower Cornstalk Creek	**67**	-0.32	6	6	6	3	9	10	1	11	5	1	4
56	South Fork Ninemile Creek	**68**	-0.30	9	5	6	3	6	10	1	10	6	1	4
61	Upper Wilmont Creek (Higher Gradient)	**69**	-0.30	8	5	5	3	7	9	1	9	4	1	11
82	Stall Creek	**70**	-0.28	5	7	9	3	6	9	1	11	4	1	8
57	Upper Ninemile Creek	**71**	-0.26	4	3	4	8	6	9	1	10	6	1	11
65	Lower Stranger Creek (To Cornstalk)	**72**	-0.26	8	10	6	4	4	7	1	9	3	1	11
96	Myers/Mary Anne	**73**	-0.22	1	1	1	11	1	1	1	1	1	10	1
97	Toroda	**74**	-0.17	6	6	6	6	4	6	6	1	1	3	4

Table 30.6. Tornado diagram for resident redband/rainbow trout Upper Columbia Subbasin. Degree of confidence for protection and current habitat conditions range from 0.0 to 1.0 with the greatest confidence equal to 1.0. Protection reach scores are presented on the left side and current habitat reach scores are presented on the right. Negative scores are in parentheses.

NP = Not present



Sequence	Reach Name	Protection Confidence	Current Habitat Condition Confidence
1	Lower Cottonwood Ck	0.33	0.25
2	Upper Cottonwood Ck	0.33	0.25
9	Lower North Fork/ S Fork Chewelah	0.33	0.25
10	Bayley Ck/Upper N Fk Chewelah	0.33	0.25
11	LPO Lakes	NP	
12	LPO River	0.33	0.25
13	Addy/Indian/Morahan/12 Mile Ck	NP	
14	Huckleberry Range	0.33	0.25
15	Lower Colville River	NP	
16	Mill/N Mill Ck	0.33	0.25
17	Middle and South Forks Mill Ck	0.50	0.33
18	Rocky/MDW Cks	NP	
19	Smackout Ck	NP	
20	Deep Lake	NP	
21	Deep Ck	NP	
22	Onion Ck	0.33	0.25
23	Lower Sheep Ck	0.33	0.25
24	Middle Sheep CK	0.33	0.25
25	Upper Sheep Ck	0.50	0.33
26	Lower Deep Ck	0.50	0.33
27	Middle Deep Creek	0.50	0.33
28	Upper Deep Ck	0.50	0.33
29	Lower Pierre Ck/TouLou Ck	0.33	0.25
31	Little Boulder Ck	0.50	0.33
32	E Deer Ck	0.50	0.33
33	Boulder Ck	0.50	0.33
34	Deadman Ck	0.50	0.33
35	Lower Sherman Ck	0.33	0.25
36	Middle Sherman Ck	0.50	0.33
37	Upper Cherman Ck	0.50	0.33
38	S Fk Sherman Ck	0.50	0.33
39	Nancy Ck	0.50	0.33
40	Roper/LaFleur/Mantin cks	NP	
41	Lower Kettle River	NP	
42	N and S Fks St Peters Ck	0.50	0.33
43	Upper Curlew Ck	NP	
44	Long Alec/W Deer Cks	0.50	0.33
45	Lone Ranch Ck	0.50	0.33
46	Tonata Ck	0.50	0.33
47	Upper Kettle River	0.33	0.25



30.4.3.2 Adfluvial Redband/Rainbow Trout

Adfluvial redband/rainbow trout are currently present in 32 of 98 delineated areas within the Subbasin. Historically, the distribution of adfluvial redband/rainbow trout also included Deadman Creek. The comparison between present and reference conditions includes the 32 reaches plus Deadman Creek.

The first 13 reaches listed in Table 30.7, with the exception of Deadman Creek; show habitat diversity as undergoing the largest habitat alteration. Deadman Creek identifies obstructions as the major change experienced within that reach. The reaches listing habitat diversity as varying the most from the reference are all part of what was historically the mainstem and is now the reservoir, Lake Roosevelt.

The reaches that were listed with the highest ranking for protection primarily consist of northern tributaries of the reservoir. Some of these reaches encompass Boulder, Sheep, Deep, and Nancy creeks (Table 30.8).

The tornado diagram (Table 30.9) and maps (Map UC-3, Map UC-4, located at the end of Section 30) present the reach scores for both current habitat condition (ranging from zero to positive one, Map UC-3) and protection (ranging from zero to negative one Map UC-4). Scores closest to positive one depict reaches with habitat conditions least similar to reference conditions. Confidence scores range from zero to one and are associated with the ratings assigned by local biologists based on documentation or their expert opinion regarding reference and current habitat attributes for each reach.

Table 30.7. Ranking of reaches with the largest deviation from the reference habitat conditions for adfluvial redband/rainbow trout in the Upper Columbia Subbasin. A reach rank equal to 1 has the greatest deviation from reference condition in comparison to other reaches. Reach scores range from 0 to 1, with 1 having the greatest deviation from reference. Values associated with each habitat attribute range from 1 to 11, a value of 1 indicates a habitat attribute having the greatest deviation from reference compared to the other attributes within that reach. In some cases multiple habitat attributes have a value of 1 indicating all attributes equally deviate the most from the reference.

Sequence	Reach Name	Reach Rank	Reach Score	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
90	Barnaby Creek to Colville River	1	0.3	7	4	1	2	8	8	4	8	6	2	8
91	Colville River To Kettle Falls	1	0.3	7	4	1	2	8	8	4	8	6	2	8
93	Ryan Narrows To Onion Creek	1	0.3	7	4	1	2	8	8	4	8	6	2	8
94	Onion Creek To Big Sheep Creek	1	0.3	7	4	1	2	8	8	4	8	6	2	8
95	Big Sheep Creek To Canada	1	0.3	7	4	1	2	8	8	4	8	6	2	8
34	Deadman Ck	1	0.3	2	5	5	2	4	10	5	10	5	5	1
49	Grand Coulee Dam To San Poil Arm	7	0.2	7	3	1	2	8	8	3	8	6	3	8
50	San Poil Arm To Hawk Creek	7	0.2	7	3	1	2	8	8	3	8	6	3	8
51	Hawk Creek to Spokane Arm	7	0.2	7	3	1	2	8	8	3	8	6	3	8
52	Spokane Arm to Ninemile Creek	7	0.2	7	3	1	2	8	8	3	8	6	3	8
58	Ninemile Creek To Hunter Creek	7	0.2	7	3	1	2	8	8	3	8	6	3	8
64	Hunters Creek To Gifford's Landing	7	0.2	7	3	1	2	8	8	3	8	6	3	8
85	Gifford's Landing to Barnaby Creek	7	0.2	7	3	1	2	8	8	3	8	6	3	8
53	Lower Ninemile Creek (Lake to Falls)	14	0.2	4	5	2	3	11	7	9	6	8	10	1
41	Lower Kettle River	15	0.2	2	9	2	1	5	5	7	9	7	2	9

Sequence	Reach Name	Reach Rank	Reach Score	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
67	Upper Stranger Creek	16	0.2	5	2	4	5	7	3	9	9	8	9	1
29	Lower Pierre Ck/TouLou Ck	17	0.2	2	6	2	2	5	1	9	9	6	6	9
92	Kettle Falls To Ryan Narrows	18	0.2	7	4	1	2	8	8	4	8	6	2	11
62	Nez Perce Creek	19	0.2	2	8	2	2	6	6	9	11	2	9	1
74	Lower Hall Creek (Canyon)	20	0.2	6	8	6	1	4	5	10	9	2	10	3
59	Lower Wilmont Creek (Lake To falls)	21	0.2	4	9	2	4	6	3	10	8	7	10	1
65	Lower Stranger Creek (To Cornstalk)	22	0.2	2	1	5	2	7	7	10	9	6	10	2
87	Lower Barnaby Creek (Reservation)	23	0.1	2	2	5	2	11	6	9	7	7	9	1
35	Lower Sherman Ck	24	0.1	6	6	6	1	2	2	6	6	4	4	6
68	Lower Cornstalk Creek	25	0.1	3	6	3	6	6	6	6	2	5	6	1
33	Boulder Ck	26	0.1	1	4	4	1	3	9	4	9	4	4	11
32	E Deer Ck	27	0.1	3	3	3	2	3	3	3	3	3	3	1
26	Lower Deep Ck	28	0.1	2	4	2	1	4	4	4	4	4	4	4
39	Nancy Ck	29	0.1	1	4	2	3	4	4	4	4	4	4	4
23	Lower Sheep Ck	30	0.0	4	4	1	1	4	4	4	4	1	4	4
27	Middle Deep Creek	30	0.0	1	4	1	1	4	4	4	4	4	4	4
28	Upper Deep Ck	30	0.0	1	4	1	1	4	4	4	4	4	4	4
31	Little Boulder Ck	33	0.0	2	2	2	1	2	2	2	2	2	2	2

Table 30.8. Ranking of streams whose habitat is most similar to the reference condition for adfluvial redband/rainbow trout in the Upper Columbia Subbasin in comparison to other reaches. A reach rank equal to 1 reveals the reach with current conditions most similar to reference conditions in comparison to other reaches. Reach score ranges from 0 to -1, with -1 having the least deviation from reference. Values associated with each habitat attribute range from 1 to 11, a value of 1 indicates a habitat attribute being most similar to the reference compared to the other attributes within that reach. In some cases multiple habitat attributes have a value of 1 indicating all attributes are equally the most similar to the reference.

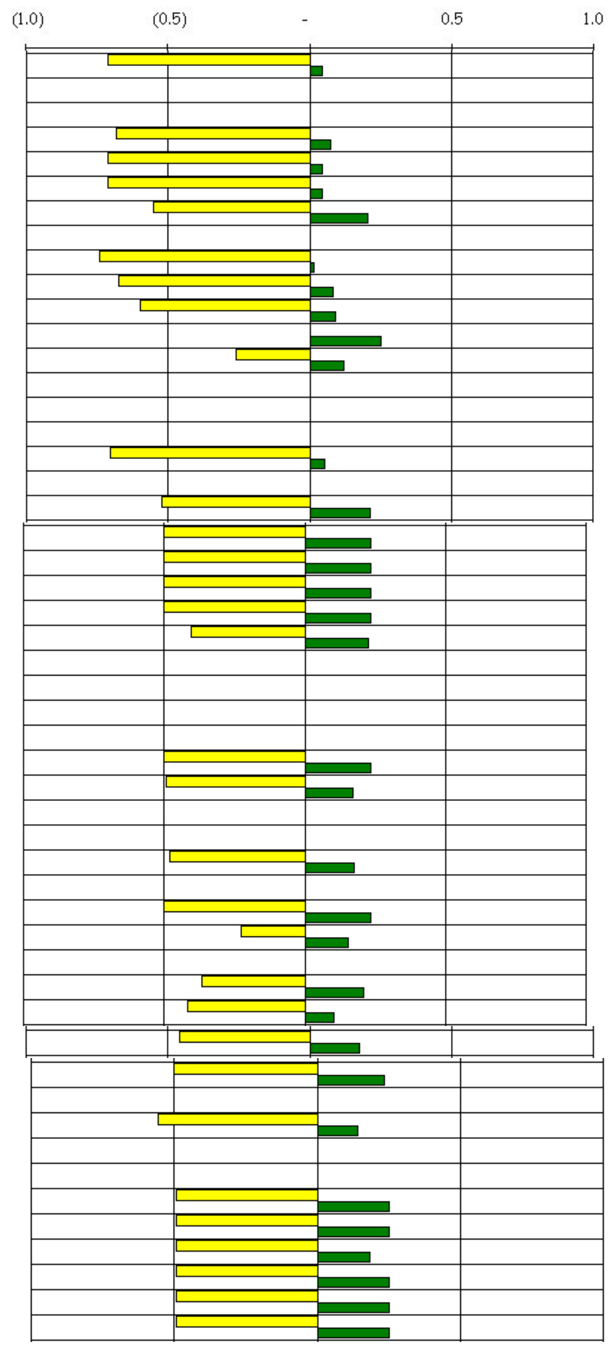
Sequence	Reach Name	Reach Rank	Reach Score	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
31	Little Boulder Ck	1	-0.74	4	4	4	11	1	1	4	4	4	4	1
23	Lower Sheep Ck	2	-0.71	4	4	9	9	1	1	4	4	9	4	1
27	Middle Deep Creek	2	-0.71	9	4	9	9	1	1	4	4	4	4	1
28	Upper Deep Ck	2	-0.71	9	4	9	9	1	1	4	4	4	4	1
39	Nancy Ck	5	-0.70	11	4	10	9	1	1	4	4	4	4	1
26	Lower Deep Ck	6	-0.68	9	4	9	11	1	1	4	4	4	4	1
32	E Deer Ck	7	-0.67	3	3	3	10	1	1	3	3	3	3	11
33	Boulder Ck	8	-0.60	10	5	5	10	3	1	5	4	5	5	1
87	Lower Barnaby Creek (Reservation)	9	-0.56	7	7	6	7	1	2	3	10	5	3	11
29	Lower Pierre Ck/TouLou Ck	10	-0.55	9	5	9	9	2	5	3	3	5	5	1
41	Lower Kettle River	11	-0.52	8	4	8	11	2	2	6	4	6	10	1
49	Grand Coulee Dam To San Poil Arm	12	-0.50	5	7	11	10	1	1	7	4	6	9	1
50	San Poil Arm To Hawk Creek	12	-0.50	5	7	11	10	1	1	7	4	6	9	1
51	Hawk Creek to Spokane Arm	12	-0.50	5	7	11	10	1	1	7	4	6	9	1
52	Spokane Arm to Ninemile Creek	12	-0.50	5	7	11	10	1	1	7	4	6	9	1
58	Ninemile Creek To Hunter Creek	12	-0.50	5	7	11	10	1	1	7	4	6	9	1
64	Hunters Creek To Gifford's Landing	12	-0.50	5	7	11	10	1	1	7	4	6	9	1
85	Gifford's Landing to Barnaby Creek	12	-0.50	5	7	11	10	1	1	7	4	6	9	1

Sequence	Reach Name	Reach Rank	Reach Score	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
90	Baraby Creek to Colville River	**19**	-0.49	5	7	11	9	1	1	7	4	6	9	1
91	Colville River To Kettle Falls	**19**	-0.49	5	7	11	9	1	1	7	4	6	9	1
92	Kettle Falls To Ryan Narrows	**19**	-0.49	5	7	11	9	1	1	7	4	6	9	1
93	Ryan Narrows To Onion Creek	**19**	-0.49	5	7	11	9	1	1	7	4	6	9	1
94	Onion Creek To Big Sheep Creek	**19**	-0.49	5	7	11	9	1	1	7	4	6	9	1
95	Big Sheep Creek To Canada	**19**	-0.49	5	7	11	9	1	1	7	4	6	9	1
59	Lower Wilmont Creek (Lake To falls)	**25**	-0.49	11	3	9	7	4	8	1	6	5	1	10
62	Nez Perce Creek	**26**	-0.48	5	4	10	5	3	5	1	9	5	1	11
74	Lower Hall Creek (Canyon)	**27**	-0.46	9	6	7	9	1	2	3	5	7	3	11
68	Lower Cornstalk Creek	**28**	-0.42	7	7	7	4	3	7	1	11	6	1	4
53	Lower Ninemile Creek (Lake to Falls)	**29**	-0.40	9	6	9	8	1	2	3	5	4	7	9
67	Upper Stranger Creek	**30**	-0.36	7	10	9	6	3	7	1	5	4	1	11
35	Lower Sherman Ck	**31**	-0.26	6	6	6	6	1	1	3	3	5	6	6
65	Lower Stranger Creek (To Cornstalk)	**32**	-0.23	6	6	6	6	1	2	2	5	4	6	6

Table 30.9. Tornado diagram for adfluvial redband/rainbow trout Upper Columbia Subbasin. Degree of confidence for protection and current habitat conditions range from 0.0 to 1.0 with the greatest confidence equal to 1.0. Protection reach scores are presented on the left side and current habitat reach scores are presented on the right. Negative scores are in parentheses.

NP = Not present

Sequence	Reach Name	Protection Confidence	Current Habitat Confidence
23	Lower Sheep Ck	0.33	0.25
24	Middle Sheep CK	NP	
25	Upper Sheep Ck	NP	
26	Lower Deep Ck	0.50	0.33
27	Middle Deep Creek	0.50	0.33
28	Upper Deep Ck	0.50	0.33
29	Lower Pierre Ck/TouLou Ck	0.33	0.25
30	Upper Pierre Ck	NP	
31	Little Boulder Ck	0.50	0.33
32	E Deer Ck	0.50	0.33
33	Boulder Ck	0.50	0.33
34	Deadman Ck	0.50	0.33
35	Lower Sherman Ck	0.33	0.25
36	Middle Sherman Ck	NP	
37	Upper Cherman Ck	NP	
38	S Fk Sherman Ck	NP	
39	Nancy Ck	0.50	0.33
40	Roper/LaFleur/Mantin cks	NP	
41	Lower Kettle River	0.33	0.25
49	Grand Coulee Dam To San Poil Arm	0.33	0.33
50	San Poil Arm To Hawk Creek	0.33	0.33
51	Hawk Creek to Spokane Arm	0.33	0.33
52	Spokane Arm to Ninemile Creek	0.33	0.33
53	Lower Ninemile Creek (Lake to Falls)	0.25	0.21
54	Ninemile Creek 2 (Confined reach)	NP	
55	Ninemile Creek 3 (Meadow reach)	NP	
56	South Fork Ninemile Creek	NP	
57	Upper Ninemile Creek	NP	
58	Ninemile Creek To Hunter Creek	0.33	0.33
59	Lower Wilmont Creek (Lake To falls)	0.43	0.30
60	Middle Wilmont Creek (Unconfined)	NP	
61	Upper Wilmont Creek (Higher Gradient)	NP	
62	Nez Perce Creek	0.37	0.27
63	Bourgeau, Apex, Fish Lakes	NP	
64	Hunters Creek To Gifford's Landing	0.33	0.33
65	Lower Stranger Creek (To Cornstalk)	0.40	0.37
66	South Twin Lake	NP	
67	Upper Stranger Creek	0.37	0.27
68	Lower Cornstalk Creek	0.33	0.25
74	Lower Hall Creek (Canyon)	0.37	0.27
85	Gifford's Landing to Barnaby Creek	0.33	0.33
86	Lafluer and Simpson Lakes	NP	
87	Lower Barnaby Creek (Reservation)	0.25	0.21
88	Upper Barnaby Creek (State)	NP	
89	Nicholes and Sugar Lake	NP	
90	Barnaby Creek to Colville River	0.33	0.33
91	Colville River To Kettle Falls	0.33	0.33
92	Kettle Falls To Ryan Narrows	0.33	0.33
93	Ryan Narrows To Onion Creek	0.33	0.25
94	Onion Creek To Big Sheep Creek	0.33	0.25
95	Big Sheep Creek To Canada	0.33	0.25



30.4.4 Current Management

In the 1980s, volunteers from Lake Roosevelt piloted a successful net pen rearing rainbow trout program. Fingerling rainbow trout were raised by state and federal hatcheries, transferred to net pens in the fall where the volunteers reared the fish until the following spring and then released them into Lake Roosevelt. Creel surveys performed by Peone et al. (1989) estimated 65,515 rainbow trout were harvested from January to December 1989. In comparison, Harper et al. (1981) estimated anglers harvested 1,517 rainbow trout from April 15, 1981 to September 15, 1981. This large increase in harvest was attributed to the net pen rearing program (Peone et al. 1989). Fishery surveys in 1986 and 1987 conducted by the Upper Columbia United Tribes Fisheries Center indicated net pen reared rainbow trout grew in length at rates ranging from 22 to 36 mm/month and anglers caught most of the fish within 14 months after release (Peone et al. 1989). Prompted by excellent harvest returns and growth rates of net pen reared rainbow trout, additional space was incorporated in the design of 2 kokanee hatcheries constructed in 1990-1991 to rear 500,000 rainbow trout fingerlings annually for Lake Roosevelt net pens. Currently 500,000 rainbow trout are annually stocked into Lake Roosevelt through the Lake Roosevelt Net Pen Project.

Although nonnative coastal rainbow trout are still used in many artificial supplemented stocking efforts, today the WDFW operates one hatchery within the Subbasin that cultures native redband rainbow trout (Phalon Lake). A wild native redband broodstock was established in 1992 to supplement waters in the state of Washington. Stocking of native redbands occurred for three years in both the Kettle River upstream of Curlew, Washington (26,000/yr) and in the Laurier to FDR reach (26,000/yr). These stockings ended in 2003. Stock status of these areas did not occur in 2002 and 2003 because of low flow conditions due to drought, which made electrofishing unfeasible (Curt Vail, Fish Biologist, WDFW, personal communication, 2003). WDFW is currently evaluating the effectiveness of native redband rainbow trout to supplement the Lake Roosevelt rainbow trout fishery.

In addition to the stocking of redband trout, WDFW's management strategies for Kettle River rainbow and redband trout also include restrictive harvest and angling regulations. Previous regulations were very liberal including a year-around season, no minimum length, and liberal eight fish bag limit. These were changed in 1992. Current regulations include a June 1 to October 31 harvest season, and a November 1 to May 31 catch and-release-season. Bait is not allowed and the catch limit is two fish over 12 inches.

Currently the CCT does not have a captive broodstock of native redband trout. The Colville Tribal Hatchery Program evaluated whether captive breeding programs for native adfluvial redband trout stocks would be feasible, but concluded that unpredictable adult returns and collection conditions (high water flows, etc.) may limit the applicability of the program (Kirk Truscott, Fish Biologist, WDFW, personal communication, 2003).

30.5 Focal Species – Kokanee Salmon

Kokanee salmon have been used as partial mitigation for the loss of anadromous salmonids in the region. They are an economically and culturally important species in the

Lake Roosevelt area subsistence and recreational harvest, and may contain important genetic material linking them to historic anadromous sockeye. They were selected as a focal species because of these attributes. The San Poil and Nespelem stocks of kokanee salmon are genetically distinct from the hatchery strains stocked into Lake Roosevelt and are viewed as an important part of the overall diversity of the Upper Columbia Subbasin fish assemblage.

The salmon *Oncorhynchus nerka* occurs in two forms: the anadromous sockeye salmon, and the nonanadromous or resident kokanee salmon. Kokanee are distributed from the Columbia River system in the South to northern Alaska (Meehan and Bjornn 1991). Kokanee are usually smaller than sockeye salmon, since adult rearing takes place in less productive lake environments rather than the productive Pacific Ocean.

Kokanee are fall spawners and may spawn in either tributaries to nursery lakes or within suitable habitat along the shores of lakes. Substrate composition, cover, water quality, and water quantity are important habitat elements for spawning kokanee salmon (Meehan and Bjornn 1991). Planktonic crustaceans are the primary food source for juvenile and adult kokanee salmon (Meehan and Bjornn 1991).

Kokanee are a very popular game fish because of their excellent taste. Native stocks of kokanee salmon within the Columbia River system may be important for the conservation and the possible future reintroduction of sockeye salmon, since stocks of kokanee salmon may contain genetic material from stocks of extirpated sockeye salmon.

30.5.1 Historic Status

Prior to impoundment, the Columbia River provided a migration corridor for abundant stocks of sockeye salmon from as far upstream as British Columbia (Behnke 2002). Historically, the upper Columbia River likely supported large numbers of both life history types for *Oncorhynchus nerka*, resident or adfluvial kokanee and anadromous sockeye salmon (Fish and Hanavan 1948; Behnke 2002). Passage for anadromous sockeye was blocked with the construction and lack of fish passage facilities of both Chief Joseph and Grand Coulee Dams, altering fish assemblages to resident and adfluvial forms. "Landlocked" or kokanee salmon persist in the basin today.

From the 1940's to the late 1960's fishery surveys indicated a prominent population of kokanee salmon were abundant in Lake Roosevelt. Large numbers of kokanee were reportedly harvested in the forebay of Lake Roosevelt and high gill net and purse seine catches were made in the forebay in 1966 and 1967 by Bureau of Commercial Fisheries personnel (Scholz et al. 1986). There were additional reports of large numbers of kokanee that emigrated through Grand Coulee Dam during this time period. Interviews of local residents as well as National Park Service and Bureau of Reclamation personnel indicated that there was a salvage fishery for the "tens of thousands to hundreds of thousands" of disabled kokanee in the tailrace of Grand Coulee Dam (Cash 1985). These observations indicate that ecological conditions after 1939 to the late 1960's were favorable for successful reproduction and survival of kokanee.

Kokanee abundance declined precipitously commencing in 1968, after the reservoir was drawn down for the construction of a third powerhouse at Grand Coulee Dam. The drawdown was thought to negatively effect kokanee in at least two ways; first, through increased entrainment through the dams because of a higher flushing rate; second, by reducing access to tributaries and shoreline areas for spawning (Scholz et al. 1986). Since completion of the third powerhouse, the magnitude and duration of reservoir level fluctuations has been altered (U.S. Geological Survey reports for water years 1960-1984; reviewed by Scholz 1986). Analysis of the increased annual drawdown over time, specifically 1941 to 1976, indicated the kokanee decline after 1968 was because reservoir elevations reduced egg and fry survival rates (Stober 1977).

Stober et al. (1977) evaluated the historical drawdown patterns of Lake Roosevelt in relation to spawning and incubation timing of kokanee and concluded that the decline in kokanee during the 1960's and 1970's could be explained by the impact of the annual drawdown regime on kokanee reproductive success (Scholz et al. 1985). Since 1968, the reservoir has been operated to produce more power, follow flood control rule curves and meet ESA requirements (1990's), thus causing lower water elevations and reduced water retention times from winter through spring. Since kokanee spawn in late fall when water levels are high, maintenance of reservoir levels in winter and spring are critically important to the normal development of eggs and the early life history stages. Given these current reservoir operations, any type of natural production to support a sustainable kokanee salmon fishery would be difficult (Scholz et al. 1986, Peone et al. 1989).

Comparison of zooplankton standing crops in Lake Roosevelt to those of other good kokanee producing lakes indicates zooplankton densities in Lake Roosevelt are greater than, or comparable to, other kokanee lakes (Jagielo 1984, Beckman et al. 1985, Peone et al. 1989, Griffith and Scholz 1991). Taking into account that kokanee are primarily planktivorous feeders and analyzing the high productivity of zooplankton (e.g., *Daphnia* sp.), Beckman et al. (1985) estimated the forage base in Lake Roosevelt could support 16 million fingerlings and 5.9 million adult kokanee (Scholz et al. 1986, Peone et al. 1989).

Nigro et al. (1981) determined that 27,200 m of suitable natural spawning habitat was available for kokanee in Lake Roosevelt and tributaries, and calculated that 181,000 adult fish or 5.4 fish/hectare could be produced by natural spawning if the habitat was fully utilized. Thus, the ability of naturally spawned kokanee to populate the reservoir was far less than the number that could be produced given the food availability in the reservoir. The primary (phytoplankton) and secondary (zooplankton) biological productivity of the reservoir can support 5.9 million adults, whereas the maximum number that can be produced, if all natural spawning habitat is used, is 0.18 million adults (Scholz et al. 1986, Peone et al. 1989). Continued fishery investigations in the 1980s indicated the use of artificial production as a viable way to restore and enhance kokanee salmon in Lake Roosevelt. Following recommendations in a feasibility study by Scholz et al. (1986), measures to construct two hatcheries were amended into the Northwest Power Planning Council 1987 Columbia Basin Fish and Wildlife Program. The measures for the hatcheries included one constructed in 1991 at Galbraith Springs on the Spokane Indian Reservation operated by the Spokane Tribe of Indians (STOI) (Spokane Tribal Hatchery), and one constructed in 1992 at Sherman Creek (a northern tributary in Lake Roosevelt) operated by the Washington Department of Fish and Wildlife (Sherman Creek Hatchery).

30.5.2 Current Status

The Upper Columbia Subbasin currently supports adfluvial (residualized) stocks of kokanee as well as hatchery-supported stocks originating from Lake Roosevelt, Lake Whatcom and Kootenay Lakes. No anadromous life history types are present, although current populations are thought to possess remnant genetic material of anadromous sockeye salmon making them prone to emigration. Kokanee are considered abundant within the Upper Columbia Subbasin, although recruitment from the natural spawning population is limited. While artificial propagation contributes to the population, entrainment, predation and precocity problems are known limiting factors to the survival/success of hatchery releases.

Stocking of hatchery-reared kokanee from 1988 to 1994 predominantly consisted of fry releases. However, coded wire tag data and a study to chemically imprint and assess smoltification of hatchery produced kokanee indicated that kokanee released as residualized smolts (e.g. yearlings/age 1+) performed more favorably than the kokanee released as fry/fingerlings (age 0+) (Scholz et al. 1993, Tilson et al. 1995). Additionally, entrainment losses and losses from predation were thought to be a greater negative factor for kokanee released as fry as opposed to residualized smolts (Tilson et al. 1995). As a result, hatchery stocking shifted from kokanee fry to residualized smolts/yearling releases. Since 1995 hatchery operations have targeted a release of 1-million yearling (residualized smolt) kokanee.

In 1995 fishery managers implemented a harvest goal of 300,000 fish based upon the theoretical number of fish the impoundment could support. Ongoing fisheries investigations include objectives to develop a model to predict biological responses to reservoir operation, evaluate the effects of releasing hatchery origin kokanee salmon and rainbow trout on the fishery and evaluate success of various stocking strategies to increase fish harvest while maximizing the return of spawning kokanee to egg collection facilities.

Wild kokanee escapement into the San Poil River has been monitored since 1995. These data have suggested kokanee escapement is critically low. However, trapping activities initiated in 2003 and new genetic information (Loxterman and Young 2003) indicate that these data are likely to be flawed (John Arterburn, CCT, personal communication, 2003). Creel, net, and electrofishing surveys conducted by the STOI three times per year, annually from 1988 to current, have revealed the presence of kokanee with intact adipose fins, which suggested wild production or that fish are emigrating from other waters.

Recent genetic information (Loxterman and Young 2003) indicates that there are several distinct kokanee stocks in Lake Roosevelt. A San Poil River naturally reproducing stock contributes to the wild kokanee population in the vicinity of Grand Coulee Dam. Additionally, there is evidence for immigration of kokanee produced in other upper Columbia River sources including Norns Creek and Hill Creek Hatchery, although the extent that kokanee fall-out from upstream areas is not currently known. Data from this study did not support the hypothesis that kokanee from the Spokane River system or Kootenay Lake in British Columbia are contributing to the kokanee populations in Lake Roosevelt. Results from this study should be taken with caution, due to the inherently large size of Lake Roosevelt and the limited sample size and locations that were used for genetic testing.

30.5.3 Limiting Factors Kokanee Salmon

Kokanee are a lake species that utilize riverine habitat for spawning and rearing, thus were included in the QHA approach to identify potential limiting factors to the life stage, spawning and incubation. Details of the QHA process are provided in Section 3.

Kokanee are currently present in 22 of 98 delineated reaches and watersheds in the Subbasin. The degree of deviation of the current from past habitat conditions were compared for all 22 areas (Table 30.10). The reaches and watersheds most similar to reference conditions are shown in Table 30.11.

Oxygen, followed by pollutants, were listed as the first and second habitat attributes having the greatest degree of deviation from reference conditions for 12 of the 14 top ranked reaches (Table 30.10). This was characteristic for the entire reservoir (Lake Roosevelt). However, interpretation of this analysis should be undertaken with caution. Initial data entry into the QHA model indicating oxygen was a problem was in reference to increased TDG levels identified in Lake Roosevelt. Decreased oxygen levels have not been identified as a problem in Lake Roosevelt (Lee et al. 2003). An increase in fine sediments was listed as the main change for Upper Pierre Creek (ranked 1st), and obstructions were listed as the main change for one of the reaches (ranked 7th) along the mainstem (Table 30.10). The rankings for habitat protection as shown in Table 30.11 found Lower Sheep and Upper Pierre creeks most similar to reference conditions.

Kokanee entrainment through Grand Coulee Dam was not assessed in the QHA analysis, but has been documented to negatively affect the population within Lake Roosevelt. Current kokanee populations in Lake Roosevelt are thought to possess remnant genetic material of anadromous sockeye salmon making them prone to migrating. This tendency to migrate is believed to be influential in the large numbers of kokanee salmon being entrained through Grand Coulee Dam on an annual basis (LeCaire 1999). Entrainment at Grand Coulee, as reported by LeCaire (1999) ranges annually between 211,000 and 650,000 for all fish species combined. Of the total, rainbow trout and kokanee salmon are approximately one half of all entrained fish, with kokanee making up the larger proportion and approximately 33% of all fish being entrained through Grand Coulee Dam (LeCaire 1999).

Table 30.10. Ranking of reaches with the largest deviation from the reference habitat conditions for kokanee salmon in the Upper Columbia Subbasin. A reach rank equal to 1 has the greatest deviation from reference condition in comparison to other reaches. Reach scores range from 0 to 1, with 1 having the greatest deviation from reference. Values associated with each habitat attribute range from 1 to 11, a value of 1 indicates a habitat attribute having the greatest deviation from reference compared to the other attributes within that reach. In some cases multiple habitat attributes have a value of 1 indicating all attributes equally deviate the most from the reference.

Sequence	Reach Name	Reach Rank	Reach Score	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
30	Upper Pierre Ck	1	0.1	7	2	5	1	7	7	2	7	6	2	7
90	Barnaby Creek to Colville River	2	0.1	5	3	5	5	5	5	1	5	4	2	5
91	Colville River To Kettle Falls	2	0.1	5	3	5	5	5	5	1	5	4	2	5
93	Ryan Narrows To Onion Creek	2	0.1	5	3	5	5	5	5	1	5	4	2	5
94	Onion Creek To Big Sheep Creek	2	0.1	5	3	5	5	5	5	1	5	4	2	5
95	Big Sheep Creek To Canada	2	0.1	5	3	5	5	5	5	1	5	4	2	5
59	Lower Wilmont Creek (Lake To Falls)	7	0.1	7	6	7	7	3	2	7	4	5	7	1
49	Grand Coulee Dam To San Poil Arm	8	0.1	5	2	5	5	5	5	1	5	4	2	5
50	San Poil Arm To Hawk Creek	8	0.1	5	2	5	5	5	5	1	5	4	2	5
51	Hawk Creek to Spokane Arm	8	0.1	5	2	5	5	5	5	1	5	4	2	5
52	Spokane Arm to Ninemile Creek	8	0.1	5	2	5	5	5	5	1	5	4	2	5
58	Ninemile Creek To Hunter Creek	8	0.1	5	2	5	5	5	5	1	5	4	2	5
64	Hunters Creek To Gifford's Landing	8	0.1	5	2	5	5	5	5	1	5	4	2	5
85	Gifford's Landing to Barnaby Creek	8	0.1	5	2	5	5	5	5	1	5	4	2	5
41	Lower Kettle River	15	0.1	6	6	6	6	1	1	1	6	5	1	6
87	Lower Barnaby Creek (Reservation)	16	0.1	6	2	6	6	11	3	6	4	5	6	1
53	Lower Ninemile Creek (Lake to Falls)	17	0.1	6	2	6	6	11	4	6	3	5	10	1

Sequence	Reach Name	Reach Rank	Reach Score	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
74	Lower Hall Creek (Canyon)	18	0.1	7	5	7	7	2	3	7	6	4	7	1
65	Lower Stranger Creek (To Cornstalk)	19	0.1	7	1	7	7	3	3	7	6	5	7	1
35	Lower Sherman Ck	20	0.0	5	5	5	5	1	1	5	5	4	3	5
92	Kettle Falls To Ryan Narrows	21	0.0	5	3	5	5	5	5	1	5	4	2	11
23	Lower Sheep Ck	22	0.0	2	2	2	2	2	2	2	2	1	2	2

Table 30.11. Ranking of streams whose habitat is most similar to the reference condition for kokanee salmon in the Upper Columbia Subbasin in comparison to other reaches. A reach rank equal to 1 reveals the reach with current conditions most similar to reference conditions in comparison to other reaches. Reach score ranges from 0 to -1, with -1 having the least deviation from reference. Values associated with each habitat attribute range from 1 to 11, a value of 1 indicates a habitat attribute being most similar to the reference compared to the other attributes within that reach. In some cases multiple habitat attributes have a value of 1 indicating all attributes are equally the most similar to the reference.

Sequence	Reach Name	Reach Rank	Reach Score	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
23	Lower Sheep Ck	1	-0.73	11	1	9	7	1	1	1	1	10	1	8
30	Upper Pierre Ck	2	-0.63	11	4	9	8	1	1	4	1	10	4	7
87	Lower Barnaby Creek (Reservation)	3	-0.63	10	4	9	4	3	6	1	6	8	1	10
59	Lower Wilmont Creek (Lake To falls)	4	-0.60	11	3	9	5	6	8	1	4	7	1	10
35	Lower Sherman Ck	5	-0.56	10	1	7	8	4	4	1	1	9	4	10
49	Grand Coulee Dam To San Poil Arm	6	-0.36	9	6	9	9	1	1	6	1	5	8	1
50	San Poil Arm To Hawk Creek	6	-0.36	9	6	9	9	1	1	6	1	5	8	1
51	Hawk Creek to Spokane Arm	6	-0.36	9	6	9	9	1	1	6	1	5	8	1
52	Spokane Arm to Ninemile Creek	6	-0.36	9	6	9	9	1	1	6	1	5	8	1
58	Ninemile Creek To Hunter Creek	6	-0.36	9	6	9	9	1	1	6	1	5	8	1
64	Hunters Creek To Gifford's Landing	6	-0.36	9	6	9	9	1	1	6	1	5	8	1
85	Gifford's Landing to Barnaby Creek	6	-0.36	9	6	9	9	1	1	6	1	5	8	1
90	Baraby Creek to Colville River	13	-0.35	9	6	9	9	1	1	6	1	5	8	1
91	Colville River To Kettle Falls	13	-0.35	9	6	9	9	1	1	6	1	5	8	1
92	Kettle Falls To Ryan Narrows	13	-0.35	9	6	9	9	1	1	6	1	5	8	1

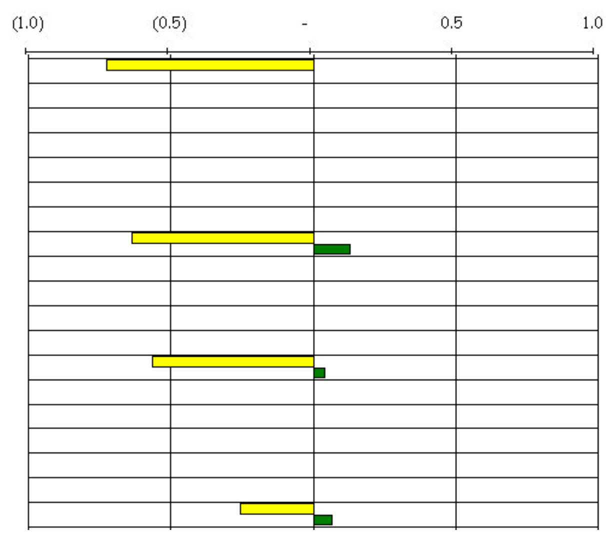
Sequence	Reach Name	Reach Rank	Reach Score	Riparian Condition	Channel stability	Habitat Diversity	Fine sediment	High Flow	Low Flow	Oxygen	Low Temperature	High Temperature	Pollutants	Obstructions
93	Ryan Narrows To Onion Creek	**13**	-0.35	9	6	9	9	1	1	6	1	5	8	1
94	Onion Creek To Big Sheep Creek	**13**	-0.35	9	6	9	9	1	1	6	1	5	8	1
95	Big Sheep Creek To Canada	**13**	-0.35	9	6	9	9	1	1	6	1	5	8	1
53	Lower Ninemile Creek (Lake to Falls)	**19**	-0.35	8	5	8	8	2	6	1	4	2	7	8
41	Lower Kettle River	**20**	-0.26	7	1	7	7	7	7	3	1	3	6	5
74	Lower Hall Creek (Canyon)	**21**	-0.23	6	3	6	6	6	6	1	2	4	4	6
65	Lower Stranger Creek (To Cornstalk)	**22**	-0.20	6	5	6	6	6	6	1	3	2	4	6

The tornado diagram (Table 30.12) and maps (Map UC-5, Map UC-6, located at the end of Section 30) present the reach scores for both current habitat condition (ranging from zero to positive one, Map UC-5) and protection (ranging from zero to negative one, Map UC-6). Scores closest to negative one depict reaches that are most representative of reference habitat conditions. Scores closest to positive one depict reaches with habitat conditions least similar to reference conditions. Confidence scores range from zero to one and are associated with the ratings assigned by local biologists based on documentation or their expert opinion regarding reference and current habitat attributes for each reach.

Table 30.12. Tornado diagram for kokanee salmon in the Upper Columbia Subbasin. Degree of confidence for protection and current habitat conditions range from 0.0 to 1.0 with the greatest confidence equal to 1.0. Protection reach scores are presented on the left side and current habitat reach scores are presented on the right. Negative scores are in parentheses.

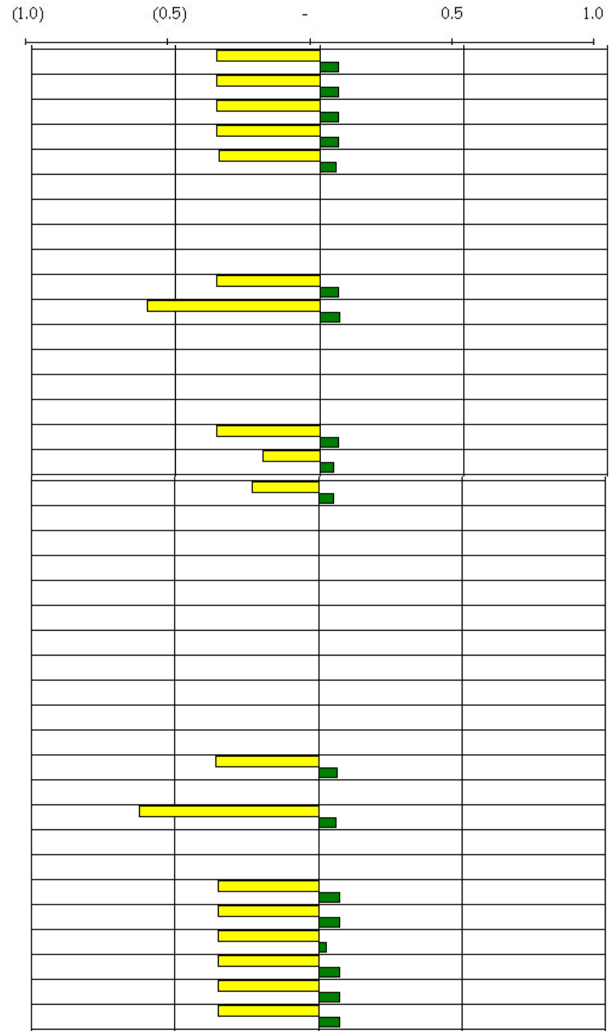
NP = Not present

Sequence	Reach Name	Protection Confidence	Current Habitat Confidence
23	Lower Sheep Ck	0.33	0.25
24	Middle Sheep CK	NP	
25	Upper Sheep Ck	NP	
26	Lower Deep Ck	NP	
27	Middle Deep Creek	NP	
28	Upper Deep Ck	NP	
29	Lower Pierre Ck/TouLou Ck	NP	
30	Upper Pierre Ck	0.50	0.33
31	Little Boulder Ck	NP	
32	E Deer Ck	NP	
33	Boulder Ck	NP	
34	Deadman Ck	NP	
35	Lower Sherman Ck	0.33	0.25
36	Middle Sherman Ck	NP	
37	Upper Cherman Ck	NP	
38	S Fk Sherman Ck	NP	
39	Nancy Ck	NP	
40	Roper/LaFleur/Mantin cks	NP	
41	Lower Kettle River	0.33	0.25



NP = Not present

Sequence	Reach Name	Protection Confidence	Current Habitat Confidence
49	Grand Coulee Dam To San Poil Arm	0.33	0.33
50	San Poil Arm To Hawk Creek	0.33	0.33
51	Hawk Creek to Spokane Arm	0.33	0.33
52	Spokane Arm to Ninemile Creek	0.33	0.33
53	Lower Ninemile Creek (Lake to Falls)	0.25	0.21
54	Ninemile Creek 2 (Confined reach)	NP	
55	Ninemile Creek 3 (Meadow reach)	NP	
56	South Fork Ninemile Creek	NP	
57	Upper Ninemile Creek	NP	
58	Ninemile Creek To Hunter Creek	0.33	0.33
59	Lower Wilmont Creek (Lake To falls)	0.43	0.30
60	Middle Wilmont Creek (Unconfined)	NP	
61	Upper Wilmont Creek (Higher Gradient)	NP	
62	Nez Perce Creek	NP	
63	Bourgeau, Apex, Fish Lakes	NP	
64	Hunters Creek To Gifford's Landing	0.33	0.33
65	Lower Stranger Creek (To Cornstalk)	0.40	0.37
74	Lower Hall Creek (Canyon)	0.37	0.27
75	Middle Hall Creek (Meadow)	NP	
76	Onion Creek (No. Fork Hall Creek)	NP	
77	Lower Lynx Creek (Unconfined)	NP	
78	Middle Lynx Creek (Confined/Falls)	NP	
79	Upper Lynx Creek	NP	
80	Upper Hall Creek	NP	
81	Sitdown Creek	NP	
82	Stall Creek	NP	
83	West Fork Hall Creek	NP	
84	North Fork Hall Creek	NP	
85	Gifford's Landing to Barnaby Creek	0.33	0.33
86	Lafluer and Simpson Lakes	NP	
87	Lower Barnaby Creek (Reservation)	0.25	0.21
88	Upper Barnaby Creek (State)	NP	
89	Nicholes and Sugar Lake	NP	
90	Barnaby Creek to Colville River	0.33	0.33
91	Colville River To Kettle Falls	0.33	0.33
92	Kettle Falls To Ryan Narrows	0.33	0.33
93	Ryan Narrows To Onion Creek	0.33	0.25
94	Onion Creek To Big Sheep Creek	0.33	0.25
95	Big Sheep Creek To Canada	0.33	0.25



30.5.4 Current Management

Kokanee management in the Upper Columbia consists of measures to enhance harvest opportunities, maintain genetic integrity of existing stocks and restore adult returns of wild and hatchery populations. Ongoing activities to meet these measures include an artificial production program, conservative harvest regulation of 2 fish per day, a program to evaluate naturally occurring stocks with respect to conservation and/or recovery efforts and a program for monitoring and evaluating the kokanee population reservoir wide. Fishery managers from the STOI, CCT and WDFW meet monthly to coordinate management and research activities. Additional support and peer review is provided by Eastern Washington University while the Lake Roosevelt Forum serves as a public interface mechanism.

Several hatcheries and rearing locations, including Trout Lodge hatchery (private), WDFW-Sherman Creek, Colville, Spokane, Ford hatcheries, Spokane Tribal Hatchery, and Lake Roosevelt net pen program, culture kokanee for out-planting. However, there are no captive propagation facilities for the expressed culture of native stocks to prevent extirpation.

Due to the recent genetic analysis (Loxterman and Young 2003) of kokanee populations in Lake Roosevelt, current management efforts are aimed at conserving the genetic structure of the native population, while collecting new information on the origin of kokanee in Lake Roosevelt.

30.6 Focal Species – Chinook salmon

Chinook salmon were selected as a focal species for the Upper Columbia Subbasin because of their cultural significance to the Upper Columbia United Tribes, their potential recreational value as a sport fish, and to address concerns regarding native species conservation and to be in alignment with Northwest Power and Conservation Council (Council) program to reintroduce salmon where feasible.

Chinook salmon are sometimes referred to as king, tyee, spring, and quinnat salmon. The Chinook salmon is indigenous to the northern half of the Pacific Coast of North America (Meehan and Bjornn 1991), and are of great commercial and recreational importance within this area. Chinook salmon are most abundant in the large river systems, although they may be present in various sized rivers and streams. Although they have been stocked into many lakes and reservoirs throughout North America, they are usually not self-sustaining in these systems.

Chinook salmon are anadromous spawning in freshwater systems and rearing as adults in the Pacific Ocean. Chinook salmon spend between 2 and 8 years in the Pacific Ocean and display a great deal of variation in the timing of adult migration, juvenile migration, and spawning. One hundred eight stocks of Chinook salmon were identified in the State of Washington alone (Wydoski and Whitney 2003). Historically, Chinook salmon migrated to the headwaters of the Columbia River in Canada, but since the construction of Grand Coulee Dam and the subsequent construction of Chief Joseph Dam, their upstream terminus is river mile 545 (Wydoski and Whitney 2003).

30.6.1 Historic Status

Prior to hydroelectric development, Chinook salmon migrated as far inland up the Columbia River as British Columbia with estimates of several million adults making annual migrations (Behnke 2002). Chinook were the most plentiful and typically ran from June through September, peaking in mid- to late June and again in August, (Scholz et al. 1985). However, salmon were available from May through November (Ray 1954).

Summer and fall Chinook salmon were originally treated as separate populations by WDFW (NRC 1996). However, Utter et al. (1993) considered upriver brights (URB) to consist of a continuous population. Current listings (NMFS 1998) indicate fish from upriver areas above Chief Joseph and Grand Coulee dams to have been within the Upper Columbia Summer/Fall Chinook ESU.

30.6.2 Current Status
The construction of Chief Joseph and Grand Coulee dams and the lack of fish passage facilities blocked migration of Chinook salmon and extirpated them from the Subbasin. Current trends in abundance and distribution of resident Chinook salmon above Chief Joseph Dam is unknown but presumed to be minimal. Genetic variation and diversity historically present within Chinook salmon stocks above Chief Joseph and Grand Coulee dams are presumed to have been lost.

30.6.3 Limiting Factors Chinook Salmon
The primary limiting factor for Chinook salmon in the Upper Columbia Subbasin is the lack of fish passage facilities at both Chief Joseph and Grand Coulee dams. Any reintroduction program for anadromous stocks of Chinook salmon in the Subbasin would likely fail without some type of fish passage program at these dams. Efforts to introduce a naturalized resident population of Chinook salmon failed in 1977 and would likely fail again based on current knowledge of fish entrainment through Grand Coulee Dam. Chinook salmon are currently listed as extirpated in the Upper Columbia Subbasin. Efforts to restore habitat for other salmonid species would likely benefit freshwater Chinook habitat, however until the lack of fish passage on the mainstem Columbia River is addressed these benefits are academic. Because Chinook salmon have no current distribution in the Upper Columbia Subbasin they were not analyzed using the QHA model.

30.6.4 Current Management
There is no current management for Chinook salmon in the Upper Columbia Subbasin since Chinook salmon are present in extremely low numbers above Grand Coulee Dam. The desire on the part of the Upper Columbia United Tribes is that Chinook salmon will be re-established, possibly with construction of fish passage at Chief Joseph and Grand Coulee.

30.7 Focal Species – Pacific Lamprey
Pacific lamprey were selected due to their cultural significance and subsistence value historically to the Upper Columbia United Tribes, and to address concerns regarding native species conservation.

Pacific lamprey are found in streams from southern California to the Gulf of Alaska (Wydoski and Whitney 2003). In Washington state, Pacific lamprey are found in most large coastal and Puget Sound Rivers and occurs long distances inland in the Columbia, Snake, and Yakima River systems (Wydoski and Whitney 2003).

Pacific lamprey are anadromous and rear as adults in the Pacific Ocean. Adults are parasitic, feeding on the body fluids of various species of fish. Adults reach lengths of 30 inches and a weight of about 1 pound (Wydoski and Whitney 2003). Unlike Pacific salmon, Pacific lamprey may be able to spawn more than once (Wydoski and Whitney 2003). The importance of Pacific lamprey predation in the Pacific Ocean has not been clearly evaluated (Wydoski and Whitney 2003), although biologists suspect there might be significant effects on some fish populations.

30.7.1 Historic Status

Historically, Pacific lamprey were found as far upstream as Kettle Falls on the Columbia River and Spokane Falls on the Spokane River (Wydoski and Whitney 2003). Completion of Grand Coulee and Chief Joseph dams blocked the upstream migration of Pacific lamprey.

Pacific lamprey were utilized by Upper Columbia River Tribes for food. Preservation of the meat was accomplished through smoking, sun drying, and salting practices (Wydoski and Whitney 2003). It has been reported that Pacific lamprey were just as valuable as salmon to some Upper Columbia River Tribes (Landeen and Pinkham 1999 cited in Wydowski and Whitney 2003). Commercial fisheries for Pacific lamprey existed in the Lower Columbia as late as the 1940's, when lamprey were used for oil, animal food, and fertilizer (Wydoski and Whitney 2003). However, the importance of the Pacific lamprey fishery was likely overshadowed by the size and utilization of the salmonid fishery.

30.7.2 Current Status

Pacific lamprey were extirpated from the Upper Columbia with the construction of Grand Coulee and Chief Joseph Dams. Although lamprey have been known to ascend the faces of dams, they have not been observed at or above Grand Coulee Dam (Curt Vail, Fish Biologist, WDFW, personal communication, 2004).

30.7.3 Limiting Factors Pacific Lamprey

The primary limiting factor for Pacific lamprey in the Upper Columbia Subbasin is the lack of fish passage at both Chief Joseph and Grand Coulee dams. Pacific lamprey are currently listed as extirpated within the Upper Columbia Subbasin, and were not analyzed using the QHA model.

30.7.4 Current Management

Currently, the Pacific lamprey does not exist in the Upper Columbia and therefore is not managed. Establishment of Pacific lamprey above Chief Joseph Dam could create a need for management in the future.

30.8 Focal Species – Burbot

Burbot were selected as a focal species for their ecological significance, their native species status, and their potential recreational importance as a sport fish. Although burbot are not as sought after by recreational anglers as the salmonids in the region, they are excellent table fare. More research needs to be conducted to truly understand the status of burbot in this region. Burbot were not analyzed by the QHA model in this assessment, as the QHA model was developed for salmonid fishes and would not effectively identify limiting factors for populations of burbot in the Upper Columbia Subbasin.

30.8.1 Historic Status

Distribution of burbot is circumpolar in the northern hemisphere. Little is known about burbot in the Upper Columbia Subbasin, besides that they are found both in Lake

Roosevelt and the Columbia River upstream of the reservoir. Early systematic studies placed burbot into three distinct subspecies with only one of these subspecies found in North America, *Lota lota lacustris*. Current evidence suggests the sub-specific designation is unwarranted (Scott and Crossman 1973).

Burbot are benthic feeders that reside in deep waters in lakes or rivers and are not considered migratory. Sexual maturity is reached between age 2 and age 4. Burbot spawn during the winter from mid-December to early April. Spawning habitat conditions include mostly shallow waters (0.3-1.5 m) and clean substrate (sand, gravel and stones) (Morrow 1980).

Prior to 1969, burbot were not managed in Washington State (Polacek et al. 2004). Since 1969, burbot have been listed as a game fish in Washington State and harvest limits were imposed in 1998. Burbot are not known to have been stocked in the Upper Columbia Subbasin.

30.8.2 Current Status

Little is known regarding burbot biology within the Upper Columbia Subbasin. Population status, abundance, and trends are unknown. Abundance appears to be fairly stable with comparison to other harvest and species composition data (WDFW catch data for Lake Roosevelt). Carrying capacity and current habitat condition for burbot remains relatively unknown within the Subbasin. Research on burbot in Lake Roosevelt was conducted from 1997-2001, with BPA funding through the Lake Roosevelt Fishery Evaluation Program. Preparation of the final report of this research is in progress and the results will become available upon its completion.

30.8.3 Current Management

Currently there is a daily catch limit of five burbot per day with no minimum size requirement. This was increased from previous regulations of two per day in an attempt to increase angler interest and harvest for burbot (WDFW 2003). Some waters within the Subbasin allow setlines for the take of burbot, although it is now allowed in Lake Roosevelt. Of the eleven known populations of burbot in the State of Washington, one is considered in critical condition (Banks Lake), one is healthy (Lake Roosevelt), and the status of the others is currently not known (Bonar et al. cited in Polacek et al. 2004). No hatchery production or current captive breeding programs operate within the Upper Columbia Subbasin. Current management direction is to maintain the harvest regulations that are in place.

30.9 Environmental Conditions

The Subbasin consists of the impounded portion of the Columbia River above Grand Coulee Dam (reservoir habitat), several tributaries that drain into the lake (riverine habitat), and many basin lakes within the watershed that are heavily used for Tribal subsistence and recreational harvest.

30.9.1 Environmental Conditions within the Subbasin

30.9.1.1 Lake Roosevelt

Lake Franklin D. Roosevelt (Lake Roosevelt) reaches upstream from Grand Coulee Dam 151 miles to the Canadian border. Approximately 494 miles of shoreline exists, where sixty-five tributaries streams contribute their flow and biomass to the fishery in the lake (LeCaire and Peone 1991). Grand Coulee Dam inundated 135 miles of habitat in the mainstem Columbia River from the dam to within 15 miles of the Canadian border (USGS 2004), 28 miles of the lower Spokane River, 12 miles of the San Poil River, and 15 miles of the Kettle River as well as numerous other tributaries. What had been a shallow, free-flowing river was converted into a deep reservoir. Native westslope cutthroat trout, redband trout, bull trout, and mountain whitefish that were adapted to a fluvial environment were probably selected against in relation to other native and nonnative fishes following impoundment. Selection against native salmonid fish populations, combined with fish entrainment has resulted in declining native fish populations. Furthermore, resident fish species were impacted through lost productivity (absence of marine-derived nutrients from anadromous fish) and habitat degradation related to land-use practices (for example, agriculture, hydro-operations, grazing, logging, and municipal development).

The lacustrine habitats of Lake Roosevelt do not exhibit physical characteristics normally associated with natural lake environments. In high water years, when the spring freshet is anticipated to be large, reservoir levels have been drawn down more than 80 feet and refilled over the span of three to five months. These drawdowns decrease invertebrate productivity, eliminate littoral habitat used as nursery areas, and therefore are limiting production in Lake Roosevelt (Cichosz et al. 1999; Underwood and Shields 1995; Griffith and Scholz 1991). Additionally, the drawdowns likely increase fish entrainment (LeCaire 1999). Lake Roosevelt, which is a relatively deep reservoir, does not thermally stratify (McLellan et al. 2003). The variable habitat conditions exhibited by Lake Roosevelt are due to the operations of Grand Coulee Dam for flood control and downstream flow augmentation. As a result, current practices severely impact resident fish populations and limits fisheries managers in their ability to achieve objectives and goals set by their respected Tribes or agencies.

Although Lake Roosevelt supports relatively healthy fisheries, portions of the reservoir are heavily contaminated with trace elements that were discharged into the Columbia River from mining activities. A smelter in Trail, British Columbia owned by Teck Cominco Ltd. legally released approximately 360 metric tons per day of smelter slag into the Columbia River from 1900 to 1998 (USGS 2004). Contamination has been found downstream in the U.S. portions of Lake Roosevelt. A study by the USGS reported that Lake Roosevelt bed sediments were contaminated with arsenic, lead, and other metals based upon high concentrations, impaired benthic invertebrate communities, and laboratory sediment bioassays (USGS 2004). Although the impacts of the contaminants on aquatic life have not been well documented, man aquatic species may be greatly affected by these contaminants, along with wildlife that depend on the system. While there has been a reduction in point source discharge of metals to the upper Columbia River, there is a substantial quantity of metals residing in the bottom sediments of Lake

Roosevelt. The threat from the remobilization and availability of metals may be most pronounced in shallow, backwater habitats that are dominated by fine-grained sediment and higher biological productivity.

In 1999, the CCT petitioned the Environmental Protection Agency (EPA) to conduct an assessment at the Upper Columbia River. The petition expressed concerns about risks to human health and to the health of the environment from contamination in the river. In December 2000, EPA completed a preliminary assessment of the Upper Columbia River and determined that a sampling investigation was necessary. In mid-2001, EPA collected samples from the Upper Columbia River to learn more about the types and amounts of pollution in the sediments. The results of the sampling were released in November 2002 in a draft Site Inspection Report. Sampling results suggest that further investigation of contamination in the Upper Columbia River is warranted.

Negotiations about cleanup measures are ongoing. In December 2002, the U.S. Environmental Protection Agency asked Teck Cominco to pay for a study of the contamination. However, jurisdictional issues remain and, as of this writing (February 2004), no agreement on studies or cleanup has been reached. In 2004, EPA is contracting a six-part study of existing information on the river. Also, the USGS is continuing to study the effects of airborne contaminants.

30.9.1.2 Colville River

Colville River discharge is driven by a snowmelt regime. The high-flow period occurs in the spring as a result of melting of the previous winter snow pack, combined with spring rainfall. April is the highest month for discharge, while August is the lowest. The majority of the tributaries to the Colville River are small, generally averaging less than 20 cfs, except for Chewelah Creek, Little Pend Oreille River, and Mill Creek. These three large streams account for just over half of the Colville River discharge. Sheep Creek, a headwater stream, is the only other tributary accounting for more than 5 percent of the river volume, at about 5.9 percent. Eighty-two percent of the land cover for the Colville River basin is forest, shrubland, woody wetlands, and upland grasses (WDOE 2002). Most of the remaining area is divided between agriculture and transitional or barren grounds. Urban, residential, commercial/industrial, transportation, and recreational grasses (lawns) cover less than 2 percent of the basin. The urban/residential areas of the watershed are near the population centers of Chewelah, Colville, Kettle Falls, Springdale, and along portions of the highway corridors. The subbasins are rural/residential, with agriculture the predominant land use along the valley bottoms and on some terraces higher up. The uplands account for approximately 75 percent of the basin and are dominated by evergreen forests.

Physical habitat in nearly all 53 miles of the Colville River has been severely degraded. In most areas, ditching and tiling have drained wetlands, and pasture or croplands extend to the edge of eroding banks. Most of the riparian vegetation has been removed and in many areas livestock have direct access to the river. This has resulted in increased levels of sediment loading and above normal turbidity. Channelization and diking of the Colville River has decreased complexity and increased embeddedness, severely limiting habitats necessary for native salmonids at virtually every life stage. Similar conditions exist for many of the lower sections of tributaries.

The Colville River is listed in Section 303(d) of the Federal Clean Water Act for temperature, fecal coliform bacteria, dissolved oxygen, chloride, pH, and ammonia-N. Tributaries of the Colville River in Section 303(d) of the Federal Clean Water Act include: Blue Creek (dissolved oxygen and fecal coliform), Chewelah Creek (fecal coliform, dissolved oxygen, pH, and temperature), Cottonwood Creek (fecal coliform and temperature), Haller Creek (fecal coliform), Huckleberry Creek (fecal coliform), Jump off Joe Creek (fecal coliform) Little Pend Oreille River (fecal coliform), Mill Creek (fecal coliform and pH), Sheep Creek (dissolved oxygen and fecal coliform), Sherwood Creek (fecal coliform), Stensgar Creek (dissolved oxygen, fecal coliform and temperature), and Stranger Creek (fecal coliform).

30.9.1.3 Kettle River

A significant tributary to Lake Roosevelt, the Kettle River flows out of Canada at Ferry, Washington, back into Canada at Danville, Washington, and then back into Washington at Laurier, Washington. The over 25 miles of river between Ferry and Danville is impacted by agriculture and residential development. Two county roads traverse most of the stream course on both sides if the river. Gradient of the river is flat and the channel is broad with few meanders. Habitat complexity is low with little large woody debris. Few deep pools provide limited trout habitat. Areas of riprap along the county roads provide limited riffle habitat.

The river from Laurier to Lake Roosevelt courses through over 25 miles of mostly scenic forested terrain. The gradient is steeper and the river is generally narrower. More pools and riffle and run habitat provide more trout habitat than the upper portion. However, large woody debris is still lacking (Curt Vail, Fish Biologist, WDFW, personal communication).

The largest towns located in the Kettle River watershed are just across the border in Canada (Grand Forks, Greenwood and Midway). Within Washington, small towns with populations of less than 1,000 are located along the Kettle River valley. About 75 percent of the watershed is federally managed forest including Okanogan and Colville National forests. In the Kettle River, water quality generally meets State water quality standards, with the exception of high in-stream temperatures during the summer months in the lower reach of the river between Laurier and the confluence with the Columbia River. Additionally, non-point source water quality degradation in the Curlew Lake area has been documented for bacteria, turbidity and excess nutrients (WDOE 1995).

The total flow of the river, while varying on an annual basis, has declined just slightly since the 1950s similar to trends in precipitation. However, declines have been somewhat greater at Laurier, compared to Ferry, indicating greater declines in flow in the lower portions of the river, which includes Washington (WDOE 1995). Trends in tributary streams have not been identified due to lack of long-term stream flow data.

Some tributary streams get extremely low or cease to flow in late summer.
These include streams located in the central portion of the watershed, including the Curlew Creek area, coinciding with an area of lower precipitation and higher summer evaporation. Although stream flow data are incomplete for these tributary streams, the low flows indicate seasonally limited water availability (WDOE 1995).

30.9.1.4 Other Waters

Tributary habitat on National Forest Service lands range from poor to very good depending upon past and present level of activities. In general, where habitat is poor to fair, road densities are high and many roads are located within the riparian areas of these tributaries. In addition, stream habitat is degraded where the riparian habitat is easily accessible to livestock and in many cases the vegetation is overgrazed (Tom Shuhda, Fish Biologist, Colville National Forest, personal communication, 2003). The natural shape of the valley and channel type form relatively wide and shallow reaches in many streams. Stream temperatures have increased in areas due to the higher bankfull width-to-depth ratio and degraded riparian areas. The resulting warmer water reaches make for marginal salmonid habitat during the hot summer months (Tom Shuhda, Fish Biologist, Colville National Forest, personal communication, 2003). Good habitat areas typically have adequate canopy shading, little disturbance in the riparian area, and low levels of embeddedness.

30.9.1.5 Curlew Lake

Curlew Lake, the largest lake in the north half of Ferry County is located approximately five miles north of Republic, Washington. Combined with Lake Roberta, which is connected via a short channel, it is 921 surface acres. Maximum depth is 130 ft. The lakes' long axis is oriented north and south and is approximately five miles long. Lake elevation is 2,333 ft msl. The highest geographical point in the watershed at 7,135 ft is Copper Butte; with several other high points between 5,101 ft and 7,000 ft. Tributaries to the lake are intermittent with the exception of Trout Creek, which enters the lake from the west. Major land uses in the lake basin include timber harvesting, livestock grazing, and intermittent mining operations.

Curlew Creek is the only outlet and drains into the Kettle River to the north at the town of Curlew. The Kettle River enters the Columbia River between Kettle Falls and Boyds, Washington.

30.9.1.6 Other Lakes

Seven lakes on the Colville Indian Reservation are located within the Subbasin. Most are closed basin lakes with Chara Bench traits and limnological conditions characteristic of eutrophic or meso-eutrophic productivity status. These characteristics, combined with hot arid climatic conditions, create habitat conditions not optimal for salmonids. As early as May, the temperatures in the epilimnion (comprises up to 10 meters of the water column) of these lakes reach over 20º C. There is generally a two-meter thermocline with a 15-degree temperature change between the hypolimnion and epilimnion. The hypolimnion characteristically has lower dissolved oxygen (DO) levels (<5 mg/l) due to a relatively high biological oxygen demand (BOD), nutrient loading, and nutrient cycling.

Off reservation lakes within the Subbasin are managed by WDFW. There are thirty-five lakes managed for trout fisheries. Most are small, relatively pristine waters, located predominantly on the Colville National Forest. These lakes are stocked annually from the WDFW Colville Trout Hatchery with westslope cutthroat and rainbow trout. Over 1 million trout are stocked to provide a recreational fishery (Curt Vail, WDFW, personal communication, 2003).

30.9.2 Out-of-Subbasin Effects and Assumptions

Hydroelectric development along the Columbia River upstream and downstream of the Upper Columbia has drastically altered the historic hydrograph of the region along with the structure and function of the aquatic ecosystem. There are an additional ten dams downstream of Grand Coulee Dam that have undoubtedly had significant impacts on the Upper Columbia Subbasin, which must be taken into consideration with the potential reintroduction of migratory salmon, steelhead, and Pacific lamprey. The blocked anadromous runs of salmon and steelhead have eliminated a source of marine-derived nutrients to an already oligotrophic system. Studies have suggested that marine-derived nutrients are an important component of the nutrient cycle for fish health and survival (Stockner 2003). Due to the elimination of marine-derived nutrients, primary and secondary productivity has likely been affected, although not quantified. Other out-of-Subbasin influences include activities upstream in the Spokane Subbasin.

30.10 Limiting Factors and Conditions

30.10.1 Physical Habitat Alterations/Limiting Habitat Attributes

QHA was utilized to compare historic versus current physical stream conditions with respect to 11 habitat attributes. Details of the analysis method are provided in Section 3. QHA model does not determine which habitat attributes are most biologically limiting, but does identify which physical attributes have undergone the greatest deviation from reference conditions. These results, coupled with knowledge of local biologists and biological status of the focal species, can assist in identifying key limiting factors. This section provides QHA results on a Subbasin level for Upper Columbia Subbasin. Results specific to each focal species are discussed in each focal species section.

In the Upper Columbia Subbasin most areas were delineated into smaller watersheds with the exception of Sherman, Sheep, Deep, and Cottonwood creeks, which were delineated into 12 reaches (Map UC-7, located at the end of Section 30). Using the QHA model, habitat conditions were analyzed where rainbow (adfluvial and resident) and kokanee were historically and are currently present. Table 30.13 presents reaches having less than optimal habitat attributes in the reference condition.

Table 30.13. Reaches that were ranked as containing less than optimal habitat conditions in the reference condition

Sequence	Reach Name	Habitat Attribute < Optimal
21	Deep Ck	Obstructions
24	Middle Sheep Ck	Obstructions
25	Upper Sheep Ck	Obstructions
33	Boulder Ck	Obstructions
36	Middle Sherman Ck	Obstructions
53	Lower Ninemile Creek (Lake to Falls)	Riparian Condition, High and Low Flow, Pollutants
54	Ninemile Creek 2 (Confined reach)	Fine Sediments, Low and High Flow, Low Temperature, Pollutants, Obstructions
55	Ninemile Creek 3 (Meadow reach)	Riparian Condition, Habitat Diversity, Fine Sediments, Low and High Flow, Low Temperature, Pollutants
56	South Fork Ninemile Creek	Riparian Condition, Habitat Diversity, Low and High Flow, Low Temperature, Pollutants
57	Upper Ninemile Creek	Fine Sediments, Low and High Flow, Low Temperature, Pollutants
59	Lower Wilmont Creek (Lake To falls)	Riparian Condition, High and Low Flow, Low Temperature
60	Middle Wilmont Creek (Unconfined)	Habitat Diversity, Fine Sediments, High and Low Flow, Low Temperature
61	Upper Wilmont Creek (Higher Gradient)	High and Low Flow, Low Temperature
62	Nez Perce Creek	Habitat Diversity, High and Low Flow, Low Temperature
65	Lower Stranger Creek (To Cornstalk)	Riparian Condition, Channel Stability, Habitat Diversity, Low and High Flow, Low Temperature, Obstructions
67	Upper Stranger Creek	Fine Sediment, High and Low Flow, Low Temperature
68	Lower Cornstalk Creek	Channel Stability, Fine Sediment, High and Low Flow, Low Temperature
70	Upper Cornstalk Creek	Riparian Condition, Channel Stability, Habitat Diversity, Fine Sediment, High and Low Flow, Low Temperature
72	Granite Creek	Habitat Diversity, Fine Sediment, High and Low Flow, Low Temperature
73	Beaver Dam Creek	Habitat Diversity, High and Low Flow, Low Temperature
74	Lower Hall Creek (Canyon)	Riparian Condition, Habitat Diversity, Low Flow, Obstructions
75	Middle Hall Creek (Meadow)	Habitat Diversity, Fine Sediment, Low Flow, Low Temperature
76	Onion Creek (No. Fork Hall Creek)	Riparian Condition, Habitat Diversity, Low and High Flow, Low Temperature, Obstructions
77	Lower Lynx Creek (Unconfined)	Riparian Condition, Habitat Diversity, Low and High Flow, Low Temperature, Obstructions
78	Middle Lynx Creek (Confined/Falls)	Low Flow, Low Temperature
79	Upper Lynx Creek	Habitat Diversity, Low and High Flow, Low Temperature, Obstructions
80	Upper Hall Creek	Riparian Condition, Habitat Diversity, Low Flow, Low Temperature, Obstructions
81	Sitdown Creek	Riparian Condition, Fine Sediments, Low Flow, Low Temperature, Pollutants
82	Stall Creek	Channel Stability, Habitat Diversity, High and Low Flow, High and Low Temperature
83	West Fork Hall Creek	Habitat Diversity, Low Flow, Low Temperature, Pollutants
84	North Fork Hall Creek	Habitat Diversity, High and Low Flow, Low Temperature
87	Lower Barnaby Creek (Reservation)	Low and High Flow, Low Temperature
88	Upper Barnaby Creek (State)	Habitat Diversity, Fine Sediment, High and Low Flow, Low Temperature, Obstructions

Sequence	Reach Name	Habitat Attribute < Optimal
92	Kettle Falls To Ryan Narrows	Obstructions

The habitat parameters with the greatest deviation from reference conditions vary by species and are presented in Table 30.14. This table should be interpreted as an indication of the types of habitat parameters that are problematic for the focal species in the Subbasin as a whole. Some reaches had more than one habitat parameter that was ranked as being equally deviant from the reference, hence the number of reaches listed adds up to more than the total number of reaches ranked. Most reaches had more than one habitat parameter that is currently ranked less than the reference. Table 30.14 only lists those habitat parameters that had the greatest deviation from reference, not all the parameters that could be less than optimal.

Degradation of habitat diversity and riparian areas are by far the leading habitat attributes that have most greatly impacted habitat quality for resident redband/rainbow trout in the Subbasin (Table 30.14). Similarly, habitat diversity as well as obstructions and fine sediments are the habitat attributes deviating most frequently and to the greatest degree from reference conditions with respect to the analysis of adfluvial redband/rainbow trout (Table 30.14). While oxygen and obstructions were the most common habitat attribute identified as deviating the greatest from the reference condition when evaluating kokanee salmon.

Table 30.14. Habitat conditions with the greatest deviation from reference conditions as presented in the QHA model output for each focal species in Upper Columbia Subbasin. In parentheses is the number of reaches or watersheds with the particular habitat attribute exhibiting the largest deviation within that area.

Adfluvial Redband/Rainbow (33)	Resident Redband/Rainbow (68)	Kokanee (22)
Habitat Diversity (13)	Habitat Diversity (32)	Oxygen (13)
Obstructions (8)	Riparian Conditions (22)	Obstructions (5)
Fine Sediments (5)	Obstructions (21)	Fine Sediments (1)
Riparian Condition (2)	Channel Stability (8)	Pollutants (1)
Channel Stability (1)	Fine Sediment (8)	High and Low Flows (1)
Low Flow (1)	Low Flow (7)	Channel Stability (1)
	High Temperature (5)	
	Oxygen (2)	
	Low Temperature (1)	
	Pollutants (1)	

30.10.2 Description of Historic Factors Leading to Decline of Focal Species

30.10.2 Lake Roosevelt

The most significant limiting factor to fish populations managed in Lake Roosevelt is hydro-operations. In 1999, collection reports from the Rock Island Dam bypass facility confirmed the presence of 986 kokanee and 234 floy-tagged rainbow trout that were released behind Grand Coulee Dam in 1998 and 1999 (LeCaire 1999). Entrainment of fish, specifically rainbow trout and kokanee salmon, severely limits the fishery in Lake Roosevelt.

In addition to increased emigration, Grand Coulee Dam and other upriver hydroelectric project operations (outside of the Intermountain Province) are detrimental to habitat-related parameters, therefore likely limiting fish populations. Spilling at upriver projects creates total dissolved gas (TDG) levels in Lake Roosevelt that exceed clean water standards (>110 percent). It is hypothesized that these elevated levels are causing significant mortality to certain fish species throughout the reservoir, including net pen fish that cannot avoid high levels of TDG because of their confinement to surface waters. Furthermore, drastic fluctuation of reservoir elevation frequently changes the littoral zone, thus limiting productivity. The lack of stable littoral habitats in the lake has resulted in virtually no macrophyte communities and severely depressed benthic macroinvertebrate communities. Ultimately, the lack of littoral habitats limits fish communities that depend on such habitats. Impoundment has also eliminated salmonid spawning and rearing habitats by replacing rapids and gravel bars with deep zero velocity lacustrine environments with sand as the dominant substrate. Therefore the lack of suitable spawning and rearing habitats are limiting natural salmonid production in the inundated sections of the Columbia River. Changing flow dynamics within the reservoir has the potential to dewater salmonid redds and increases silt deposition over incubating eggs.

Since Lake Roosevelt has short water retention times (8-65 days), the reservoir could lack dimictic traits characteristic of deep lacustrine environments in eastern Washington. The lack of stratification during the summer creates uniform water temperatures throughout the water column. As a result, the uniform temperature regime creates limited refugia of preferred temperature areas that fish are known to prefer (Cichosz et al. 1999).

Data presented in Cichosz et al. (1999) suggests that periphyton growth and colonization in Lake Roosevelt appeared to be inhibited during summer drawdowns and was benefited during refill conditions in the lake. Efforts to model zooplankton density and biomass to environmental variables (chlorophyll a, secchi depth, daily WRT, daily temperature, reservoir inflow, reservoir outflow, and reservoir elevation) were generally unsuccessful using simple regression analyses (Cichosz et al. 1999). On the other hand, Underwood and Shields (1995) were able to show that zooplankton density generally decreased as water retention time decreased below 30 days. Zooplankton is the primary food source for kokanee, rainbow trout, suckers, whitefish and fry fishes of all species (Cichosz et al. 1999). Thus, hydro-operations, which reduce water retention time, reduce food availability for fish and reduce fish carrying capacity of the lake.

Zooplankton abundance (fish food availability) does not appear to be an overriding limiting factor, evidenced by current growth rates of kokanee. However, if substitution or mitigation actions build a kokanee population to the size necessary to achieve an annual harvest goal of 300,000 kokanee, food production will most likely be a limiting factor resulting in reduced fish growth and perhaps survival (Cichosz et al 1999). Continued monitoring of the zooplankton community is imperative to determine fish food availability and identify actions, which enhance zooplankton densities.

Tributary spawning and rearing habitats limit Lake Roosevelt salmonid fish production (Beckman et al. 1985). Furthermore, natural recruitment of kokanee in Lake Roosevelt is limited, since annual drawdowns expose shoreline redds (Stober et al. 1981). As a result, hatchery and net pen production are used to overcome the production limitation.

Limiting factors directly related to hatchery operational strategies and success in terms of survival to the creel and adult return include early maturity (precocity) and skewed sexual ratios (McLellan et al. 2003). In 2002, hatchery operations have employed thermal manipulation strategies and use of alternative protein source feeds to lower the incidence of early maturing fish.

30.10.3 Curlew Lake

The stocking of silver trout in the late 1940s and kokanee salmon in the 1970s failed to produce a self-reproducing population; currently these species are absent from the Lake. The failure of these stocking efforts was most likely due to the lack of perennial tributaries and the severe stratification of the lake during summer months, which rendered and continues to render most of the lake volume anoxic. In addition, the only perennial tributary to Curlew Lake, Trout Creek, has an intermittently impassable culvert, which is positioned a short distance upstream from its mouth. Low flows in the fall season prevent fish from passing through the culvert, and spring freshets are too strong for fish to navigate through the culvert in most years.

30.10.4 Kettle and Colville Rivers

Timber production, grazing, road construction, water diversions, and recreational uses have all led to a decrease in habitat quality in the Kettle and Colville rivers. These activities have increased sediment loads, altered seasonal water regimes and destabilized streambanks, resulting in simplification of stream habitats and an overall decrease in water quality. These impacts, combined with stocking of exotic species, have resulted in significant reduction in the ranges of redband and cutthroat trout. While it is uncertain if bull trout were historically present in the Kettle River above Cascade Falls or in the Colville River above Meyers Falls, although their have been bull trout sightings within the last fifteen years in the Kettle River.

For a more detailed analysis of specific limiting habitat factors in the Upper Columbia Subbasin see sections on focal species where limiting factors based on QHA results and key findings for each focal species are discussed.

30.10.5 Description of Historic Factors Leading to Decline of Focal Species

Hydroelectric operations at Chief Joseph and Grand Coulee dams block anadromous and resident fish migration. This has resulted in the reduction of the native salmonid species assemblage by 64 percent (Scholz et al. 1985). Loss of salmon and steelhead and the change from a fluvial to a lacustrine environment negatively impacted the ecosystem and forever changed the ecological structure of the area above the dam. The current fish assemblage is a result of anthropogenic actions that have created an unbalanced, ever shifting, perturbated lotic/lentic hybrid reservoir-based ecosystem. Anadromous fish have been absent in this Subbasin for more than 60 years and has allowed people to forget that anadromous fish dominated the native fish assemblage and were a keystone component to the ecosystem (Lichatowich 1999; Willson and Halupka 1995; Cederholm et al. 1989; Kline et al. 1990; and Mills et al. 1993).

Resident fish species were also impacted through habitat alteration (inundation), lost productivity (absence of marine-derived nutrients), habitat degradation relating to land-use practices (hydroelectric development, agriculture, grazing, logging, and municipal development), and altered aquatic communities (exotic introductions) attributable to Euro-American settlement. The current resident fish assemblage has little resemblance to the pre-impoundment assemblage. Currently, bull trout, westslope cutthroat trout, and redband trout are rarely encountered in Lake Roosevelt (Cichosz et al. 1999; Underwood and Shields 1995). Moreover, tributaries of Lake Roosevelt contain limited populations of adfluvial stocks of salmonids. As a result, a majority of the current salmonid assemblage consists of nonnative coastal rainbow trout, brook trout, and brown trout. The non-salmonid community and abundance structure has changed from an assemblage/abundance of mostly white sturgeon, lamprey, and burbot to that of walleye and smallmouth bass. In addition, lake whitefish have displaced mountain whitefish populations (Cichosz et al. 1999). Since impoundment, white sturgeon populations have declined to unhealthy levels, with the only known spawning location just below the confluence with the Pend Oreille River in British Columbia.