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Columbia Basin System Planning

SALMON and STEELHEAD PRODUCTION PLAN

YAKIMA RIVER SUBBASIN

Supplement 1

September 1, 1990

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SUPPLEMENT 1
Appendices 1 - 7

Columbia Basin System Planning

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APPENDIX 1

Summary of Aquatic Habitat Provided by Major Reaches of the Yakima and Naches Rivers and Their Principal Tributaries

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The following summary is presented in a tabular format with the major reaches of the Yakima River and Naches River listed first and their respective tributaries second. It should be noted that this summary was formed by the initial data collected in the Bureau of Reclamation's water supply analysis study for potential Yakima/Klickitat outplanting sites.

Legend: P=Poor, F=Fair, G=Good, E=Excellent

MAINSTEM YAKIMA

Mouth to Kiona (29 miles)

This is the main fall chinook spawning area, but other anadromous salmonids use this reach only for overwintering because of high summer temperatures. (The main overwintering area for spring chinook and steelhead is above Prosser Dam, possibly in the vicinity of the Naches confluence.) The area contains good riffles and pools. The riparian corridor is fair. Spawning gravel contains deposited sediments, but the problem here is probably less severe than in reaches further upstream.

	PROBLEMS						
HAS ANAD. FISH?	SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	F	G	P-F	None	F... Riprap, grazing	G	

Kiona to Prosser Dam (16 miles)

This is a fall chinook spawning area used by other anadromous salmonids only for overwintering because of high summer temperatures. The river flows through a narrow valley, has a fairly swift current and few gravel beds. As judged by suspended sediment, sedimentation is probably worse than in mouth to Kiona reach. This reach may have the worst overall water quality in system; dissolved oxygen may be a problem in deeper areas in summer, ammonia concentrations may reach toxic concentrations for 10 miles below Prosser sewage treatment plant during low flows, and pesticide concentrations highest in drainage. Riparian corridor is poor to fair. Many smolts may be lost to predators at below the Chandler bypass outfall and in Chandler Canal in front of the screens.

	PROBLEMS						
HAS ANAD FISH?	SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	P	P	P...lacks dilution.	Low flow	F... grazing.	P: muck, bedrock.	NH_3, pesticides.

Prosser Dam to Yakima (60 miles)

The reach around Granger (approximately RM 80) is a secondary fall chinook spawning area, and the upper 37 miles (Ahtanum Creek to Satus Creek) probably supports some steelhead spawning and rearing. The lower 23 miles of this reach is used by anadromous salmonids mainly for overwintering because of high summer temperatures.

The lower 36 miles of this reach (below Granger Drain, RM 83) has a "slough-like" character, being deep and slow moving, with a silt/algae bottom and very few riffles. The upper 24 miles is more riverine, with a fair number of riffles and much less fine organic material in the substrate.

Relative to unregulated flows, this is the most dewatered reach in the Yakima mainstem. Low natural flow in summer combined with proximity to major irrigation returns also make this the reach most severely impacted by sedimentation, although the sedimentation improves significantly above Granger. Although instream cover is scarce, the riparian corridor is either quite brushy (below Granger), or has reasonably dense stands of trees (above Granger) and would have to be classed as fair to good. The reach from Sunnyside to Prosser is associated with large smolt mortalities when flows are low.

HAS ANAD FISH?	PROBLEMS SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	P	P	P	Flows impede adults.	F-G	P-F:muck, algae in lower 36 miles.	smolt losses.

Yakima to Ellensburg (40 miles)

Most of this reach lies in the deep, narrow Yakima Canyon. This is a fast-flowing reach with few gravel bars and little spawning above Pomona. It is, however, the primary rearing area for spring chinook parr from upper Yakima spawning grounds, and in the reach from Roza Dam to Selah, a secondary spawning area as well. Water quality in this reach is good to excellent, with two exceptions. First, Roza Dam acts as a settling pond and, when Roza pool is drained, large volumes of sediment are deposited on the redds below the dam. Second, wakes from power boats in the pools above Roza are causing some bank erosion and thus turbidity and sedimentation problems. The riparian corridor in the lower reaches of this section, roughly from Yakima (RM 114) to the Harrison Bridge (RM 122), has suffered from overgrazing and riprapping associated with the construction of Interstate Highway 82. A relatively small (50-150) number of spring chinook redds are deposited late in the season in the reach below Roza Dam and above the Naches confluence. Discharge in the canyon is usually too great for optimal rearing during irrigation season, and sometimes may be too little during winter. The canyon area probably would benefit from more instream cover (boulders, large organic debris).

The area near the Naches confluence is probably important overwintering habitat, as is the Yakima Canyon. Both reaches occasionally experience winter flows low enough to impact production adversely.

HAS ANAD FISH?	SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
	PROBLEMS						
yes	F-G	G	G	None	P-G:bank sloughing, riprap in lower reaches.	G...some bedrock.	power boats.

Ellensburg to Easton Dam (47 miles)

The upper portion of this reach, from Cle Elum (~RM 183) to Easton Dam (RM 202), contains the best spring chinook spawning area in the upper Yakima, and could also be excellent steelhead spawning and rearing habitat. This reach contains many excellent gravel bars and resting pools. Cover, especially large organic debris, is abundant. The riparian corridor is excellent except for clusters of summer homes where banks have been riprapped and vegetation removed.

The lower half of this reach does not, however, afford such excellent habitat. Areas of severe bank sloughing are patchily distributed in the 19-mile stretch between Wilson Creek (RM 147) and Taneum Creek (RM 166). This damage is primarily attributable to streambank grazing and other agricultural practices.

Low flows during winter and early spring may be a problem here; early spring flows must not be so low as to impede fry in their dispersal to primary rearing areas in the Yakima Canyon.

There are about 25 to 30 small, inadequately screened diversions on the Yakima above the Naches confluence. All of these represent a substantial hazard to dispersing fry, especially those diversions above the Yakima Canyon.

HAS ANAD FISH?	SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
	PROBLEMS						
yes	E	G	E	None	G	E	

Easton Dam to Lake Keechelus

This reach was made accessible in the summer of 1989 when the old, non-functional ladder at Easton Dam was replaced. With the exception of seasonally regulated instream flows, habitat quality is superb. The stream is meandered and braided with excellent gravelly substrate, a lush riparian and abundant large organic debris. This reach has the "look" of excellent coho habitat, but would probably afford nearly as good an environment for spring chinook and steelhead.

The major factor limiting production here will be low flows during the winter and early spring; and prolonged, excessively high and fluctuating flows in the summer. Of the two flow problems, the low flows form October through April (the period of refilling for Keechelus Reservoir) are the more serious, as they can result in many dewatered redds in dry years. There is, however, little doubt that operational changes in reservoir operation can reduce much of this problem. Moreover, the problem of inadequate winter-spring flows would be eliminated if a project to divert water from Cabin Creek and Silver Creek to Kachess Reservoir were implemented. Under this scheme, fisheries managers would be able to use as necessary an amount of water in Keechelus Reservoir equal to the amount diverted from Cabin and Silver Creeks to Kachess to augment instream flows in the upper Yakima. Although this project would work best in combination with another proposed project -- the renovation of antiquated check structures on Sunnyside Canal -- that would boost smolt passage flows in the lower river, there is little doubt that flexible use of the diversion scheme alone would essentially eliminate the problem.

HAS ANAD FISH?	PROBLEMS SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
No	E	P, but correctable	E	After '89 none.	E	E	

NACHES RIVER

Mouth to Wapatox Dam (17 miles)

This reach is 60 percent braided with many good gravel bars and a good riparian corridor. There is a lack of cover, especially large organic debris, below Cowiche Dam. Temperature is not usually a problem, rarely exceeding 70 F. Water quality is excellent in this reach, as it is throughout the Naches system, but instream flows frequently become critically low from mid-July through mid-September in the reach between the Wapatox Canal inlet and outfall.

This reach is considered prime summer chinook spawning and rearing habitat, and is rated poor to fair for spring chinook and coho, and fair to good for steelhead. Much of this interspecific difference in habitat suitability is attributable to the differential impact of the typical instream flow patterns in the reach. Instream flows between Wapatox Dam and the power plant outfall are too low for optimal rearing and adult passage from July through mid-September, when releases from Naches system reservoirs are increased ("flip-flop" reservoir control). Wapatox Canal diverts from 300 cubic feet per second (cfs) to 500 cfs from the Naches, while four smaller diversions downstream take an additional 100 cfs. From mid-July through mid-September, these diversions leave about 150 cfs in a reach with a mean unregulated discharge of about 1,800 cfs.

Indeed, instream flows in this reach in the period preceding flip flop are critically low (in the "Montana method" sense) more frequently than any other mainstem reach in the subbasin. This period of low flow coincides with much of the spring chinook spawning period, but would precede most summer chinook spawning and would follow all steelhead spawning. The reach would therefore provide better habitat for summer chinook and steelhead than spring chinook because the former would encounter better spawning flows than the latter. Moreover, summer chinook, unlike spring chinook, coho and steelhead, would smolt and begin emigrating from the reach as July subyearlings, and thus would escape the period of poor rearing conditions.

	PROBLEMS						
HAS ANAD FISH?	SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	G	P-G	E	None	G	G...some large rocks.	

Wapatox to Bumping (28 miles)

This reach is one of the best spawning reaches in the subbasin -- abundant spawning beds interspaced with deep, clear resting pools, near pristine riparian and abundant instream cover. Flows are seldom too low to cause problems.

HAS ANAD FISH?	PROBLEMS						
	SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	G-E	G-E	E	None	G-E	G-E	

NACHES RIVER TRIBUTARIES

Cowiche Creek (33 miles with South Fork)

Cowiche Creek enters the Naches from the east at RM 2.7. A survey in July 1988 indicated that Cowiche Creek has many miles of good to excellent spawning and rearing habitat for steelhead and coho. Instream flows in the mainstem and in most reaches of the South Fork are permanent and sufficient to support rearing despite substantial irrigation withdrawals. Water temperatures were favorable, ranging from the low to upper 50s F. Riparian vegetation was dense along most reaches, even in areas of residential development or cropland. Stream configuration and cover provided good to excellent rearing habitat in most areas. A moderate gradient was associated with many pools, riffles and glides. Large organic debris was abundant, and banks were stable in all, but a few locations. It was judged that there were enough gravel bars for spawning to seed the habitat fully.

In decreasing order of importance, the major problems in the Cowiche system consist of migration barriers, low flows in the North Fork, and riparian degradation on the North Fork and South Fork. A rubble check dam at the mouth of the creek diverts water into the Yakima City Canal. This structure, and a wooden plank diversion dam just below the confluence of the North Fork and the South Fork (RM 7.5), would probably be passable at high flows. However, three concrete diversion dams on the South Fork (RM 1.3, RM 3.9 and RM 4.4) represent total barriers at all flows. Except for the City of Yakima diversion at the mouth of the creek, all diversions are unscreened. A debris jam at a railroad trestle at RM 5.8 on the mainstem constitutes a migration block now, and there is the potential for jams at several other crossings. Beaver dams are fairly common on the South Fork, and one, just above the confluence of Reynold's Creek (RM 11.8), might constitute a migration barrier. Flows in the North Fork were too low to provide rearing habitat except in the lower two to three miles (the North Fork dried up at RM 5.9). Bank sloughing due to overgrazing was severe on the South Fork from RM 10 to about RM 12, and along much of the lower three miles of the North Fork. The overall impact of overgrazing is, however, small; siltation was minor except for the North Fork where low flows promoted settling.

Cowiche Creek could be a major producer of steelhead and coho today (and perhaps a minor producer of spring chinook) if adult passage facilities were installed at five diversion dams, if the three diversions on the South Fork were screened, and if the debris jam under the railroad trestle was removed. In addition, if the check dam at the mouth of the creek were redesigned to permit adult passage while still backing up water, lower Cowiche Creek and a number of intersecting canals could be used as off-channel winter refuges for pre-smolt spring chinook and steelhead.

	PROBLEMS						
HAS ANAD FISH?	SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	G	F-G	G.	yes	G-E	G	

Tieton River (21 miles to Rimrock Reservoir)

The Tieton enters the Naches River from the south at RM 17.5. Although the Tieton was historically a major producer of spring chinook, flip-flop storage control makes successful spawning in the Tieton extremely unlikely. When Rimrock reservoir is refilling in the winter, discharge is very low (100-200 cfs or less), whereas during flip-flop (mid-September to mid-October), discharge is quite high (800-1000 cfs or more). Whatever salmon redds may be constructed in the fall are probably dewatered in the winter. Flows for steelhead, which spawn in April and emerge in July and August, are much more favorable, at least for the period of early rearing. Subyearlings are, however, probably flushed from the system during flip flop, and it is debateable whether the Tieton has more potential for steelhead production than salmon.

Rimrock Dam below Rimrock Lake represents a permanently impassible barrier, and Yakima-Tieton diversion dam at RM 14.5 is a barrier to upstream migration at low flows.

HAS ANAD FISH?	PROBLEMS						
	SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	G	P	G	yes	G	F...large rocks.	

Rattlesnake Creek (24 miles)

Rattlesnake Creek enters the Naches River from the south at RM 27.8. Although long, this stream carries little water. The upper half of the drainage is probably unusable by anadromous salmonids, either because of too little water or too steep a gradient. Some spring chinook spawning does occur in this stream, but low flows in August and September keep this to a minimum. Instream flows in the period September through April are much better, and conditions are much more favorable for steelhead spawning. The lower mile (below the Little Rattlesnake) has been channelized, but the habitat above this point is generally good.

HAS ANAD FISH?	PROBLEMS						
	SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	G	F	E	None	G above confl. L. Rsnk.	G but bed rock in canyon.	

Nile Creek (13 miles)

Nile Creek enters the Naches River from the south at RM 29.4. Nile Creek is fairly long, and carries adequate flows for steelhead (and perhaps coho) rearing through most of its length. It is inaccessible to salmon due to low flows in the fall, but probably supports a small run of steelhead today. The riparian corridor is generally good throughout the drainage, and no diversions have been identified.

HAS ANAD FISH?	PROBLEMS SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	G	F	G	None	G	G	

Bumping River (17 miles)

The Bumping River "becomes" (has its name changed to) the Naches River at the confluence with the Little Naches at RM 44.6 of the Naches. A substantial amount of spring chinook spawning occurs on the Bumping, and the potential for steelhead exists as well. This stream has many bouldery reaches unsuitable for spring chinook spawning, but probably adequate for steelhead. It also suffers to a lesser degree from the same problem that afflicts the Tieton; discharge during the spawning period is substantially higher than during the incubation period. Otherwise the Bumping affords excellent habitat below the permanent barrier of Bumping Dam.

HAS ANAD FISH?	PROBLEMS SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	E	F-G: flashy	G	None	G, some riprap.	F-G: bouldery.	

Little Naches River (21 miles with North Fork)

The Little River enters the Naches River from the west at RM 44.6 (the mouth of the Little Naches marks the upstream end of the Naches River and the downstream end of the Bumping). Until recently, the Little Naches represented no more than a minor spring chinook producer, with moderate amounts of spawning in the lower 4.4 miles (below Salmon Falls). A fishway over the formerly impassible falls was finished in 1988 along with an extensive instream restoration project in the area below the falls, which had been degraded by a severe flood in the late 1970s. The fishway opens up about 18 miles (252,853 square yards) of pristine habitat suitable for spring chinook, steelhead and coho. Spawning gravel is very abundant, the riparian zone is excellent, summer flows are adequate and large organic debris and instream cover are plentiful. The major limiting factor for this new system will probably be rearing habitat during the summer low flow period. There is much concern that clearcutting and fires in the upper drainage may increase peak flows, possibly to damaging levels, as well as decrease already marginal summer low flows. There is now, however, no conclusive evidence of a change in the hydrograph. Deposition of fine sediments have increased since the initiation of large-scale clearcutting.

HAS ANAD FISH?	PROBLEMS SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	F-G	P-G	E	None	E above RM 4.4.	G but some fines & large rock.	

American River (24 miles)

Next to the Easton-Cle Elum reach the upper Yakima, this is the most productive spring chinook spawning area in the subbasin. Over its 24 miles, the American has a mean gradient of about 1 percent, although in its lower five miles the gradient is about 2 percent. This steep, lower section is filled with large boulders and choked with fallen trees, and is the only section not affording excellent spring chinook spawning. The middle and upper sections have abundant spawning gravel, and deep, well protected resting pools average about six per mile. The river enters a narrow gorge 14 miles upstream, above Union Creek, where it drops 100 feet in 400 yards in a series of cascades. Under low flows these cascades probably constitute a barrier to upstream passage. Production in the American River is probably limited by low flows in the summer and fall, which typically range from 50 cfs to 300 cfs.

HAS ANAD FISH?	PROBLEMS SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	E	E	E	yes (?)	E	E	

YAKIMA RIVER TRIBUTARIES

Corral Canyon Creek (5 miles)

Corral Canyon Creek enters the Yakima River from the east at RM 33.5. This stream is below the historic spring chinook production area. There is an unscreened diversion into Kiona Canal near its mouth. This diversion is impassable during the irrigation season, but if the check boards are removed at the end of the season, Corral Canyon Creek should be accessible to steelhead. With good summer flows and good riparian conditions, this stream could be a producer of steelhead (and possibly coho) if the diversion near its mouth were screened.

HAS ANAD FISH?	PROBLEMS SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
No	?	G(?)	G (?)	At mouth.	G	(?)	

Spring/Snipes Creek (16 miles)

Snipes Creek enters the Yakima River from the east at RM 41.8. Spring and Snipes creeks are below the historic spring chinook production area. These creeks, which join a quarter of a mile from the Yakima confluence, are used as a wasteway conduit in the summer, and constitute a false attraction hazard to upper

Yakima spring chinook spawners. Discharge in Snipes Creek drops precipitously in the fall and winter, and spawning gravel is scarce in both creeks. Nonetheless, this system obviously has some potential for steelhead and coho spawning and rearing as small numbers of both spawn and rear there now. Pesticide concentration in irrigation returns causes some concern. In the past, sizeable numbers of adult spring chinook have been lost in Snipes Creek because of the false attraction flows. A permanent adult barrier should be installed at the mouth of Snipes Creek to prevent these losses.

	PROBLEMS						
HAS ANAD FISH?	SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	P-F	P-F	P-F	None	P-F	P-F:mucky in many places.	pesticides; false attraction

Satus Creek system (49 miles)

Satus Creek enters the Yakima River from the west at RM 69.6. The principal tributaries to Satus Creek include Mule Dry Creek (18 miles), Dry Creek (39 miles), Logy Creek (14 miles to falls) and Kusshi Creek (11 miles). Only Logy Creek has sufficient fall flows for salmon spawning. Spring chinook were reported to be abundant in Logy Creek before 1910, and there have been unverified reports of spawning chinook in Logy Creek in recent years. With the historic exception of Logy Creek, the Satus system is not now nor was it historically a significant spring chinook producer. It is, however, the primary producer of steelhead in the entire subbasin. The lower six miles of Satus Creek is slow moving with a mud-sand streambed and a few isolated riffles. The remainder of the system, however, contains considerable spawning area. Gradient is slight (0.2 percent to 0.3 percent) in the lower 37 miles of Satus Creek, thereafter becoming quite steep (1 percent to 2 percent). There are only three unscreened diversions on Satus Creek, the Wapato Irrigation Project at RM 10 (unused for a number of years), the nearby Shattuck diversion, and the Holwegner diversion at approximately RM 28.

With the exception of Logy Creek, all of the Satus tributaries would be more productive if summer flows were higher. Mule Dry Creek, Dry Creek, Kusshi Creek and Wilson Charly Creek normally dry up in one or more downstream reaches by September at the latest. There are good sites for small impoundments to provide additional water for instream flows at a number of places in the Satus drainage (K. Mitchell, YIN, pers. commun.): at the "Lakebeds" area, just below the crest of Satus Pass at the source of Satus Creek; in "Starvation Flats," near the headwaters of the North Fork of Dry Creek; a site near the headwaters of Kusshi Creek; and perhaps an area near the headwaters of Mule Dry Creek. A 2,400-acre-foot impoundment can provide four months of flows at 10 cfs. Reservoirs of this size on the headwaters of Satus Creek and especially on the North Fork of Dry Creek, Mule Dry Creek and Kusshi Creek, would allow steelhead juveniles year-round residence in their natal tributary, probably increasing egg-to-smolt survival and making large portions of the drainage much more productive.

Fairly large areas of the Satus Creek drainage have suffered riparian damage from overgrazing. Much of this damage consists primarily of bank sloughing; many impacted areas still support fair numbers of large trees that often provide adequate shading. These areas have been prioritized by productive potential and need for restoration as follows. In descending order of importance: Satus Creek from Dry Creek (RM 18.7) to High Bridge (RM 30.1); Dry Creek from the mouth to a point about three miles above Elbow Road crossing (~RM 27); Logy Creek from the mouth to the first crossing above Sheep Camp (~RM 2.5); the entire Mule Dry Creek drainage (18 miles); and lower Satus Creek from Mule Dry Creek (RM 8.5) to the mouth.

HAS ANAD FISH?	PROBLEMS SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	F-G	F-G	G	None	F-G	G	Lack of summer flow RM 30-24.

SATUS CREEK TRIBUTARIES

Mule Dry Ck.

HAS ANAD FISH?	PROBLEMS SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	P	P	G but warm.	None (but dry spots June-Oct)	P-F	F-P: much fine material.	

Dry Ck.

HAS ANAD FISH?	PROBLEMS SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	F	F-P: poor below Elbow.	G but warm.	Falls at RM 21.	F-G	F-G: some large rock.	

Logy Ck.

HAS ANAD FISH?	PROBLEMS SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	F	G	G	Falls at RM 14.	F-G	G: some large rock.	

Kusshi Ck.

HAS ANAD FISH?	PROBLEMS SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	G	P in lower section.	G	None	G	G	

Wilson Charlie Ck.

HAS ANAD FISH?	PROBLEMS SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	G	P	G	None	G	G but some fines.	

Toppenish/Simcoe system (Toppenish=70 miles, Simcoe=32)

Toppenish Creek enters the Yakima River from the west at RM 80.4. Toppenish Creek is 70 miles long, Simcoe Creek is 18.9 miles long, the North Fork and South Fork of Toppenish Creek are about 18 and 6 miles long, respectively. The North and South forks of Simcoe Creek are 13.9 and 12.8 miles long. The system is thus quite large and, with improvements, has the potential to be a major producer of steelhead and perhaps of coho as well. Indeed, as recently as the early 1950s, the Toppenish Creek system produced more steelhead than the Satus Creek system, which currently produces well over half of all steelhead in the subbasin (Wendell Oliver, YIN, personal communication, 1989). Toppenish Creek is not now, nor apparently has it ever been, a significant producer of spring chinook, although a limited amount of fall chinook spawning may occur in the last few miles.

The lower 33 miles of Toppenish Creek, up to the confluence with Simcoe Creek, have a low gradient, are extremely braided, and are heavily impacted (both diversions and wastewater returns) by the Wapato Irrigation Project (WIP), the largest irrigation system in the Yakima Valley. Indeed, the connections between Toppenish Creek and WIP's major return ditches are so intricate and extensive that lower Toppenish Creek and the major fish-bearing irrigation returns are best considered as a unit. "Mud Lake Drain" discharges WIP wastewater and operational spills are into Toppenish Creek just below the Simcoe Creek confluence (RM 32.7); this water is subsequently diverted for re-use at the Unit II Pump (RM 26.5), and the Satus II diversion (RM 3.6). In addition, substantial quantities of mixed Toppenish Creek/WIP water are diverted from Toppenish Creek at RM 26.5 and re-routed via a flood control ditch to Marion Drain, the main return drain for the WIP system. Marion Drain runs east-west, and receives discharge from a north-south drain, "Wanity Slough," about five miles from its confluence with the Yakima River. Both Marion Drain and Wanity Slough are, primarily from delayed inflow of groundwater, perennial, and both support small populations of steelhead and rainbow trout at the present time. Marion Drain also supports a small population of URB fall chinook, and some fall chinook spawning may occur in Wanity Slough. Moreover, a substantial number of Toppenish Creek steelhead spawners gain access to Toppenish Creek via Marion Drain and the flood control ditch that links the two.

This sketchy summary of the interconnections of Toppenish Creek and the WIP system may be more confusing than enlightening, but a complete description would not be appropriate in this context. Interested readers are referred to the Draft Fisheries Report of the WIP Enhancement Project (Watson and Lind 1990) for a more detailed presentation.

The Toppenish Creek drainage suffers from eight distinct types of habitat problems, five of which are directly attributable to Wapato Irrigation Project operations. These problems are as follows.

A. Habitat Problems Attributable to Wapato Irrigation Project Operations

1. Dewatered reaches.

Three reaches in the Toppenish Creek drainage are totally dewatered for extensive periods by irrigation withdrawals. Wapato Irrigation Project diversions dry up a section of upper Toppenish Creek and upper Simcoe Creek, while a private diversion dries up a section of the lower North Fork of Simcoe Creek.

a) Toppenish Creek below Toppenish Lateral Canal. WIP's Toppenish Lateral Canal (TLC) is located at RM 44.2. A 4-foot-high dam diverts the entire creek from mid-June to mid-December, about 180 days. The dewatered reach extends from the dam at RM 44.2 to a spring near Pom Pom Road at RM 38.9, a distance of 5.3 miles.

The WIP diversion is not the only problem in this 5.3-mile reach. Almost the entire section has been diked, channelized and relocated. Riparian vegetation is absent from most of the reach, and the bed material within the channelized section consists of large, highly fractured rock and cobble. As the channel is dry half the year, it has never become armored and it allows considerable subsurface flow. Although the magnitude of subsurface flow has not been measured directly, Wapato Irrigation Project personnel have observed that spills of as much as 6 cfs to 7 cfs over the dam sink into the channel before reaching Pom Pom Road.

b) Simcoe Creek below Simcoe Narrows diversion. WIP diverts the entire flow of Simcoe Creek at "the narrows" (RM 13.9). In the spring, excess water flows back into the creek over two spillways. However, Simcoe Creek is totally dewatered by this diversion for roughly the same period as the TLC, about 180 days, from mid-June through mid-December. The dewatered reach extends downstream to Agency Creek, a distance of 4.4 miles. Perhaps because of irrigation returns, some of which are from the TLC, Agency Creek is perennial in its lowermost reaches. As will be detailed below, the Simcoe Narrows diversion is totally unscreened, and the spillways into the creek are only partially negotiable by adult steelhead.

c) North Fork Simcoe below Hoptowit diversion. The Hoptowit Ditch is a private irrigation system. The ditch originates at approximately RM 1 of the North Fork of Simcoe Creek. The entire stream is diverted into a ditch containing a crude headworks with no means of regulating flow. The bypass between the headworks and the creek channel is blocked with debris to ensure that almost no water returns to the creek channel during the summer. During high water events, the ditch floods downstream from the headworks, and for about 180 days between mid-June and mid-December, the diversion dewaters the North Fork down to its confluence with the South Fork. Although adult steelhead would have no difficulty negotiating the diversion bypass during high water in the spring, a very high proportion of smolts are undoubtedly lost down the unscreened ditch.

2. Excessive summer temperatures in middle and lower Toppenish Creek.

Temperatures in middle and lower Toppenish Creek are excessive for salmonid health and growth, and may occasionally be lethal. Summertime temperatures are excessive from a point near the Simcoe confluence to the mouth, a distance of over 33 miles. Continuous (24-hour) temperature data are not available for any point in Toppenish Creek at the present time, although continuous discharge and temperature recording devices were installed in the summer of 1989 at the TLC diversion and the Lateral C crossing (RM 21.3). U.S. Geological Survey and Yakima Indian Nation fisheries personnel have made many instantaneous temperature observations. Most of these observations have been made within several hours of noon and should approximate the mean temperature of the diel cycle. These point observations indicate that the mean temperature in July and August from the Simcoe confluence to the mouth is between 66 and 68 F (19 to 20 C). Maximum temperatures observed have been as high as 85 F (29.5 degrees C) near the Simcoe confluence, and 88 F (31 C) just below the Satus II diversion. Diel fluctuations, as measured by maximum-minimum thermometers, are quite large: 27 F (15 C) near the Simcoe confluence, and up to 36 F (20 C) below the Satus II diversion.

The temperature regime in this portion of Toppenish Creek is too high for positive production of steelhead; that is, mortality rates exceed growth rates such that the population as a whole loses biomass. Near the Simcoe confluence and below the Satus II diversion, the temperature midway between the mean and the maximum of the diel cycle may be about 79 F (26 C). When this "75th percentile temperature" exceeds 23 C, steelhead populations lose biomass. This would clearly be the fate of a population of steelhead in this region of Toppenish Creek in the summer. More importantly, it may not be possible for steelhead to survive at all in much of this region, as the upper incipient lethal temperature for steelhead is about 26 C. Although a number of juvenile steelhead were observed in middle and lower Toppenish Creek in the summer of 1989, they may have been residing in localized thermal refuges, such as spring seeps.

Three factors contribute to the high temperatures in Toppenish Creek. First and perhaps most important is the large volume of warm irrigation water routed down Simcoe and Toppenish Creek to the Toppenish Creek Pump and Satus II diversions. This water, which comprises as much as 80 percent or 90 percent of the flows approaching the Toppenish Creek Pump diversion, has mean summer temperatures ranging from 68 to 73 F (20 to 23 C; Ken Mitchell, WRPP, pers. commun., 1989). The second and third problems -- poor riparian conditions and the east-west orientation of the stream -- both contribute to a severe lack of shade in middle and lower Toppenish. Although patches of very dense riparian vegetation exist, they are interspersed with larger areas, primarily used as pasture, with little or no vegetation. The only sections receiving extensive shade are those few narrow reaches over which the riparian canopy has closed, or those reaches so deeply incised as to be shaded by the streambanks themselves. Thus, a stream already heated by irrigation water becomes even warmer.

3. Passage problems.

   a) Hoptowit diversion. The principal structural (as opposed to flow-related) passage problem at the Hoptowit diversion is the lack of screening at the point of diversion. The lack of control structures at the headworks plus obstruction of the bypass, ensure that 100 percent of outmigrating smolts will be entrained when flows are not high enough to overtop the 2-foot debris berm blocking the bypass.

   b) Unnamed diversion in South Fork Simcoe Creek. Just 0.1 mile above its confluence with the North Fork, the South Fork of Simcoe Creek is diverted south into a 2-mile irrigation ditch, referred to as the Smartlowit Ditch. There is no dam, and about half of the creek flow enters the ditch. Most of the winter and spring ditch flow appears to return to Simcoe Creek, some through a bypass (or washout) about 0.1 mile down the canal, and the rest after flowing in sheets over 40 to 80 acres of pasture. Steelhead redds have yet to be found in the South Fork, but juvenile steelhead have been captured in electrofishing surveys above the diversion. Migrants from the South Fork could easily be entrained in the ditch and stranded on pastureland.

c) Simcoe Narrows diversion. The structures at the Simcoe Narrows diversion affect both adult and juvenile steelhead. At the present time, spawning adults are forced to swim up one of two 12-foot-long spillways if they are to ascend Simcoe Creek above the diversion. However, before temporary corrective measures (the dumping of several yards of rock and gravel below the spillway) were taken in the spring of 1989, the streambed below the spillways had scoured out, and the vertical jump to both spillways had increased to five or six feet. To make matters worse, the scoured area had an irregular contour, so that there was no pool and standing wave close to the spillways that adults could use for the jump. As long as a permanent fishway is not in place, it will be only a matter of time before the modified streambed scours out, and passage is once again severely restricted.

   Entrainment of smolts in the unscreened Simcoe Narrows ditch may be even more of a problem than is at first evident. While it might at first be thought that entrainment would be proportional to the percent of surface flows diverted, with 100 percent entrainment occurring only when all the water is diverted, the situation could actually be worse. The spillways are located on the right side of the flume, and usually are checked from below so that several inches to a foot of water pass over the boards and into the creek. If the spill over the boards is substantially less than a foot, it is unlikely that many smolts will be at the proper depth to pass over the spillway. Smolts do not normally swim at the water surface; even if they did so, flows over the spillway would have to greatly exceed canal flows for many smolts to make a sharp right turn and avoid entrainment.

d) Toppenish Creek Pump. This diversion is totally unscreened, and may represent the single largest threat to outmigrating smolts on Toppenish Creek. The pumps are located at the end of a mile-long diversion ditch at RM 26.5, and move 60 cfs to 90 cfs up the north slope of Toppenish Ridge. As much as 80 percent or 90 percent of Toppenish Creek flows are routed down this ditch, and the risk of entrainment of smolts is extreme.

e) Toppenish/Marion Drain flood control ditch. A ditch running from the Toppenish Creek Pump diversion on Toppenish Creek to Marion Drain was constructed in the 1970s for the purpose of draining flood waters in the vicinity of the diversion into Marion Drain (see Fig. 4). This ditch enters Marion Drain where it merges with Harrah Drain (RM 19). Water from the ditch discharges into Marion Drain through a large pipe perched about five feet above the water surface.

It has become apparent in recent years that fair numbers of adult Toppenish Creek steelhead ascend Marion Drain, possibly because of its component of Toppenish Creek water. These fish attempt, sometimes successfully, to jump into the pipe and swim over to Toppenish Creek. Unfortunately, poachers with nets and guns frequent the pipe, taking a considerable number of fish. In late May of 1989, one individual built a rock trap below the pipe to catch and hold fish exhausted from attempting to jump into the pipe. This trap was regularly destroyed by Yakima Indian Nation fisheries personnel, and just as regularly rebuilt by the poacher. In the course of investigation, YIN fisheries personnel recovered 15 dead adult steelhead from the trap. The number of fish taken away by poachers can only be surmised, but was probably at least as great as the number of carcasses recovered. A loss of 30 or 40 spawners is highly significant given the depressed state of the steelhead runs in Toppenish Creek; the estimated spawning escapement to the entire Toppenish drainage in 1989 was only 52 fish.

The Wapato Irrigation Project also diverts Toppenish Creek water through the flood control ditch into Marion Drain during the irrigation season, ostensibly to prevent its loss to small diverters between the pump house and the Satus II diversion 23 miles downstream. As the July-August discharge through this reach is estimated to be only 10 cfs to 20 cfs, it could easily be dewatered by opening the ditch gate (also see below). Even if a flow of 50 cfs, the estimated capacity of the ditch, were saved by diverting it to Marion Drain, the savings represents only a fourth of the capacity of the Satus II diversion and less than an eighth of the summer discharge of Marion Drain. It would be preferable to leave the ditch gate closed and regulate diversions of Toppenish Creek under a tribal water code.

f) Unscreened diversions on Wanity Slough. It is believed that the number of salmonids that spawn and rear in Wanity Slough is quite small at the present time, although potential production, especially of fall chinook and coho, may be significant. Attempts to promote fall chinook and coho spawning in Wanity Slough might, however, best be deferred until three large diversions are screened. These diversions, the Track Lateral, the Spencer Lateral and the Lateral Four Extension, divert 120 cfs, 41 cfs and 140 cfs, respectively. As the two larger diversions take the majority of the flows in their vicinity, entrainment risk for juveniles spawned upstream is extreme.

g) Braids on middle Toppenish Creek. There are at least eight braids on Toppenish Creek from a point about a mile and a half below the TLC (RM 44) to a point about half a mile upstream of Slayton Road (RM 6). Many of these braids dry up every spring, after the high water period, and all of them dry up occasionally. Thus, all constitute a stranding hazard. Five of these braids branch off Toppenish Creek below the Toppenish Creek Pump diversion. Stranding of smolts in these lower braids are attributable to WIP operations to the extent that WIP withdrawals cause them to be dewatered, or to be dewatered earlier in the spring. It is known that WIP operations can directly cause dewatering in these braids. It has, for instance, been reported that Snake Creek, a braid which normally flows year-round, was completely dried up following an increase in the diversion rate at the Toppenish Creek Pump several years ago.

Many of the braids are also choked with tules and brush, and some, such as the braid looping to the north of the Toppenish Creek Pump diversion, feed numerous small, unscreened diversion ditches. Thus, entrainment hazards remain even in exceptionally high water years, when none of the braids are dewatered.

4. Poor substrate in Toppenish and Simcoe Creek.

The quality of substrate in Toppenish Creek from the Simcoe confluence to the Satus II diversion ranges from poor to extremely poor. Similar conditions are observed in Simcoe Creek, at least from Olney Flat Drain to the Toppenish confluence. Except for some areas in the upper portion of Toppenish Creek, where the streambed is composed almost entirely of clay, the problem in both areas consists of a heavy deposition of sediments and organic silts. No rocks or gravel are even visible in Toppenish Creek from the pump diversion to the Satus II diversion; the bottom is everywhere coated with several inches to a foot or more of viscous muck. Gravel and cobbles are visible in the uppermost portion of the affected area of Toppenish Creek, as well as in Toppenish Creek below the Satus II diversion, but even here the substrate is fairly heavily embedded in sediment. Between the Satus II diversion and the Toppenish Creek Pump diversion, the only area with substrate remotely approaching spawning quality is Snake Creek, a 3.5-mile braid of Toppenish Creek.

Although the large quantities of suspended sediments in WIP return water contribute to the substrate problem in Toppenish Creek, irrigation is by no means wholly to blame. Numerous small diversion dams and widespread riparian degradation probably play a role of equal importance. Nevertheless, the substrate would certainly benefit if the tens of thousands of tons of sediments discharged by drains such as Mud Lake Drain were eliminated.

5. Excessive velocities and depths in Toppenish Creek.

Flows through "run" sections of Toppenish Creek between the Simcoe confluence and the Toppenish Creek Pump were found to have velocities of three to four feet per second during August of 1989. About half of this reach consists of runs, with the remainder consisting of glides and pools having velocities on the order of one foot per second. The channel through this reach appears to have been deepened and straightened, although historical records that would verify this impression have not been found. Whatever the initial cause, riffles are rare; large rocks or other obstructions in the streambed are uncommon, and are submerged by high volumes of WIP return flows where they do occur. Most runs were 1 or 2 feet deep, while pools were 3 to 4 feet deep.

Through most of this reach, both velocity and depth are excessive for steelhead fry. Velocity here, given the lack of obstructions in the channel, is excessive for juvenile steelhead of all ages. Larger juveniles will utilize pools, especially if they contain large organic debris or boulders for cover. Unfortunately, the pools in this reach lack such structural cover elements.

B. Habitat Problems Not Attributable to the Wapato Irrigation Project

1. Hunting club waterfowl ponds.

There are approximately 20 private waterfowl hunting clubs and one large federal waterfowl refuge on Toppenish Creek (George Fenn, Manager, Toppenish National Wildlife Refuge, pers. commun., 1989). All of these organizations maintain one or more ponds at least from mid-October through the end of goose hunting season in January. Almost all of them fill their ponds by erecting small dams on Toppenish Creek and diverting instream flows. The adverse impact on Toppenish Creek fisheries is attributable not so much to the actual amount of water diverted as to the manner in which it is diverted.

There are probably about 30 or 40 small gun club diversions on middle and lower Toppenish Creek. None of these diversions is screened. Although most diverted water is ultimately returned to the creek, the return path may be tortuous and include virtually impenetrable sections of dense vegetation and brush. The potential for smolt loss through entrainment and eventual stranding in gun club ponds is obvious. This potential even exists in the admirably managed Toppenish National Wildlife Refuge, which has been cleared of the dense snares of tules and reedgrass that clog waterways at many of the private clubs. The 650 acres of ponds on the Wildlife Refuge are strung out along nine or 10 miles of intricately interconnecting channels. As water velocities through much of this system are virtually nil, it seems probable that entrained smolts could become disoriented and fail to find an exit before residualizing or becoming stranded. However, the collective entrainment hazard posed by the private diversions and ponds is much greater.

The impact of gun club diversion dams on fish habitat may be as serious as the threat they pose to outmigrants. As mentioned, most dams begin to divert flows in October, continuing at least through January (an exception is the main diversion for the Toppenish Wildlife Refuge, which is removed in mid December). Many of the less sophisticated structures are frozen in place in January, and cannot be removed until late May or June, after the period of high water. Toppenish Creek thus sustains over 30 small impoundments through much of the high water period of fall and winter, and a somewhat smaller number through the entire annual period of high water. This series of obstructions slows water velocities which otherwise might flush deposits from the system, and may instead create conditions favoring increased deposition. Some long-time residents of the Toppenish Basin recall that, 30 to 40 years ago, before the establishment of most gun clubs, middle Toppenish Creek contained gravelly riffles. In any case, the prolonged slowing of flows during the high water season cannot but exacerbate the sediment problem in middle and lower Toppenish Creek.

2. Riparian degradation.

Although riparian conditions have never been formally inventoried, it is immediately apparent to the casual observer that degradation is severe throughout most of the middle and lower portions of the Satus and Toppenish drainages. Both Satus and Toppenish creeks have suffered some degree of riparian damage wherever the channel does not flow through a steep canyon, and the same holds true for their tributaries.

Riparian damage on the reservation is mainly attributable to unrestricted streamside grazing of cattle. This term was used instead of "overgrazing" because the numbers of cattle on the reservation are not actually excessive. Rather, because of the lack of water and shade, and because stream margins are rarely fenced, the cattle that are present spend virtually all of their time in and around streams.

Riparian conditions in the Satus and Toppenish drainages are influenced by land ownership patterns. The middle and lower portions of the Toppenish drainage have many small, fenced, private pastures, whereas much of the Satus drainage consists of tribal land that is managed as open range. As a result, riparian conditions on Toppenish Creek are extremely variable; patches of "riparian jungle" alternate with sections that resemble feed lots. The number of cattle and the intensity of agriculture are considerably lower in much of the Satus drainage, and riparian damage is less severe but more uniformly distributed. Most reaches in the Satus drainage contain some trees or large brush, but little understory vegetation, and overland erosion and bank sloughing is widespread.

There has not been an exhaustive riparian inventory in the Toppenish drainage. However, the probable areas of worst damage are as follows, in decreasing order of their significance according to Yakima Nation fisheries personnel:

a) Toppenish Creek from Highway 22 (RM 3.3) to the Simcoe confluence (RM 32.7), 29.4 miles. (Damage is scattered throughout this area.)

b) Simcoe Creek from the mouth to Wahtum Creek (RM 14.4).

c) Toppenish Creek from Pom Pom Rd. (RM 38.9) to the Toppenish Lateral Canal (RM 44.2), 5.3 miles.

d) About eight miles of Toppenish Creek between the Toppenish Lateral Canal and the mouth of the North Fork (RM 55.4).

e) Wanity Slough, from the headworks to the Marion Drain outfall (about 20 miles). (Damage is not uniformly distributed.)

3. Water quality problems in Wanity Slough.

Wanity Slough, unlike any other fish-bearing water on the reservation, is plagued by low dissolved oxygen (DO) concentrations in the summer. Fretwell (1979) monitored DO in lower Wanity Slough over a 24-hour period beginning at 0800 hours August 28, 1974. The maximum DO observed was 10.8 parts per million (120 percent saturation) at 1400 hours, and the minimum was 5.6 ppm (60 percent saturation) at 0600 hours. Fretwell believed that DO probably drops below 5.0 ppm during warm summer months, and that a very hot, dry summer could cause drops substantially below 5.0 ppm. He attributed the diel fluctuation in DO to photosynthesis and respiration, and believed the growth of the plant community was stimulated by elevated nutrient concentrations, and the fact that Wanity Slough contains relatively clear water, a cobble bottom and a large surface area to volume ratio. The mean nitrate (including nitrite) and mean total phosphorous concentrations in Wanity Slough were 1.4 ppm and 0.12 ppm, respectively, more than sufficient for luxuriant growths of aquatic plants and algae. Clear, shallow waters allow sunlight to stimulate photosynthesis, and the cobble bottom provides substrate for a large population of attached algae.

It should also be noted that lower Wanity Slough receives point source effluents from fruit and vegetable processing plants and a meat packing plant, and illegal discharges of domestic sewage, as well as a significant non-point input attributable to cattle grazing in and alongside the channel. These effluents can be expected both to stimulate algal growth and to generate a biological oxygen demand of their own.

The uppermost 25 miles of Toppenish Creek, as well as the North and South Forks of Toppenish Creeks, maintain adequate flows year-round. Discharge was measured at 4 cfs at RM 55 in August 1988, and was about 1 cfs at RM 69.2, less than one mile from the source (K. Mitchell, pers. commun.). Spawning gravel is abundant and of very high quality, and the riparian corridor is excellent except for a stretch of several miles just above the Wapato Irrigation Project diversion. The major problem for these upper reaches appear to be a number of large, slightly perched culverts.

	PROBLEMS						
HAS ANAD FISH?	SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	P-G	P-G	P-G	yes	P-E	P-G	

TOPPENISH CREEK TRIBUTARIES

Simcoe Creek

	PROBLEMS						
HAS ANAD FISH?	SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	P-F	P-F	G but warm.	WIP div., dry spots.	P-F	G	

NF Simcoe Ck.

HAS ANAD FISH?	PROBLEMS SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	G	G	G	Hoptowit Diversion.	G: some grazing.	G	

SF Simcoe Ck.

HAS ANAD FISH?	PROBLEMS SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	G	G	G	One div.	G	G	

Agency Ck.

HAS ANAD FISH?	PROBLEMS SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	F	F	G	White Swan mill (at low flows)	G upstream P below.	G	

Upper Toppenish Ck.

HAS ANAD FISH?	PROBLEMS SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	G	G	G	None	G-E	G	

NF Toppenish Ck.

HAS ANAD FISH?	PROBLEMS SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	G	G	G	None	G-E	G	Culverts

Ahtanum Creek (46 miles including North Fork)

Ahtanum Creek enters the Yakima River from the west at RM 106.9. Ahtanum Creek is in many ways like Cowiche Creek Many miles of good to excellent habitat for steelhead, coho and spring chinook are unused because of relatively easily correctable passage problems. The two major passage problems facing the Ahtanum are the fact that none of the ditches in the system are screened, and that a diversion at RM 19.6 partially dewaters all points downstream from July 10 through mid-October.

The gradient in the lower eight to nine miles is slight to moderate, and bank sloughing from overgrazing has caused the deposition of a large amount of sand and mud. Good riparian is patchily distributed. Concrete dams divert water into side channels named Hatton Creek (RM 18.2) and Bachelor Creek (RM 18.9), which serve as irrigation conduits for the Ahtanum Irrigation District. Numerous pumps and small gravity ditches (~1 cfs) divert water from these "creeks" during the irrigation season (April 15-July 10), and as water is shifted back and forth between three channels, one or more streambeds is frequently dry. Both Hatton and Bachelor creeks should probably be screened at their upstream ends. Two large Wapato Irrigation Project diversions are located near Ahtanum village (RM 9.8) and Tampico (RM 19.6). The upper Wapato Irrigation Project facility diverts most or all of the stream flow from July 10 through mid-October, and the streambed is totally dry for a distance of seven to eight miles (to about RM 12) after the first week in August. At RM 12, ground water and irrigation returns recharge the stream, even during the worst period of dewatering. This flow of 5 cfs to 10 cfs persists to the mouth. It should be noted that discharge is substantial below the Wapato Irrigation Project diversions from mid-October through July. The lower Wapato Irrigation Project diversion constitutes a total barrier to spawning adults.

The North and South forks come together to form Ahtanum Creek at RM 23.1. The North Fork is about 23 miles long and the

South Fork 15 miles. There are two diversions on the North Fork, the moderately sized (~13 cfs) John Cox Diversion at RM 3, and the small (~2 cfs) Shaw-Knox Ditch at RM 2. The South Fork has one small (~2 cfs) diversion about RM 3.

Water quantity, water quality, riparian conditions and substrates are good to excellent in the 10 to 20 miles of tributary stream above Tampico. Except for passage and flow problems associated with downstream diversions, Ahtanum Creek would probably be a major steelhead producer today.

It should be noted that a 2,400 acre-foot reservoir has been proposed for the upper South Fork of Ahtanum Creek (see Draft Fisheries Report, Opportunities for Optimizing Land and Water Use on the Yakima Indian Reservation by Improving the Wapato irrigation Project, March 30, 1990). The purpose of the reservoir would be exclusively the improvement of instream flows. This project, if approved by the Tribal Council and implemented, would eliminate the summer dewatering problem in middle and lower Ahtanum Creek.

ABOVE TAMPICO

	PROBLEMS						
HAS ANAD FISH?	SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
No	G	G	G	yes	G-E	G	

BELOW TAMPICO

	PROBLEMS						
HAS ANAD FISH?	SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	F	P-F	F	yes	P-F	G	

Wide Hollow Creek (22 miles)

Wide Hollow Creek enters the Yakima River from the west at RM 107.4. This stream flows directly through the city of Yakima and its surrounding orchards, and suffers from many of the problems typical of urban streams (leaking septic tanks, miscellaneous storm sewer pollution) and agricultural streams (elevated pesticide concentrations). In addition, a mill dam at RM 0.6 has totally blocked upstream migration since 1869. The dam is about 10 feet high, and could easily be made passable with one or two pieces of Alaska steep pass laddering. If this were done, and if small-scale adult and juvenile passage facilities were installed at two diversions at RM 1.3 and 2.1, 14 to 15 miles of stream would be accessible to salmon and steelhead. Wide Hollow Creek has been designated a Centennial Salmon Project, and funds and manpower will be made available to install the necessary passage facilities.

In a habitat survey on August 10, 1988, Wide Hollow Creek was found to provide a surprising amount of good habitat. Instream flows were very good, ranging from 20 cfs to 30 cfs in the lower four miles to 3 cfs to 4 cfs near RM 14, and temperatures were in the mid-60s. Except for several small reaches near the mouth (RM 0.2-0.6 and RM 1.3-2.5), where overgrazing had caused severe bank sloughing, the riparian corridor was in excellent condition; clumps of willows provided patches of heavy shading interspersed with sunny areas with abundant overhanging grasses and undercut banks. Pools and runs were fairly deep (2 feet or more), and were rather more frequent than riffles. Within areas of heavy residential development, the stream tended to be deeply incised, and very deeply shaded by dense foliage on the tops of steep banks. A number of debris jams were noticed in such areas, one of which (~RM 3.5) constituted a total migration barrier. The overall impression of the stream is that it would provide excellent coho and steelhead rearing habitat in most reaches, but that spawning gravel was in short supply.

	PROBLEMS						
HAS ANAD FISH?	SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
no	F	E	P-F	yes	patchy: E in spots.	F	fecal-coliform, pesticides.

Wenas Creek

Wenas Creeks suffers from both extremely heavy irrigation diversions, which usually dry up the lower nine miles of the creek, and from severe riparian damage, which results in water temperatures above 80 F in the reaches that have some water. As the small size of the watershed limits the potential for storing additional water to augment instream flows, and as Wenas creek is already over appropriated for irrigation, it has virtually no potential for production of anadromous salmonids.

HAS ANAD FISH?	PROBLEMS						
	SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
no	P	P	P: warm.	many	P	P	

Umptanum Creek (16 miles, 8 below falls)

Umptanum Creek enters the Yakima River from the west at RM 139.8 and flows through rugged and arid terrain in the eight miles below an impassible falls. In this reach there is no development and the adjacent rangeland is only lightly used. Accordingly, the deciduous and brushy riparian habitat is nearly pristine. The stream channel is stable, with only occasional sign of high seasonal runoff (none recent). In August 1988, stream temperatures were acceptable, ranging from 55 to 61 degrees F in this reach. Rearing habitat for coho and steelhead was judged excellent, spawning gravel was present in all areas surveyed, and was abundant in some areas. No irrigation diversions were observed. A good run of coho is reported to have used this stream prior to the construction of Pomona Dam in the late 19th century.

The primary limiting factor is the small amount of available habitat. Flows of barely 1 cfs were estimated in the lower and middle part of the accessible reaches. In the section between RM 0.5 and RM 0.8, flows were intermittent. The only physical impediment to anadromous salmonids was a wire basket gabion at RM 4.9 that stabilized a ford crossing (Old Durr Road). At high flows, this structure would be passable to some migrants, but at lower flows it constitutes a total barrier.

The riparian area is overgrazed and badly degraded upstream of the falls, and the stream dries up above RM 10. A very small impoundment in this area, or perhaps merely a riparian fencing project, might generate enough additional summer flows to increase productivity substantially.

HAS ANAD FISH?	SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
	PROBLEMS						
yes	G	P-F	F	yes	E	G	

Wilson Creek system

Wilson Creek enters the Yakima River from the east at RM 147. Naneum Creek and Coleman Creek have been channelized and diverted into lower Wilson Creek, and no longer have their natural mouths. All streams in this system are heavily diverted on the valley floor, and have been channelized into an intricate drainage and irrigation system that bears little resemblance to the original drainage pattern. There are over 200 unscreened diversions on this system. The riparian zone of the lower portions of these streams is massively impacted by grazing and other agricultural activities. Wilson, Naneum and Coleman creeks flow through timbered canyons in their upper reaches, where flows are adequate year-round, and the riparian zones are in good condition. Gravel quality and size distribution is generally good in the upper reaches of these tributaries.

The major problem with these streams is access to and from headwater areas. If upstream migration were much easier than it is now, if all diversions were screened, and if there were an above-Roza run of steelhead or coho to exploit them, these streams would probably produce substantial numbers of anadromous fish. The probability of rectifying passage problems of such magnitude in the foreseeable future is, however, extremely remote. Therefore, the Wilson/Naneum system is judged to have very little potential for anadromous fish production at the present time.

HAS ANAD FISH?	SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
	PROBLEMS						
No	P	P-F	F	Diversions.	P-G	G	

Manastash Creek (29 miles with South Fork)

Manastash Creek enters the Yakima River from the west at RM 154.5. The creek branches at RM 8.5 into the 12-mile-long North Fork and the 20-mile-long South Fork. The lower five miles of the mainstem flow through fields and pastures, and eight diversions from RM 5.7 down have severely constricted anadromous production potential. Many miles of excellent spawning and rearing habitat remain relatively undisturbed above the diversions, but are presently inaccessible because of both upstream and downstream passage problems at the diversions. Moreover, despite the diversions, some positive habitat features remain even in the lower portion of the stream, and spring chinook redds have been observed near the mouth several times in the past five years. Vegetation and streambank cover is favorable to salmonid production in nearly all areas of the mainstem. The North and South forks flow through forested lands where the riparian corridor is near pristine. Current logging activity is restricted to the highest parts of the drainage, and does not now impact the stream significantly. Except for a 1-mile stretch of overgrazed riparian habitat between RM 2 and RM 3, agricultural activity along the mainstem consists primarily of crop production, with little effect on streamside vegetation. Trees and brush were dense along the lower several miles of the mainstem and in the lower 1.5 miles often formed a complete, "jungle-like" canopy over the stream. The riparian corridor remains in good condition even along reaches that are seasonally dewatered.

Both the streambanks and channel of the creek and its forks appear to be very stable. Instream habitat is diverse, ranging from high gradient riffles to pools. Spawning habitat ranges from reaches with adequate "patch gravel" to reaches in which gravel bars are numerous.

Three factors currently limit Manastash production -- adult migration barriers, unscreened ditches and low streamflows. Four diversion dams on the mainstem represent partial or total barriers to migrating adults. The Larry Anderson diversion at RM 3 is concrete with large riprap at the base. With a head of eight feet, this dam represents a total barrier at all flows. The Reed diversion at RM 4.9 is formed by a broad concrete sill across the stream that backs up about five feet of water. The structure may be passable at high flows, especially by steelhead, but nevertheless requires a fishway or other passage structure if upper reaches are to be accessible to all steelhead and salmon. Steelhead and coho can probably negotiate the lower Larry Anderson diversion (RM 1.4) and the Keach-Jenkins diversion (RM 5.5) at the higher flows that are expected during their spawning migrations. Both structures should, however, be closely monitored during spawning migrations; in the event of impaired migration, the head should be reduced by removing check structures.

None of the ditches diverted from Manastash Creek are screened. All eight diversions will require screening if outmigrating smolts are not to be lost. Provision for these bypasses, as well as the two adult passage facilities, should be made pursuant Section 803(b)(4) of the Columbia River Basin Fish and Wildlife Program, in which the Bonneville Power Administration proposes to "implement needed fish passage improvements at irrigation diversion dams, canals and ditches in the subbasin."

Manastash Creek was totally dry between RM 1.5 and RM 3, and between RM 3.3 and RM 4.9 in August of 1988. All other flowing reaches downstream of the uppermost diversion (the Manastash Ditch, RM 5.7) carried a less-than-natural discharge. Three branches of the Kittitas Reclamation District delivery system intersect the mainstem, at RM 5.5, RM 3.3 and RM 1.4. These points of intersection provide the basis for a solution to the instream flow problem. The streambed is presently used at two locations to deliver Kittitas Reclamation District water. Water enters at RM 3.3 and is removed at RM 3, and enters again at RM 1.5 to be removed at RM 1.4. Except for these "conduit reaches," the stream is dry between RM 4.9 and RM 1.4. An immediate solution to the flow problem would be to increase the flows in the Kittitas Reclamation District Main Canal with "untouchable" water allocated to Roza Irrigation District, and then divert an augmented flow from the South Branch Canal into the creek at the uppermost Kittitas Reclamation District crossing. Alternatively, a small impoundment could be built near the headwaters of the North or South Fork. If the impoundment were properly sized, it could meet the diverters' full entitlement and have enough left over to augment instream flows substantially over a large portion of the entire drainage.

	PROBLEMS						
HAS ANAD FISH?	SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	G	P-G	G	Diversions, low flow.	F-E	G	

Taneum Creek

Taneum Creek enters the Yakima River from the west at RM 166.1. There are four diversions on the mainstem, at RM 1.6, RM 2.4, and two at RM 3.5. The Taneum Ditch Project drops water into the creek at RM 2.6, most of which is removed at the Taneum Ditch diversion at RM 2.4. The North Fork and South Fork of the Taneum branch from the mainstem at RM 12.7, and are, respectively, 12 and nine miles long.

The Taneum is considered to have substantial potential for producing steelhead and coho, and to a lesser degree, spring chinook. Bryant and Parkhurst (1950) report the stream supported good runs of coho prior to the construction of Taneum Ditch in 1910. A vestigial run of steelhead may still exist in the Taneum, and spring chinook juveniles are known to rear in the lower reaches. The riparian corridor on the mainstem is generally in good condition, with deciduous vegetation in the lower valley areas and progressively more coniferous cover upstream. Except for crop production in the valley, which has little impact on streamside vegetation, the drainage is largely undeveloped. The North Fork and South Fork flow through heavily timbered land. Riparian conditions on the North and South forks are excellent, and instream cover in the form of large organic debris and boulders is abundant. Logging occurs at the highest elevations of the drainage, and so far has not affected the stream appreciably. While streamside cover partially or totally shades much of the mainstem, water temperatures in late July 1988 were fairly high, ranging from 58 to 70 degrees F. The stream channel is stable in most places, but dry gravel bars in a number of locations indicate seasonal runoff may occasionally be high. Stream gradient is moderately steep in the lower reaches, and the substrate is composed primarily of rubble. Patches of good spawning gravel are, however, abundant, and are more than adequate to satisfy the spawning needs of steelhead or coho. The gradient also tends to limit pool frequency, therefore making the habitat relatively more suitable for steelhead than coho.

Constraints on production include the lack of adult passage facilities at the diversions at RM 1.7 and RM 2.4 (the Bruton and Taneum Ditch diversions, respectively); the lack of juvenile bypass systems on all ditches; very low summer and fall flows (1 cfs to 2 cfs in places) in the lower 3.3 miles of the mainstem; relatively high temperatures at several locations; and a wastewater return below the Bruton diversion that could represent a false attraction flow.

The installation of juvenile bypass systems and adult passage facilities at all Taneum diversions have already been adopted into the Columbia River Basin Fish and Wildlife Program [Section 803(b)(5), Item F], and thus this particular problem will be resolved soon.

Low flows in the lower mainstem could be augmented by increasing the flows in the Kittitas Reclamation District Main Canal with "untouchable" water allocated to Roza Irrigation District, and then diverting this water from the South Branch Canal into Taneum Creek at RM 2.6. Alternatively, a small impoundment could be built near the headwaters of the North or South Fork. If the impoundment were properly sized, it could meet the diverters' full entitlement and have enough left over to augment instream flows substantially over a large portion of the entire drainage. Either provision, along with protection of riparian vegetation, would reduce the overheating problem.

HAS ANAD FISH?	PROBLEMS						
	SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes ?	G	P-G	G	Diversions, low flows.	G-E	G	

Swauk Creek (24 miles)

Swauk Creek enters the Yakima River from the west at RM 169.9. It has two sizeable tributaries, Williams Creek at RM 11, and Iron Creek at RM 17.3. Although its drainage area is fairly large (100 square miles), precipitation is minimal and unregulated summer streamflows are very low. The lower two to three miles are in an arid canyon where the gradient is steep and the streambed consists of large rock and boulders. This reach is dry in the summer, and flows are very low or intermittent as far upstream as RM 5. The stream enters a forested zone at RM 8. Above this point, flows are marginally adequate through the summer. The riparian corridor is generally good above about RM 3, with no areas of significant overgrazing; the streambed appears stable throughout. The substrate above about RM 3 consists mostly of coarse rubble, with a patchy distribution of spawning gravel suitable for steelhead or coho spawning. Water temperatures in the perennial reaches were in the upper 50s (F) in August 1988, but reached the mid-60s in the intermittent areas and pools. The only active diversion on the creek, the Burke diversion at RM 7, is relatively small, and does not appear to impact downstream flows significantly. A large amount of recreational gold mining (suction dredging), and a smaller amount of professional placer mining, occurs above the village of Liberty (RM 11). The affect of this activity on potential anadromous fish populations might be significant, but could be regulated by existing hydraulics project application procedures.

Swauk Creek was a substantial producer of steelhead and coho in historic times. The stream is too steep, narrow and shallow for spring chinook production, and there are no records it ever supported a run of chinook. Spawning coho were observed in the creek as late as the early 1960s (J. Easterbrooks, WDF, pers. commun.), and a vestigial run of steelhead may still exist. Presently, naturally occurring low flows throughout the system and the absence of flow in the lower three to five miles in the fall limit steelhead production rather severely, and totally preclude coho production. A small (3,000 to 5,000 acre feet) impoundment near the headwaters would rectify this situation.

HAS ANAD FISH?	PROBLEMS SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes ?	G	P-F	F-G	?	P-G	P-G	gold mining.

Teanaway River (30 miles with North Fork)

The Teanaway River enters the Yakima River from the east at RM 176.1. The Teanaway is the second largest Yakima tributary, with a drainage of 200 square miles. There are 11.7 miles of mainstem and three forks, the North Fork (19 miles), the Middle Fork (15 miles) and the West Fork (15 miles). The Washington Department of Fisheries has identified 17 diversions having juvenile screening facilities. Nearly all of these structures have temporary gravel berms that wash out during high water; none have permanent diversion structures. The department formerly maintained these screens, but has not done so since 1983. All of these diversions have been identified as Phase-II passage projects, and all will be rebuilt to modern specifications, providing the Yakima Subbasin Plan indicates the necessity of doing so. (As has previously been mentioned, the Yakima Plan will very strongly recommend the rebuilding of passage facilities at these diversions.) The first 10 miles of the Teanaway flow through a broad valley. This section of the valley consists mainly of hayfields and is heavily irrigated. As natural runoff falls through the summer and fall, the flows through this reach drop dramatically, and by September and October, the lower river is nearly dry. The riparian zone, however, is in fairly good condition structurally, as streamside hay production takes precedence over grazing. The major riparian problems in this lower reach is a seasonal lack of overhanging vegetation and large organic debris; as the river recedes in the summer and fall, flowing water moves farther and farther away from the natural streambanks. The instream habitat also suffers from the disturbances associated with the annual berming of irrigation intakes.

Of the three tributaries, the North Fork appears to carry most (70 percent to 80 percent) of the summer flows. However, substrate in the North Fork is generally large, and quality spawning gravel is limited. Excellent spawning gravel exists in both the Middle and West forks, but summer discharge can be quite low in the West Fork. Summer flows are adequate through perhaps 15 miles of the North Fork and nine miles of the Middle Fork. In all three forks, water quality and the condition of the riparian corridor are good to excellent, although widely dispersed logging and grazing have had localized impacts. The impact of grazing is relatively more severe for the West and Middle forks, the lower reaches of which flow through canyons in which cattle are concentrated. Cover in the from of large organic debris may be lacking in the North Fork, but is abundant in the West and Middle forks. To summarize, the production potential of the West and Middle Forks are probably somewhat limited by low summer flows, but riparian conditions and gravel quality are excellent in all but the lowermost reaches. The North Fork, on the other hand, probably affords more than adequate flows except near its headwater, but cover and, especially, spawning gravel are lacking. It should be noted that local biologists believe the West and Middle Forks would provide excellent habitat for steelhead as they now exist.

The Teanaway was historically one of the top producers of spring chinook, steelhead and coho in the subbasin (Bryant and Parkhurst, 1950). Even now a few spring chinook routinely spawn in the lower mainstem and, occasionally, in the North Fork as well: several redds and carcasses were observed in the North Fork in the fall of 1989 (D. Fast, YIN, pers. commun.). The system also apparently supports a small run of steelhead, as about 20 adults were observed in the lower West Fork in the spring of 1989 (Dale Bambrick, YIN, pers. commun.) Given the correction of a number of significant problems, its physical diversity and size guarantee the Teanaway could still be a major producer. Suitable spawning gravels and gradients for all three species are present in most reaches of the mainstem and the lower portions of the forks, and are abundant in many areas. The upper reaches of the forks as well as the lower reaches of some smaller tributaries provide additional spawning habitat for steelhead and coho. Rearing habitat benefits from the excellent water quality and temperatures, which ranged from the mid-50s to the mid-60s F in August 1988. There is a good mix of pools, runs and riffles, and the channels and banks are generally stable, although wide channels and dry gravel bars provide some evidence of high seasonal runoff.

Surprisingly, several irrigation ditches provided excellent rearing habitat between the intake and bypass, providing excellent riparian cover and complete bank and channel stability. The length of these "rearing canals" ranged from yards to nearly a half mile, and collectively represented a significant component of potential steelhead and coho rearing habitat.

In decreasing order of importance, the main factors currently limiting production in the Teanaway system are low flows during the summer and fall in the Middle and West forks and, especially, in the lower mainstem; impaired adult passage at many gravel diversion berms; and a "flashy" runoff pattern, which has widened the streambed and generated a fringe of riparian vegetation that cannot provide shade or cover when the stream shrinks in the summer and fall.

Currently, low fall flows preclude significant spring chinook and coho spawning. Flows decrease progressively from the forks to the mouth in the summer and fall. Although some flowing water was present in all reaches in an August 1988 survey, such is not always the case. Even when the lower river does not dry up, flows may be below the minimum for salmon passage from mid-July to mid-November. Steelhead would, however, encounter good passage flows from December through April.

The solution to the instream flow problem might involve buying water rights from willing sellers and/or converting farmers to well irrigation and/or constructing one or more small impoundments at the headwaters of the forks. Farming in the Teanaway Valley is reputed to be less profitable than in neighboring areas because of a shorter growing season and, in the upper valley, because of a scarcity of level land. Judging from the use patterns of diversions, there is some indication that some individuals, particularly in the upper valley, are abandoning farming. Of 17 diversions investigated in August 1988, eight were not operating when inspected, and four (two on the North Fork and one each on the Middle and West forks) were presumed inactive. The possibility of buying water rights in the upper Teanaway Valley thus merits investigation. Of course, a series of fairly small headwater impoundments would also rectify the instream flow problem, and could contribute additional irrigation water for agriculture as well. It should be borne in mind that three 8,000-acre-feet impoundments could provide 100 cfs of flow for three months.

Gravel berms also restrict passage when instream flows are low. As these berms are made of coarse streambed material, some water flows directly through them, eliminating negotiable spills at low flows. This problem would be eliminated by increasing instream flow, and might be substantially reduced by notching the berms even without improved flows.

The flow and riparian problem may be partially attributable to extensive logging in the upper watershed and is certainly exacerbated by large-scale irrigation withdrawals during the period of lowest natural flows.

A judicious use of headwater dams might also solve the flow and riparian problem by checking the periods of extreme high runoff that are responsible for the unnaturally wide riverbed and set-back riparian. Release of stored water would also widen the wetted perimeter in the summer and fall.

MAINSTEM TEANAWAY RIVER

HAS ANAD FISH?	PROBLEMS SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	F-G	P-G, poor in summer & fall.	G	Diversions, low fall flows.	G	F-G	

NORTH FORK TEANAWAY RIVER

HAS ANAD FISH?	PROBLEMS SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	E	G	E	diversions	G	F: large rock.	cover (LOD)

MIDDLE FORK TEANAWAY RIVER

	PROBLEMS						
HAS ANAD FISH?	SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes(?)	E	F	E	diversions	E	E	

WEST FORK TEANAWAY RIVER

	PROBLEMS						
HAS ANAD FISH?	SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes(?)	E	F	E	diversions (inactive?)	E	E	

Cle Elum River

The Cle Elum River below Cle Elum Dam (a permanent barrier to anadromous fish) runs through forested land. The riparian corridor is in generally good condition. Flows are strictly regulated, but have been fairly good through much of the season in recent years, ranging from about 60 percent greater than optimal in October to 50 percent less than optimal in March. Spring and summer rearing is, however, impaired by excessive flows during the irrigation season (May through early September), which range from three to ten times optimal. Water quality is good to excellent, and although much of the substrate is made up of large materials, there are adequate numbers of good gravel bars for spawning.

HAS ANAD FISH?	SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
	PROBLEMS						
yes	G	F-G	G-E	None below Dam.	G	F-G	

Big Creek (12 miles)

Big Creek enters the Yakima River from the west at RM 195.8. The creek has been heavily channelized in its lower reaches, and in the lowermost quarter mile suffers from channel instability and bedload deposition. It has two diversions, a small, (2 cfs to 3 cfs) bermed diversion about 0.7 mile from the mouth, which has a flat screen across the ditch and is easily passable by adults; and a larger (10 cfs to 15 cfs, 5-foot head) impassable diversion dam at RM 2.1 with a permanently closed fishway and an unscreened ditch. The creek has substantial perennial flows (~10 cfs in August 1988) above the upper diversion, but below this point, the creek carries no more than 1 cfs, most of which represents leakage. Flows are recharged by groundwater over the next mile, and amounted to about 3 cfs at RM 1.2 in August 1988. However, most of this discharge is removed at the lower diversion, and the stream is totally dry at RM 0.6, and dry or intermittent from this point to the mouth. A siphon for the Kittitas Reclamation District Main Canal passes under Big Creek at about RM 1.6. Above RM 3, the creek enters a heavily forested canyon; riparian conditions are believed to be good. Riparian conditions deteriorate downstream from the canyon, becoming poor in the channelized reach near the mouth.

Big Creek is known to have produced steelhead historically and appears still to have potential for producing steelhead, coho and, to a lesser degree, spring chinook. Currently, spring chinook juveniles rear in the lower reaches in substantial numbers; 20 to 30 pounds of pre-smolts were salvaged from several isolated pools in the lower part of the creek in 1986 (J. Easterbrooks, WDF, pers. commun.).

The major factors limiting production on Big Creek are the impassable dam and unscreened diversion at RM 2.1, and the lack of instream flow from this point to the mouth. Provision for the installation of juvenile and adult passage facilities should be made pursuant to the Columbia River Basin Fish and Wildlife Program, Section 803(b)(4), in which BPA proposes to "implement needed fish passage improvements at irrigation diversion dams, canals and ditches in the subbasin." Poor summer and fall flows in the lowest reaches could be rectified by siphoning or otherwise diverting some water from the Kittitas Reclamation District Main Canal at the intersection at RM 1.6. As was proposed for Taneum and Manastash creeks, Kittitas Reclamation District discharge might be increased 10 cfs or so to accommodate the flows Big Creek requires.

HAS ANAD FISH?	PROBLEMS						
	SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
yes	G	P-G; G above RM 2.1.	G	Diversions, low flows.	P-E; E above RM 3.0.	G	

Cabin Creek (10 miles)

Cabin Creek enters the Yakima River from the west, a short distance above Lake Easton, at RM 205. It has two significant tributaries, Cole Creek and Log Creek, which enter from the south at RM 2.4 and RM 5.3, respectively. Unlike most Yakima River tributaries, Cabin Creek has no irrigation diversions to limit access or instream flows. It does, however, suffer from other serious constraints, including an impassable series of cascades and waterfalls between RM 3.1 and RM 3.8, and from various logging-related impacts. The first mile of the creek is moderately braided, with a fairly intact riparian corridor and some evidence of channel shifting. The next two miles are steep, with major streambank damage and channel shifting due to heavy seasonal runoff. The intensity of runoff has probably been exacerbated by large clearcuts throughout the watershed and associated "rain-on-snow" flood events. Streambed scouring is evident in the high gradient reaches above and below the mouth of Cole Creek (RM 2.5). Riparian conditions from the head of the cascades to about RM 1 are ruinous; late winter and spring floods have demolished the riparian zone and streambed, which is steep and choked with large, unstable boulders and rock. Stream temperatures are, however, quite good from the cascades down (as they are elsewhere in the drainage), ranging from the low 50s to low 60s in August 1988. Water quality is also good to excellent throughout the drainage.

Above the cascades, habitat quality improves markedly. Spawning and rearing habitat for steelhead and coho, and to a lesser extent for spring chinook, is plentiful. Spawning gravel is abundant and generally of excellent quality, and the gradient becomes much more gentle. Virtually all of the drainage (with the notable exception of Cole Creek) has been logged to the water's edge, so shading and large organic debris are limited. Above the falls, however, annual floods have not prevented reforestation. The riparian corridor here is in the early stages of regrowth, with short but dense ranks of deciduous and coniferous trees and brush.

If the cascades were made negotiable for steelhead and salmon, Cabin Creek could become an increasingly important producer. The watershed has undergone very little development other than logging, and its rugged terrain and remote location almost guarantee that it will remain undeveloped. Moreover, habitat quality will almost certainly improve with time, as reforestation progresses and some of the impacts of logging are naturally remedied.

The cascades could be made passable by blasting. The cascades are confined to a narrow canyon about 0.7 miles long, are choked with huge boulders and logs, and include two sections in which water drops 30 to 40 feet in a distance of 75 to 100 yards. Although a considerable amount of blasting would be required, it does seem possible that the canyon could be transformed into a more regular series of jump pools and small cascades that steelhead and salmon could negotiate.

A small to moderate-sized impoundment in the upper drainage might reduce the impact of flash flooding. This dam would serve as flood control reservoir, and would be equipped with restrictive culverts ("leak tubes") that would allow only so much discharge until the reservoir were overtopped.

	PROBLEMS						
HAS ANAD FISH?	SED.	FLOWS	WATER QUAL.	BARRIERS	RIP ZONE	SUBSTRATE	OTHER
no	F	P-F	E	Cascade ~RM 4.	P-F	P-E, E above cascade	

APPENDIX 2

Details of Estimates of Fry and Smolt Losses at Wapatox and Phase-II Diversions

INTRODUCTION

Planners used a series of studies and observations at Wapatox diversion and a similar facility about 1 mile upstream of Wapatox, the Selah/Naches diversion, to estimate both fry and smolt losses at Wapatox and all Phase-II diversions.

SMOLT AND FRY LOSSES AT WAPATOX DIVERSION

Losses of Smolts to Entrainment

The impact of Wapatox on fry is obvious, as the fish can easily be observed stuck on the screens and being carried over to the downstream side. The screens at the Wapatox bypass are typical of the older facilities (Phase-II type systems) in the subbasin. Screen orientation is perpendicular to flow, screen mesh is relatively wide (~1/4 inch), and approach velocities are high, typically greater than 1 foot per second (Bumstead 1986). Smolt impingement is much less frequently observed (Eddy 1988), but the impact on smolts is probably more severe than for fry.

With perpendicular screens, there is no "sweeping velocity" to direct smolts to the bypass ports. Moreover, the bypass ports are small and located in the screen abutments. This combination of features -- lack of directional flow, and small bypass ports -- apparently makes it difficult for smolts to find their way out of the canal. Furthermore, the head differential between the bypass ports and the river is so small that attractive bypass flows are reduced or eliminated whenever the river rises. Observed bypass efficiencies for wild spring chinook smolts range from 53 percent to 75 percent over periods of four to 14 days (J. Hubble, Yakima Indian Nation, unpublished data), while bypass efficiencies for hatchery smolts were never greater than 33 percent over periods as long as five weeks (Eddy 1988).

As a result of the difficulty smolts experience in finding the exit ports, many residualize in the canal or are eventually entrained behind the screens. Entrainment of smolts is more probable than might be imagined, as the screen rotation mechanism breaks down about six times per season (B. Eddy, PP&L, pers. commun.), and the affected screen must be removed for the duration of repair. As there is no way of blocking the canal while the screen is out, it is easy to imagine accumulations of restive smolts rushing through the gap during even brief outages.

Planners can estimate that entrainment at the Wapatox diversion is responsible for the loss of about six percent of Naches system spring chinook smolts. This estimate is derived from the following data and assumptions.

1. The mean bypass rate for four releases of actively outmigrating wild smolts that were captured in Wapatox smolt trap, branded, and released just inside the canal, was 64 percent (Yakima Indian Nation, unpublished data). These April releases of actively migrating smolts are considered better tests of passage effectiveness than a number of other fall releases of wild and hatchery pre-smolts (Eddy 1988). Some of the fall pre-smolts probably assumed residence in the canal.

2. Roughly 10 percent of the spring chinook outmigration occurs in March, 80 percent in April, and 10 percent in May (J. Hubble, Yakima Indian Nation, pers. commun.).

3. Based on mean percent river discharge diverted, the mean rate of smolt entrainment into the upper portion of the canal (upstream of the screens and bypass) is about 4 percent in March, 20 percent in April, and 12 percent in May.

4. All fish not bypassed are entrained <u>behind</u> the screens. As the screens are not normally installed before April 1, all fish entering the canal in March pass through the turbines, as do 36 percent (100 percent minus 64 percent mean bypass efficiency) of the fish entering the canal in April and May.

5. Under a worst-case scenario, 88 percent of all smolts passing through the turbines are killed (Eddy 1988). Note that there is some evidence (Eichler et al. 1987) that cumulative smolt losses may be substantially less than 88 percent at the two Wapatox generating sites. There is, however, much variability in data relating mortality at Francis turbines to such things as head, fish size, and fish species. Mortalities at the Naches facilities have never been measured. It was therefore deemed prudent to use a reasonable "worst-case" mortality figure.

When the products of monthly outmigration fraction, pre-screen entrainment, "behind-screen entrainment" and turbine mortality are summed over March, April and May, the estimate of a 6 percent loss is obtained:

$$
\begin{array}{llll}
 & \text{March} & = (0.1)(0.04)(1.00)(0.88) & = 0.0035 \\
+ & \text{April} & = (0.8)(0.20)(0.36)(0.88) & = 0.0507 \\
+ & \text{May} & = (0.1)(0.12)(0.36)(0.88) & = \underline{0.0038} \\
 & & & 0.0580 = \sim 6 \text{ percent.}
\end{array}
$$

The temporal distribution of steelhead smolts in the Naches system is somewhat later and more compressed than spring chinook, with roughly 40 percent occurring in April, and 60 percent in May (J. Hubble, YIN, pers. commun.). Using this temporal distribution and assuming that the entrainment, bypass efficiency and mortality figures for spring chinook apply to steelhead as well, it is estimated that the Wapatox diversion could be responsible for the loss of 4.8 percent of the steelhead outmigration.

<u>Losses of Fry to Entrainment</u>

Using data collected in the previously mentioned bypass efficiency study (Eddy 1988), it is possible to estimate that the Wapatox diversion is responsible for the loss of at least 1.2 percent of upstream spring chinook fry production. This estimate is based on the following facts and assumptions.

1. Downstream fry dispersal is assumed to occur from April 1 through June 30, roughly the period of spring chinook emergence observed in experimentally capped redds in the upper Yakima (Fast et al. 1985, 1986).

2. Fry movement is primarily nocturnal, occurring mainly in the seven hours between 9 p.m. and 4 a.m.

3. Eddy (1988) observed that spring chinook fry entrainment and impingement rates on the screens at Wapatox progressively decreased from April 15, when observations began, through June 11, the date of last observation. From his data, it is possible to calculate hourly impingement and entrainment rates for five periods in which the rates were relatively constant:

April	15-24:	564 fry/hr
April	25-30:	492 fry/hr
May	1-13:	276 fry/hr
May	14-31:	114 fry/hr
June	1-30:	6 fry/hr

No observations were made before April 15, although the high rates observed then indicate movement must have been substantial in early April. It has been assumed that fry movement began April 1, and that the entrainment and impingement rates occurring April 1 through April 14 were half the rate observed on April 15.

4. Turbine mortality for fry is 44 percent (Eddy 1988). Note that 44 percent mortality is well within the range of values reported by Eichler et al. (1987) for similar hydroelectric sites.

A numerical estimate of (behind-the-screens) entrainment of spring chinook fry in the year of Eddy's study (1987) can be made by summing the products of hourly entrainment, hours of entrainment per day and days:

	April 1-14:	(282)(7)(14)	=	27,636
+	April 15-24:	(564)(7)(10)	=	39,480
+	April 25-30:	(492)(7)(6)	=	20,664
+	May 1-13:	(276)(7)(13)	=	25,116
+	May 14-31:	(114)(7)(18)	=	14,364
+	June 1-30:	(6)(7)(30)	=	1,260
				128,520.

If 44 percent of these fry were killed by the turbines, the total loss was (0.44)(128,520) = 56,549.

From spawner surveys and fecundity estimates, it has been determined that 7.86 million eggs were deposited in the Naches system above Wapatox in 1986. If 60 percent of these eggs produced fry, 4.7 million fry would have been produced. The total estimated fry loss at Wapatox thus represented (56,549)/(4,700,000) = 0.012 or 1.2 percent of total upstream production. This estimate should be considered extremely conservative. Total pre-screen entrainment could easily have been two or three times the estimated figure of 128,520 if:

Although Eddy's observations preceded the period of steelhead emergence, it is not unreasonable to assume the loss of steelhead fry was at least as large as chinook --1.2 percent of upstream production.

Losses of Smolts and Fry to Dewatering Below Wapatox

As was mentioned in the text, 11 releases of marked wild spring chinook smolts indicated a 30 percent loss somewhere between Wapatox Dam and Sunnyside Dam. Planners speculate that most of these losses occur in the braided, frequently dewatered 7.4 miles between Wapatox Dam and the powerplant outfall. The proximate causes of smolt loss have been assumed to be stranding and predation. Losses of fry in the reach from the dam to the outfall have never been estimated. However, fry prefer littoral areas, have limited swimming abilities, and are vulnerable to a wider range of predators. It must therefore be assumed that the loss of fry below the dam is considerably higher than 30 percent.

Losses of Pre-smolts to Entrainment in the Fall

The hydroelectric facility fed by Wapatox Canal operates all year long, but the screens in the bypass are removed when icing problems develop, usually in late November or early December. A surprising number of spring chinook pre-smolts descend the Naches in the late fall, especially in late November, when water temperatures typically drop precipitously. These fall migrants are therefore also subject to entrainment risk.

The number of pre-smolts moving past Wapatox in December is not known, as icing has always halted operations by December 1 at the latest. It has, however, been assumed that essentially all fall movement occurs in November. This simplification is justified relative to the movements observed in September and October, which are relatively minor. The only justification for assuming negligible December movement is that about 60 percent of marked, Naches fall migrants pass Prosser in a concentrated pulse in the first two weeks of December, and the remaining 40 percent trickle by through March. This temporal distribution as observed at Prosser, 86 miles downstream, is not inconsistent with a Naches emigration of spring chinook heavily concentrated in November.

Assuming that all fall migration occurs in November, it remains to determine associated entrainment mortality. The mean percent river discharge diverted in November from 1982 to 1986 (the "base period" for System Planning Model calibration) was 53 percent. Planners therefore assumed that 53 percent of the fall migrants were also diverted into the mouth of the canal. If 36 percent of these fish get behind the screens, as is the case with spring smolts, and 88 percent then die in the turbines, the survival of November migrants past Wapatox would be:

$$S = 1 - [(0.53)(0.36)(0.88)] = 0.832 = \sim 83.2 \text{ percent.}$$

It should be noted that this mortality was incorporated in the egg-to-smolt survival rates assigned to spring chinook spawning above Wapatox.

ESTIMATION OF SMOLT AND FRY LOSSES AT PHASE-II DIVERSIONS BASED ON DATA FROM WAPATOX AND SELAH/NACHES DIVERSION AND PARTITIONING SMOLT MORTALITY IN THE WAPATOX REACH

Losses of Smolts in Phase-II Diversions

It has been assumed that smolt loss in all Phase-II diversions is equal to 36 percent of all fish entering the mouth of the diversion. This assumption is based on the facts that 36 percent of all experimental spring chinook smolts released just below the headworks of Wapatox Canal were never recovered, and that the Wapatox bypass uses a configuration and technology quite similar to Phase-II diversions. A significant difference between Wapatox and Phase-II diversions is that most of the water diverted at Wapatox returns to the river after passing through turbines, whereas most (if not all) of the water diverted at Phase-II diversions ends up in fields. Consequently, all 36 percent of the smolts entrained behind the bypass screens in Phase-II diversions are assumed lost, whereas only 88 percent of the non-bypassed smolts in Wapatox were assumed to be lost.

Planners assumed entrainment into the mouths of Phase-II diversions was equal to the mean percent river discharge diverted in April and May, the peak period of outmigration. Mean figures for April-May discharge in specific river reaches were obtained from the Bureau of Reclamation's Yakima Project office.

In computer simulations, planners assumed that all Phase-II screens have the impact detailed above. Specifically, the local (reach specific) smolt-to-smolt survival rate was decreased by a multiple of 1 - (PDC)(.36), where PDC is the mean April-May river discharge diverted. As no data for entrainment of steelhead at Wapatox or any other "Phase-II type" diversion exists, the spring chinook relationship was assumed for steelhead as well.

Partitioning Smolt Losses in Wapatox Reach

Smolt-to-smolt (Sss) survival at any reach in the subbasin represents the product of Sss in that reach and the reach-specific Sss values in all downstream reaches. The cumulative Sss just below the "Wapatox reach" (Naches River from Cowiche Creek to Tieton River) is 0.4383 for spring chinook, and represents the product of Sss in two zones of open river (Yakima below Sunnyside Dam and Yakima below Prosser Dam) and four clusters of Phase-II screens. Within the Wapatox reach, smolts are lost by entrainment at the screens by predation and stranding attributable to dewatering below the dam, and by a cluster of Phase-II diversions below the dam. Under existing conditions, Sss from a point below the dam to the bottom of the reach is 0.7018 (see description of experimental releases of marked smolts in the smolt-to-smolt survival section of text). As 0.7018 is the product of Sss values attributable to Phase-II screens and dewatering and predation, the losses specifically attributable to Wapatox dewatering can be determined once the losses attributable to the Phase-II diversions are estimated.

There are 11 Phase-II diversions in the Wapatox reach below the dam, with mean diversions ranging from 3 cfs to 60 cfs. The mean discharge in April and May through the Wapatox reach over the past seven years has been about 1625 cfs. Thus, the diversions have diverted (through their headgates) a range of from 3/1625 = 0.0018 to 60/1625 = 0.0369 of the outmigration, and the estimated smolt losses have ranged from (0.0018)(0.36) = 0.0006 to (0.0369)(0.36) = 0.0133. The product of the survival rates associated with all these diversions, 0.9404, represents the below-dam Sss attributable specifically to Phase-IIs.

As mentioned, Sss in the Wapatox reach below the dam is 0.7018, and represents the product of cumulative Phase-II Sss and Wapatox "dewatering Sss." Thus, the dewatering Sss is 0.7018/0.9404 = 0.7463. The cumulative Sss from a point immediately above Wapatox Dam to the Columbia (Swap) is:

$$\begin{aligned} \text{Swap} &= 0.4383(\text{Sss, entrainment})(\text{Sss, Phase-IIs})(\text{Sss, dewatering}) \\ &= 0.4383(0.942)(0.9404)(0.7463) \\ &= 0.2898. \end{aligned}$$

The smolt-to-smolt survival rates in critical reaches of the open river for steelhead are spring chinook rates adjusted for 11 percent lower mortality per reach. This upward adjustment is based on the mean relative survival of steelhead and spring chinook simultaneously released at the headworks of Chandler Canal. By this procedure, planners have estimated that the smolt-to-smolt survival of steelhead to a point below the Wapatox reach is 0.5084 and that the survival through the reach is 0.758. As was the case with spring chinook, the figure for the Wapatox reach is the product of Phase-II and dewatering survival rates. As Phase-II Sss was estimated identically for spring chinook and steelhead, the dewatering Sss for steelhead is 0.758/0.9404 = 0.806. The cumulative Sss from a point immediately above Wapatox Dam to the Columbia (Swap) is:

$$\begin{aligned} \text{Swap} &= 0.5084(\text{Sss, entrainment})(\text{Sss, Phase-IIs})(\text{Sss, dewatering}) \\ &= 0.5084(0.952)(0.9404)(0.806) \\ &= 0.3669. \end{aligned}$$

Losses of Fry in Phase-II Diversions

The analysis of fry loss at Wapatox can also be used to estimate fry loss at Phase-II diversions. If Wapatox Canal were like Phase-II diversions, which distribute nearly all diverted water over fields, all or most of the 128,520 fry entrained in 1987 would have been killed. It should be noted that Wapatox diversion is about one mile below the Selah/Naches diversion, a Phase-II diversion that diverts 30 percent as much water as Wapatox (135 cfs versus 450 cfs). It is probable that Wapatox entrains fewer fry than it otherwise might because Selah/Naches "filters off" many fry before they encounter Wapatox. Indeed, in the fall of 1987, nearly the same number of parr were salvaged from Selah/Naches as from Wapatox -- 3,248 parr versus 3,435 parr, respectively (J. Easterbrooks, WDF, pers. commun.).

Planners believe that the salvaged fingerlings entered the canals as fry in the spring, and reared there through the summer. As equivalent numbers of parr were salvaged from these neighboring canals, planners assumed that equivalent numbers of fry were entrained. It was therefore assumed that Selah/Naches entrained 128,520 fry in 1987. Given 1986 egg deposition above Selah/Naches and expected egg-to-fry survival rates, there should have been 4.7 million fry above the diversion in 1987. If 128,520 fry were entrained at Selah/Naches, 128,520/4,700,000 or 2.7 percent of all upstream production was entrained. Assuming entrainment proportional to diversion, 2.7/135 or 0.02 percent of upstream fry production was entrained per cfs diverted.

In computer simulations, planners have assumed that all other Phase-II screens have this magnitude of impact. Specifically, the impact of Phase-II screens was estimated by decreasing the local (reach specific) egg-to-smolt survival rate. If egg-to-smolt survival is the product of egg-to-emergent fry survival, screen survival, fry-to-late parr survival and overwinter survival, egg-to-smolt survival will be decreased by a multiple of 1 - (.0002Q) due to Phase-II screens:

$$So = (Sem)[1 - (.0002Q)](Sf/p)(Sow)$$

where
So = egg-to-smolt survival;
Sem = egg-to-emergent-fry survival;
Sf/p = emergent fry to late-summer parr survival;
Sow = overwinter survival;
[1 - (.0002Q)] = screen survival, in which Q is the mean discharge into the diversion.

APPENDIX 3

Potential New Habitat: Obstacles to Utilization, Proposed Solutions and Estimated Costs.

Cabin Creek

The only obstacle to spring chinook production in Cabin Creek is an impassible cascade or falls from RM 3.1 to RM 3.7. Passage would be assured if two 12-foot falls were laddered with a heavy, enclosed concrete structure like the one recently installed on Marion Drain; if pools were blasted in a number of steep sections; and if large boulders were moved from the main channel with heavy equipment. About one week of blasting might be required, and perhaps as much as one month of heavy equipment work (R. Johnson, consultant, pers. commun.). The ladders would cost about $30,000 per vertical foot (D. Hudson, Boise Regional Office, BOR, pers. commun.), a blasting crew would cost about $850 per day (from Instream Rehabilitation Training proceedings), and a heavy cat with a three-man crew would cost about $1,200 per day. Total costs are thus:

	($30,000/ft)(24 ft)	=$720,000
+	($850/day)(7 days)	= $5,950
+	($1,200/day)(30 days)	= $36,000
		$729,550

Note that the ladder is necessary for passage of spring chinook only; steelhead passage could probably be effected by the blasting and earthwork alone (cost = $41,950).

A trap and haul operation for spawning spring chinook could also be implemented. The cost of a portable, angle-iron and conduit weir and livebox would be about $3,300 (G. Christiansen, Idaho Fish and Game, pers. commun.). Operation would require one 24-hour guard, a trailer for the guard, two haulers and a tanker for about three months. Costs (as per estimates by Lynn Hatcher, Yakima Indian Nation Fisheries Resources) would be approximately:

guard = $2,000/month
trailer = $400/month
hauler = $3,000/month
use and mileage on 1,500-gallon tanker = $350/month

Total operational costs for a 3-month season would thus be:

(3 mo)[($2000/mo)+($400/mo)+2($3000/mo)+($350/mo)] = $26,250.

Because of the uncertainty of substantial spring chinook utilization of upper Cabin Creek, the trap-and-haul operation is the preferred option for spring chinook.

Big Creek

Big Creek is currently unusable by anadromous salmonids because a diversion dam at RM 2.1 is impassible at all flows, and because this diversion removes most of the water from the stream from late spring through late fall. A fishway at a smaller, downstream diversion also needs minor repairs and the flat screens there need renovation. A fishway was originally built into the dam at RM 2.1, but has been cemented in. Rebuilding the fishway and installing a screen at the upper dam would, along with minor improvements at the lower diversion, eliminate structural passage problems, but the instream flow problem would remain. Note that a siphon at RM 1.6 allows the Main Canal of the Kittitas Reclamation District to pass under Big Creek.

Big Creek is similar to two other West-side Yakima tributaries, Taneum and Manastash Creek. All afford substantial habitat for the spawning and rearing of steelhead, coho and spring chinook in all but their lowermost reaches. These lower reaches (~5 miles Manastash Creek, ~3 miles Taneum Creek, ~2 miles Big Creek) suffer from impassible diversion dams, unscreened ditches and nearly complete dewatering from, roughly, May through November. Installation of ladders and screens would bring these tributaries back into production for steelhead, but spring chinook and coho would still face the instream flow problem.

A potential solution to at least a substantial part of the instream flow problem lies in the fact that the South Branch Canal of the Kittitas Reclamation District crosses both Taneum and Manastash creeks above most diversions and all zones of severe late summer dewatering, and the Kittitas Reclamation District Main Canal crosses Big Creek one-half mile below a major diversion, but well above most of the dewatered zone. Provided necessary funding, it should be possible to divert more water into the Kittitas Reclamation District Main Canal at its Lake Easton headworks and spill the incremental flows into all of these tributaries. (Note that Kittitas Reclamation District already spills some water into Taneum and Manastash creeks, but this water is almost totally used by irrigators.) The extra water diverted into Kittitas Reclamation District's main canal would be targeted for delivery to a downstream user, and would neither add to nor subtract from the natural creek runoff and contracted waters legally diverted by local users.

Specifically, Kittitas Reclamation District might spill a small amount of water down all three tributaries simultaneously to provide rearing habitat in the lower reaches from May through the end of irrigation season in mid-October. The district could also spill substantially more water down each tributary in succession to provide a short period for adult passage. Most spring chinook reach the vicinity of these tributaries by early July. It is probable that returning adults, released as smolts from tributary acclimation ponds running a mixture of creek and Kittitas Reclamation District water, would home in on their "natal" stream and successfully negotiate the lower two to five miles in a two to three week period of artificially augmented flows. Because of different arrival times, it would probably be advisable that the sequence of passage spills begin in Manastash Creek, proceed to Taneum Creek, and end in Big Creek. Assuming adults would hold in the Yakima until spawning season begins, the optimal time to begin the sequence of passage spills would be in September, when irrigation demand begins to decline.

It is probable that the main Kittitas Reclamation District canal would require no structural modifications to carry enough additional water to meet Big Creek's needs, which would almost certainly be less than 40 cfs (see below). The delivery system would, however, require substantial modifications if the required additional flows were to be delivered to Taneum and Manastash. The timing of spills for adult passage is, unfortunately, just after the period of maximal irrigation demand. At this time, the lower South Branch Canal is operating near its capacity. With correction of several "bottlenecks," the South Branch Canal could probably deliver an increment approaching 70 cfs as far as Taneum Creek. As will be seen, this discharge would almost certainly satisfy instream flow requirements in Taneum Creek. However, Manastash Creek, which of the three has the greatest spring chinook production potential, lies near the end of the delivery system, suffering from all the bottlenecks afflicting Taneum Creek as well as the unpredictable drops in flow characteristic of a "tail end" delivery point.

The main obstacles to augmenting spill in Taneum Creek are a half-mile tunnel ("Tunnel 1") at the beginning of the South Branch Canal, and a 1.2-mile section of unlined canal immediately below Tunnel 1. No more than 220 cfs is currently pushed through Tunnel 1, mainly because it discharges into a stretch of earthen canal considered structurally unsafe for flows over 220 cfs (in fact, Kittitas Reclamation District prefers that discharges not exceed 210 cfs in this reach). Thus, in its present state, the South Branch Canal can carry no more than 210 cfs to 220 cfs, and all of this water is required by irrigators during peak periods. Tunnel 1 could carry more than its current operational maximum, as there is about 14 inches of freeboard when it is running 220 cfs. It is, however, not known whether it could carry an additional 70 cfs, a discharge that represents a very conservative estimate of adult passage discharge for Taneum Creek. The canal beyond Tunnel 1, if narrowed, lined with concrete and shored up in some places, probably could carry an extra 70 cfs (a total volume approaching 290 cfs).

Delivering additional water to Manastash Creek requires the solution of the preceding problems as well as two others. The first is that the siphon under Taneum Creek can carry no more than 145 cfs, most of which is needed by irrigators during the summer. The second is that deliveries to Manastash Creek are hard to regulate. A reregulating reservoir below the Taneum siphon would, to some degree, solve both problems. Water stored early in the season could be released as needed for fish passage (and periods of peak irrigation demand as well), perhaps eliminating the need to enlarge the Taneum siphon, or at least reducing the magnitude (and cost) of the enlargement.

As it is currently impossible to specify the precise nature and scope of all of the structural improvements necessary to deliver additional flows to these tributaries, it is impossible to estimate all costs. In the first place, instream flow requirements have not yet been precisely estimated. A very rough estimate of the discharge necessary for adult passage was made with Manning's equation, with some input parameters (channel width, roughness and shape) gleaned from a cursory field analysis, and others (energy gradient) estimated from topographic maps. By this procedure, it was estimated that 38 cfs, 74 cfs and 50 cfs, respectively, would be required to maintain 1 foot of depth throughout the dewatered reaches in Big, Taneum and Manastash creeks. Even if the input parameters in these calculations are correct, it is almost certain that the resulting estimates of minimal passage discharge are too high. The criterion driving these estimates -- 1 foot of depth throughout the reach -- is a conservative standard compatible with limited data, but is also considerably more stringent than is required by other generally accepted analytical techniques. The obvious consequence of uncertain minimal passage flows is that Kittitas Reclamation District engineers do not know the precise maximal capacity required of their delivery system. In the second place, even if minimal passage flows were known precisely, it is not a simple matter for an engineer to specify the necessary structural modifications in a system as complex as Kittitas Reclamation District. A series of alternate actions will have to be evaluated to determine the optimal package.

It should be noted that the Tributary Task Force of the Yakima/Klickitat Production Project will determine precise minimal passage and rearing flows in the summer of 1990. Critical sites will be located on each tributary, and a series of transects will be run through each. The data gathered will be analyzed for passage and rearing using IFIM techniques (instream flow incremental method). It should also be noted that Kittitas Reclamation District personnel have agreed to begin an analysis of structural modifications and associated costs once minimum instream flows have been estimated.

Preliminary estimates of the costs of <u>some</u> of the structural modifications are available. Lining the 1.2 miles of earthen canal below Tunnel 1 will probably cost between $750,000 (Kittitas Reclamation District estimate) and $1.5 million (Bureau of Reclamation estimate). A highly speculative estimate of the cost of a reregulating reservoir can be made for the scenario in which a below-Taneum reservoir supplies all the water for adult passage on Manastash Creek If two weeks of 50 cfs flows come entirely from the reservoir, it would have to have a capacity of at least 1,428 acre feet, (51 cfs)X(14 days)X(2 acre feet/cfs day). If the costs of such a reservoir were comparable to the costs of the reservoir built in 1988 on Wasteway 6 of the Roza Irrigation District's main canal (~$5,000/acre feet), it would cost $7,140,400.

As the preceding estimates show, the total cost of providing instream flows for salmon on these tributaries will be high. Fortunately, the project would benefit more than just the fishery. Much of the 1.2 miles of unlined canal abut Interstate 90. As the current steady leakage from the canal onto the highway concerns the Department of Transportation, as does the possibility of a catastrophic structural failure, financial assistance from the Department of Transportation may be possible, at least for this portion of the project. Moreover, the Kittitas Reclamation District and its customers would derive considerable benefits from a number of elements of the project. It is in Kittitas Reclamation District's interest to construct delivery facilities to Big Creek, and to deliver water to Big Creek in the summer if, as a trade-off, the district is allowed to "skim" flood flows from Big Creek in the spring and spare contracted water. In addition, the district hopes to install a hydroelectric generator at the bottom of the chute that delivers water to Taneum Creek; more water to Taneum would mean more electrical revenues for Kittitas Reclamation District. Finally, the need of a reregulating reservoir on the lower South Branch Canal has been painfully obvious to the Kittitas Reclamation District for a long time. The trade-off on Big Creek, the augmentation of power revenues on Taneum Creek, and the acquisition of a long-needed reregulating reservoir are all powerful incentives for the district to assume a fraction of project costs.

At this point, the consensus of opinion is that the Kittitas Reclamation District delivery system probably can be modified to enough additional water to meet instream flow needs in Big Creek and Taneum Creek. It is, however, much more uncertain that the instream flow problems on Manastash Creek can be solved solely by increasing the capacity of the Kittitas Reclamation District delivery system. Doubts arise from two concerns: the lack of suitable sites for a substantial reregulating reservoir below the Taneum Creek intersection and, more importantly, concern that the main canal may not have the ability to deliver enough water to its branches when the smolt bypass facility begins operating (water to bypass fish to the river is diverted from the Main Canal).

It is important to note that the Yakima River Basin Water Enhancement Project group is currently investigating the possibility of solving some of the subbasin's irrigation and instream flow problems by constructing a series of small to moderately sized impoundments near the headwaters of a number of upper Yakima tributaries -- specifically, on the Middle Fork of the Teanaway River, Taneum Creek, Manastash Creek and Naneum Creek (CH2MHill 1989). All of the proposed impoundments are intended specifically to improve instream flows for anadromous fish. A range of different sized impoundments has been proposed for each tributary, and the proposals for the Teanaway River, Taneum and Manastash creeks include alternatives that would completely rectify the existing instream flow problems.

Returning to Big Creek, if Kittitas Reclamation District can spill enough water at RM 1.6 to provide flows for adult passage and juvenile rearing in downstream reaches, one-half mile of dewatered stream between the Kittitas Reclamation District siphon and the upper Big Creek diversion dam would remain. There is evidence that diversions at this point exceed legal entitlements. If diversions were limited to the legal maximum, and if instream flow concentrators were installed, passage for adult spring chinook would probably be possible. Upstream V-weirs made of boulders placed every 100 feet would probably allow passage under the flow conditions expected. At $550 per weir (K. Russell, Naches Ranger District, USFS, pers. commun.), installation and maintenance costs would be:

(2640 ft)/(100 ft/weir)($550/weir) = $14,520 for installation,
(0.5 mile)($760 per mi per yr)(50 yrs) = $19,000 for maintenance,
$33,520 TOTAL for weirs.

The cost of the fishways on Big Creek (J. Easterbrooks, WDF, pers. commun.) are:

Repair of fishway at upper dam: $8,000
Repair of fishway at lower dam: $5,000
TOTAL FISHWAY COSTS: $13,000

Note that the costs of the new screens required on Big Creek, as well as the costs of new screens and fishways required anywhere in the subbasin, were estimated with the assistance of John Easterbrooks, the director of the Washington Department of Fisheries screening program in the Yakima Subbasin. Note also that the cost of refurbishing a 15-foot screen in the "Table of

Costs for Waterway Screening" in the Northwest Power Planning Council's costing directive was listed as 2.54 percent of the installation cost. As most of the screening required in the subbasin was of this size, this refurbishing rate was applied to all but the largest proposed screens.

Screening costs on Big Creek are:

Installation, upper dam: (9 cfs)($4500/cfs)=$40,500
Renovation/repair, lower dam: $5,000
O/M, all screens, first 25 yrs: 2(25)($300) = $15,000
25-yr refurbishing, all screens: $1,155
O/M, all screens, second 25 yrs: 2(25)($300) = $15,000
TOTAL 50-YR SCREEN COST:$76,655

The total cost of structural improvements needed on Big Creek is thus:

Flow Concentrators:	$33,520
Fishways:	$13,000
Screens:	$76,655
GRAND TOTAL	$123,175

Teanaway River

The Teanaway River is heavily diverted for irrigation, but all ditches are associated with temporary gravel berms that would permit adult passage at all but the lowest flows. All screens need to be rebuilt, but these costs are already covered by the Phase-II screening project. The only remaining obstacle to reintroducing spring chinook to the Teanaway system is insufficient flows for adult passage and juvenile rearing in the lower three to four miles of mainstem. It should be noted that even now a few spring chinook and steelhead do spawn in the upper Teanaway system (spring chinook in the North Fork and steelhead in the West Fork). The low numbers of spring chinook spawners is attributable to poor passage flows. The scarcity of steelhead, on the other hand, is attributable to the fact that very few steelhead spawners ascend the upper Yakima (above Roza Dam); passage flows for spring-spawning steelhead are excellent.

The solution the fall instream flow problems in the lower Teanaway will not be easy. The lower Teanaway is 40 to 100 feet wide, and thus requires a substantial flow to carry any depth. As no irrigation canals intersect the system, the only permanent solution to this dilemma is to implement a combination of interrelated actions including converting farmers to well irrigation, buying water rights (or land) from willing sellers and, perhaps, constructing a headwater impoundment. A temporary solution -- which could, however, be continued indefinitely -- is to implement a trap-and-haul operation for spring chinook.

Reestablishing completely natural runs (runs not maintained by a trap- and-haul operation) presupposes the "freeing up" of a substantial volume of water (through purchase of water rights, etc.) and/or the construction of a reservoir to augment flows. A preliminary estimate of the flows required for adult passage and juvenile rearing can be made by applying the "modified Montana method" to existing flow records. The Montana method predicts that all aquatic resources (including fish rearing and passage) will be protected so long as flow equals or exceeds 30 percent of the mean annual natural discharge. Thirty percent of the mean annual natural discharge at the mouth of the Teanaway is 113 cfs (D. Simmons, USFWS, pers. commun.). From 1981 through 1987, mean flows equalled or exceeded this figure in all months except July, August, September and October, when there was a mean shortfall of 24, 88, 91 and 70 cfs, respectively. Making up this deficit would require 16,744 acre feet. Over a 123-day period (July through October), this quantity of water could be "spared," and left in the channel as instream flow, if seven 10-cfs diversions were eliminated:

7 diversions X 123 days X 10 cfs = 8,610 cfs-days = 17,220 AF.

Alternatively, a 17,000-AF headwater reservoir could be constructed (see CH2MHill 1989).

The cost of "purchasing seven 10-cfs diversions" can be very crudely estimated as follows. Ownership of irrigated pastureland is meaningless without adequate water rights. Thus, it can be expected that purchasing the water rights to agricultural land will require the purchase of the land as well. The cost estimate therefore reduces to the cost of the land that could be served by seven 10-cfs diversions. Over a 214-day irrigation season (April through October), seven 10-cfs diversions would divert about 30,000 acre feet. The delivery efficiency of a good earthen ditch is about 50 percent (K. Mitchell, YIN, pers. commun.). Therefore, it can be expected that about 15,000 acre feet would actually be applied. If the application rate for pastureland is 4.5 AF/acre (K. Mitchell, YIN, pers. commun.), then 15,000/4.5 or 3,333 acres could be served. The cost of irrigated pastureland in the Yakima Valley is generally between $1,000 and $2,000 per acre. Thus, a very crude initial estimate of the cost of "buying" seven 10-cfs diversions would be between $3.3 million and $6.6 million. It should be noted that the lower figure is probably closer to reality, because it is certain that all of the seven diversions will not be able to divert a full 10 cfs throughout the irrigation season, and that the "served area" estimate is therefore too large.

As will be seen, the cost of a 17,000-acre-foot reservoir will be much greater than the cost of the land irrigated by 17,000 AF. On May 15, 1989, CH2M HILL was hired by the Bureau of Reclamation to perform an appraisal assessment of tributary storage potentials in the Kittitas Valley. The purpose of the study was to ascertain if any potential exists for storing spring runoff in the headwaters of tributary streams to the upper Yakima River for release in low flow months to enhance anadromous fish spawning. CH2M HILL found potential storage sites on Naneum Creek, Manastash Creek, Taneum Creek and the Middle Fork of the Teanaway River. Sites on each creek permitted a range of reservoir sizes. The site at RM 6.2 of the Middle Fork of the Teanaway included a scenario for a 16,800-AF reservoir. The estimated cost of this reservoir was $21.45 million (CH2M HILL, 1989).

A trap-and-haul operation on the Teanaway would entail the construction of a $6,600 portable weir, and operation and maintenance costs of about $26,250 per year (see Cabin Creek section).

The preferred solution of fall instream flow problems is the purchase of land and/or water rights. However, the alternative of an indefinite trap-and-haul operation for spring chinook would also be acceptable, and would probably be cheaper than either purchasing water rights or building a reservoir, even when projected over 50 years.

Taneum Creek

The cost of all necessary fishways and screens on Taneum Creek are included in the Phase-I project, and all structures were completed in 1989. The only remaining obstacle to reestablishing spring chinook in the system is the augmentation of flows in the lower 2.9 miles through additional spills from the South Branch of the Kittitas Reclamation District canal. As mentioned, the costs of increasing the capacity of the Kittitas Reclamation District delivery system would be at least $750,000 (for shoring up and lining initial the 1.2-mile section of the South Branch Canal).

Manastash Creek

In addition to increased instream flows in the lower 4.2 miles, Manastash Creek requires the installation of two fishways and eight screens. It should be noted that it was impossible to find definitive records of maximal diversions (Qmax) for most of the ditches on this creek. Consequently, Qmax was estimated as the maximum discharge possible for a diversion with an orifice of a given size and type. Therefore, it is highly probable that

Qmax and screen costs were overestimated. Given this caveat, the costs of screening are:

New screen at RM 5.0: (6.2 cfs)($4500/cfs) = $27,900
New screen at RM 4.9: (20 cfs)($4280/cfs) = $85,600
New screen at RM 4.8: (2 cfs)($4500/cfs) = $9,000
New screen at RM 4.2: (25 cfs)($4280/cfs) = $107,000
New screen at RM 2.9: (5 cfs)($4500/cfs) = $22,500
New screen at RM 2.8: (3.5 cfs)($4500/cfs) = $15,750
New screen at RM 2.3: (10 cfs)($4500/cfs) = $45,000
New screen at RM 1.3: (10 cfs)($4500/cfs) = $45,000
(Subtotal, all new installation: $357,750)
O/M, all screens, first 25 yrs: 8(25)($300) = $60,000
25-yr refurbishing, all screens:($357,750)(.0254) = $9,086
O/M, all screens, second 25 years: 8(25)($300) = $60,000
TOTAL 50-YR SCREEN COST: $486,836

The costs of constructing fishways are:

Instream earthwork for passage, RM 4.9: $1,000
Notched, concrete weirs, RM 4.2: $10,000
Notched, concrete sills, RM 2.3: $160,000
TOTAL FISHWAY COSTS: $171,000

The total costs of structural improvements needed on Manastash Creek are thus:

Fishways:	$171,000
Screens:	$486,836
TOTAL	$657,836

The best hope of a permanent solution to the fall instream flow problems in lower Manastash Creek is a legislative initiative to build a reservoir on the South Fork as proposed by CH2MHill (1989). CH2Mhill estimated the cost of a 7,000-AF reservoir, large enough to eliminate instream flow problems completely, would be $8.73 million.

Cowiche Creek

The Cowiche Creek mainstem and South Fork provide ample instream flows and good to excellent steelhead habitat throughout most of their length. (Riparian problems associated with overgrazing afflict about two miles of the South Fork and three miles of the North Fork. Rectification of these problems will be dealt with separately in the riparian rehabilitation section.) Were it not for two impassible diversion dams and five unscreened irrigation ditches, Cowiche Creek would undoubtedly be producing substantial numbers of steelhead now. With the caveat that maximal diversions were not known with certainty in all cases, the costs of a screening project on Cowiche Creek are:

New screen at RM 7.5, mainstem: (2.7 cfs)($4500/cfs) = $12,000
New screen at RM 1.3, S. Fork: (2 cfs)($4500/cfs) = $9,000
New screen at RM 3.9, S. Fork: (3 cfs)($4500/cfs) = $13,500
New screen at RM 4.4, S. Fork: (6 cfs)($4500/cfs) = $27,000
New screen at RM 4.9, S. Fork: (3.8 cfs)($4500/cfs) = $17,100
(Subtotal, all new screen installation: $78,600)
O/M, all screens, first 25 yrs: 5(25)($300) = $37,500
25-yr refurbishing, all screens:($78,600)(.0254) = $1,996
O/M, all screens, second 25 years: 5(25)($300) = $37,500
TOTAL 50-YR SCREEN COST: $155,596

The costs of constructing fishways are:

Alaska steep-pass facility, RM 3.9, S. Fork: $4,646
Notched, concrete weirs, RM 4.4, S. Fork: $8,000
TOTAL FISHWAY COSTS: $12,646

The total costs of structural improvements needed on Cowiche Creek are thus:

Fishways:	$12,646
Screens:	$155,596
TOTAL	$168,242

Wide Hollow Creek

Wide Hollow Creek has been designated a "Centennial Salmon Stream," and has already received outplantings of early coho. Small outplantings of hatchery-reared, native Yakima steelhead are planned for 1990. This low gradient stream, which flows through the cities of Union Gap and Yakima, is really more suitable for coho than steelhead, but the fact it currently supports a small population of resident rainbow trout indicates it has some potential for steelhead production as well.

A historic mill at RM 0.6 has totally excluded anadromous fish since 1869. The Washington Department of Fisheries has agreed to install an Alaska steep-pass facility at this site and at a diversion dam at about RM 2, and will also install screens and a bypass at the diversion dam. These measures will make the creek passable to both smolts and adults. The only outstanding costs consist of riparian restoration projects, which will be dealt with separately in the riparian section.

Ahtanum Creek

Ahtanum Creek suffers from severe instream flow problems in its lower 19 miles, as well as five unscreened diversions, one partial barrier (Wapato Irrigation Project dam at RM 19.6) and one total barrier (Wapato Irrigation Project dam at RM 9.8). The instream flow problems occur mainly in August, September and October, and are attributable to the total diversion of streamflow at the Wapato Irrigation Project dam at RM 19.6. Bachelor Creek and Hatton Creek are major braids of Ahtanum Creek, which branch off Ahtanum at roughly RM 19 and RM 18.5, respectively, and rejoin the mainstem at roughly RM 3 and RM 6. The WDF has listed over 50 small (~1 cfs), unscreened diversions on these braids, which collectively constitute a serious problem.

The costs of constructing fishways and installing screens at the two major Wapato Irrigation Project diversions are covered by the Phase-II project. The remaining projects consist of screening two diversions on the North Fork, one on the South Fork, as well as the "mouths" of Bachelor and Hatton Creeks. The costs of these projects are:

New screen, Bachelor Cr.: (167 cfs)($3200/cfs) = $534,400
New screen, Hatton Cr.: (167 cfs)($3200/cfs) = $534,400
New screen at RM 2, North Fork: (2 cfs)($4500/cfs) = $9,000
New screen at RM 3, North Fork: (13 cfs)($4280/cfs) = $55,640
New screen at RM 3, South Fork: (2 cfs)($4500/cfs) = $9,000
(Subtotal, all new installation: $1,141,640)

Instructions for calculating the O&M and refurbishing costs for screens of the size of those on Bachelor and Hatton creeks have not been provided. However, at 1.5 percent of capital costs per year (the approximate yearly O&M plus refurbishing costs for smaller screens), O&M and maintenance for the entire Ahtanum screening complex would come to $17,124 per year.

TOTAL 50-YR SCREEN COST: $1,997,870.

The late summer instream flow problems on lower Ahtanum could be largely rectified by the construction of a headwater impoundment. An initial feasibility study has been made for a 3,300-acre-foot impoundment located five miles from the headwaters of the South Fork (Tudor Engineering 1988). The estimated cost of this impoundment is $3,235,000. An impoundment of this size, if dedicated solely to instream flow augmentation from August 1 through October 31, could provide a continuous flow of 18 cfs in the lower creek. The Montana method of assessing instream flow requirements predicts that all aquatic resources would be protected if a flow of 29 cfs were maintained. However, the reservoir site is on the Yakima Indian Reservation, and the Yakima Nation is generally opposed to impoundments. At the present time, the Yakima Indian Nation has not decided whether it favors or opposes a small impoundment on the South Fork.

Rectification of the instream flow problem on lower Ahtanum Creek may not be absolutely necessary to reestablishing spring chinook in the drainage. As noted, the lower creek does not usually dry up until early August. The majority of the existing spring chinook run has passed the mouth of Ahtanum Creek by the end of June. Given the elimination of barriers, it may thus be possible that virtually all chinook could reach prime spawning habitat in the upper drainage before instream flow problems develop.

Simcoe Creek

Simcoe Creek, a small but lengthy Toppenish Creek tributary would, depending on precipitation, afford about 35 to 40 miles of fair spawning and rearing habitat were it not for three unscreened ditches, one partial barrier to adult passage at the Wapato Irrigation Project diversion at RM 14, and the fact 3.5 miles of mainstem between the Wapato Irrigation Project diversion and the confluence with Agency Creek are totally dewatered from mid-June through December. The need for screening projects on the mainstem diversion and one of the North Fork diversions is especially pressing as these ditches divert most of the flow in April and all the flow by the end of May. The juvenile and adult passage problems can be fairly easily rectified, but the instream flow problem may be somewhat difficult politically.

The cost of fully screening Simcoe Creek is:

New screen at RM 14.0, mainstem: (20 cfs)($4280/cfs) = $85,600
New screen at RM 0.5, N. Fork: (15 cfs)($4280/cfs) = $64,200
New screen at RM 0.1, S. Fork: (5 cfs)($4500/cfs) = $22,500
(Subtotal, all new screen installation: $172,300)
O/M, all screens, first 25 yrs: 3(25)($300) = $22,500
25-yr refurbishing, all screens:($172,300)(.0254) = $4,376
O/M, all screens, second 25 years: 3(25)($300) = $22,500
TOTAL 50-YR SCREEN COST: $221,676

The costs of constructing the fishway at the Wapato Irrigation Project dam is:

Three notched, concrete weirs: $6,000
Associated earthwork: $1,000
TOTAL FISHWAY COSTS: $7,000

The mainstem of Simcoe Creek between the Wapato Irrigation Project diversion and Agency Creek is usually completely dry about 170 days a year. A 2,332-acre-foot RCC dam has been proposed for upper Simcoe Creek (Tudor Engineering 1988). Such a reservoir could provide 6 to 7 cfs continuous flow for a 170-day period which, as evaluated by an existing IFIM habitat/discharge curve, might provide 80 percent optimal flows. However, the cost of this reservoir is $3.5 million. Moreover, the dam site is on the Yakima Indian Reservation, and it is questionable whether the YIN would find the dam culturally acceptable.

A more likely solution to the instream flow problem in the Simcoe drainage is simply to purchase the land irrigated with Simcoe Creek water. [Note that there are several other potential solutions presented in the Draft Fisheries Report of the initial phase of the On-Reservation YRBWEP Report (Watson and Lind 1990). These alternate solutions are all relatively less practicable for one reason or another than the simple purchase of irrigated land]. As about 1,350 acres are now irrigated with Simcoe Creek water, all irrigated lands could be purchased for $1.35 million at $1,000 per acre.

Upper Toppenish Creek

The upper Toppenish Creek drainage is here construed as the portion of the system above and in the vicinity of the Toppenish Lateral Canal diversion dam at RM 44.2, and includes Toppenish Creek, the North and South forks of Toppenish Creek, and Branch Creek. This fairly extensive area has recently been made fully passable to juveniles and adults by the construction of a rock-filled gabion backwater and a state-of-the-art screen and bypass system at the dam. However, upper Toppenish Creek still suffers from a number of problems including the dewatering of four to six miles below the diversion dam from early June through December; the existence of a large number of perched and blocked culverts; and an extreme degree of riparian and instream damage extending from the dam about six miles downstream.

Aside from the loss of spawning and rearing habitat, the annual dewatering below the Toppenish Lateral Canal diversion dam adversely impacts steelhead by causing dispersing fry to be bypassed into a streambed that dries up almost immediately or, in the event the bypass is closed, to be concentrated in a small area immediately above the dam. This problem could conceivably be eliminated by the construction of several headwater impoundments to provide continuous instream flows. Two dams, with a combined capacity of 5,642 acre feet and a combined cost of $6.85 million, have been proposed for upper Toppenish Creek (Tudor Engineering 1988). However, these proposed dams suffer from the same drawbacks as the North Fork Simcoe dam: they are extremely expensive and might well be culturally unacceptable to the Yakima Indian Nation. As with the dewatering problem on Simcoe Creek, a number of alternate solutions to the Toppenish dewatering problem have been proposed (see Watson and Lind 1990), but the most practicable one is the purchase or lease of lands irrigated with Toppenish Creek water. At $1,000 per acre, the outright purchase of the 1,214 acres irrigated with Toppenish Creek water would require $1.214 million. It should be noted that this $1.214 million is <u>not</u> to be ascribed to subbasin planning. If such a project is approved by the Yakima Indian Nation, it will become part of a legislative initiative (part of the on-reservation Yakima River Basin Water Enhancement Project) which would be funded by Congressional appropriation.

The problems with impassible culverts on upper Toppenish Creek (and elsewhere on the Yakima Indian Reservation) have been described at some length. A proposal to the Bureau of Indian Affairs, Branch of Roads, for initial minor improvements and a subsequent in-depth analysis of especially troublesome structures was made in 1988 (Wasserman 1988). The budget for culvert repair put forth in this proposal for Yakima Subbasin culverts, almost all of which are on the Toppenish system, was:

Phase 1: Cleaning and construction of downstream backwaters.	
18 sites @ $970/site	$17,460
Phase 2: In-depth survey and redesign of troublesome structures.	
Biologist, 2.5 months @ $2075/month	$5,187
Vehicle rental;	
2.5 months @ $175/month,	$437.50
($.21/mile)(1500 miles)	$1,575
Fringe, @ 18.5% of salary	$959.50
Indirect costs, @ 24.6% of salary	$2,007
Phase 3: Rebuilding critical crossings with oversize culverts.	
Total number needed unknown at this time. Because two culverts on Toppenish Creek require this order of improvement, and because each rebuilt oversized culvert would cost $22,670, costs would be at least	$45,340
TOTAL COSTS in excess of	$72,966

<u>Logy Creek</u>

Logy Creek is a tributary to Satus Creek, which once supported a run of spring chinook. As instream flows and habitat conditions in Logy Creek are fair to excellent, the only major obstacle to reestablishing chinook in Logy Creek are the low flows in lower Satus Creek in August and September. (A problematic diversion on lower Satus will be corrected by the Phase-II program). The Montana method of instream flow assessment predicts all aquatic resources should be protected so long as flows are 60 cfs or greater in lower Satus, and a preliminary analysis of a wide, braided section of Satus Creek below Logy Creek indicates that a depth of 1 foot would be maintained, and adult passage would be assured, so long as flow was at least 52 cfs. From 1971 to 1973, the mean discharge in Satus Creek below Logy in May through September was 162, 127, 52, 25 and 23 cfs, respectively (Water Resources of the Satus Creek Basin, Yakima Indian Reservation, WA, 76-685, 1982). It would thus seem that spring chinook should be able to reach Logy Creek so long as they arrive at its mouth by the end of July. As most spring chinook have passed the mouth of Satus Creek by the end of June, it may be possible that most fish imprinted to Logy Creek water would require no assistance in returning to their natal (or "imprinted") stream. However, to facilitate passage of fish attempting to negotiate lower Satus in August and September, planners propose that boulder weirs be installed in about two miles of wide, braided channel. If weirs were spaced 100 feet apart, and if each weir cost $550, total construction and maintenance costs would be:

(2)(5280 ft per mi/100 ft per weir)($550 per weir) = $58,080.
(2)($760/mi/yr)(50 yrs) = $76,000
TOTAL = $134,000

The following table summarizes the smolt carrying capacity and approximate adult carrying capacity (expressed as MSY <u>terminal harvest</u>) of all tributaries described above. Note that the carrying capacities assume full implementation of the most comprehensive strategy, and adult capacities were calculated by multiplying the terminal harvest estimate for the entire subbasin by the proportion of the subbasin's total smolt capacity contributed by the tributary in question.

TRIBUTARY	SPRING CHINOOK SMOLT CAPACITY	SPRING CHINOOK ADULT CAPACITY	STEELHEAD SMOLT CAPACITY	STEELHEAD ADULT CAPACITY
Cabin Creek	39,568	157	8,797	86
Yakima, Easton Dam to Keechelus Dam	257,378	1,024	28,598	279
Big Creek	28,254	112	3,832	37
Teanaway River and tributaries	244,785	974	38,896	380
Taneum Creek	74,179	295	21,840	213
Manastash Creek	97,574	388	23,585	230
Little Naches above Salmon Falls	75,506	300	21,708	212
Cowiche Creek	N/A	N/A	13,047	127
Wide Hollow Creek	N/A	N/A	2,880	28
Ahtanum Creek	49,902	198	14,874	145
Upper Toppenish and upper Simcoe Creeks	N/A	N/A	36,336	355
Logy Creek	52,921	211	N/A	N/A

APPENDIX 4

Data on Utilization of Smaller Canals as Off-Channel Winter Refuges

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Planners deemed 18 smaller canals, largely located on the lower Naches, suitable as off-channel winter refuges. Table 1 summarizes the area and habitat quality of these potential sites. Table 2 summarizes the winter "holding capacities" of pre-smolt spring chinook and steelhead in pool habitat (>2 feet deep) of various types. Winter holding capacities were provided by Cleve Stewart, a University of Idaho graduate student investigating the area, and were estimated for pools affording cover of various types over 0, 1/4, 1/2, 3/4 or all of their wetted area. It should be noted that calculations used in TPM/SPM simulations usually assigned the "no cover" or "1/4-area" density, and never assigned higher than the "1/2-area" density, to any potential refuge.

Table 1. Area and habitat quality afforded by small canals in the Yakima Subbasin with potential as off-channel winter refuges.

CANAL(S)	LOCATION	AREA (sq. meters) AND HABITAT TYPE
Union	Naches R.	556; overhanging brush.
Fruitvale	Naches R.	1,512; some undercuts, aquatic vegetation.
Cowiche bypass	Naches R.	762; trees, depth >3 ft, aquatic vegetation.
Naches/Cowiche	Naches R.	1317; rubbly substrate.
Congdon	Naches R.	15,476; good riparian, depth often 3-4 ft, undercuts, rubble, and overhanging brush.
S. Naches Channel	Naches R.	17,088; undercuts, overhanging brush, interconnected pond.
Kelly-Lowerie	Naches R.	6,191; good undercuts, rubble, overhanging brush.
Tenant	Naches R.	10,219; good riparian, large interconnected pond.
Stevens	Naches R.	1,422; undercuts but little instream cover.
Emrick	Naches R.	192; undercuts.
Lost Creek	Naches R.	3,239; three large pools in series, good aquatic vegetation.
Vertrees 1 & 2	Yakima R.	2,230; frequent undercuts.
West Side and Packwood	Yakima R.	6,131; undercuts.
Old Cascade	Yakima R.	3,679; undercuts.
Wanity Slough & Lateral Drain 4	Yakima R.	348,264; long areas offering little except depth, some overhanging vegetation.

Table 2. Winter holding capacities of pools for spring chinook and steelhead pre-smolts as a function of cover type.

COVER TYPE AND AMOUNT[1]	SPRING CHINOOK DENSITY (fish/sq. meter)	STEELHEAD DENSITY (fish/sq. meter)
No cover	0.15	0.21
1/4 undercut	0.13	0.47
1/2 undercut	0.33	1.55
3/4 undercut	1.52	no data
1.0 undercut	13.71	0.96
1/4 rubble	0.09	no data
1/2 rubble	0.25	0.50
3/4 rubble	0.98	no data
1.0 rubble	1.53	1.46
1/4 rock pile	1.58	1.13
1/2 rock pile	2.08	4.07
3/4 rock pile	2.20	no data
1.0 rock pile	3.61	10.01
1/4 brush	2.87	3.92
1/2 brush	5.68	12.11
3/4 brush	8.33	no data
1.0 brush	11.93	28.37

[1] "1/4" = 1/4 pool contains cover of given type
"1/2" = 1/2 pool contains cover of given type
"3/4" = 3/4 pool contains cover of given type
"1.0" = entire pool contains cover of given type

APPENDIX 5

Riparian Restoration Projects for Spring Chinook and Steelhead: Locations, Impact on Smolt Capacity, Requirements, and Costs

The following table summarizes the expected impact of riparian restoration on spring chinook smolt capacity. The total net increase in smolt production is 100,200 smolts. Note that this figure will differ somewhat from the figure reported in the text. The latter figure represented an incremental difference between two strategies, and "antecedent strategy" had already incurred some changes in smolt capacity.

Expected impacts on spring chinook production potential in candidate areas for riparian restoration.

REACH	CLASS NOW[1]	PRESENT SMOLT CAPACITY (X1000)	CLASS AFTER[1]	IMPROVED SMOLT CAPACITY (X1000)	NET SMOLT INCREASE (X1000)
Yakima: 8 miles in Wilson Creek to Taneum Creek reach.	SAR-G	150.7	SAR-E	211.9	61.2
Yakima: the 6-mile Naches R. to Wenas Creek reach	R-G	47.7	R-E	67.1	19.4
Logy Creek: the lower 2.5 miles.	SAR-F	33.3	SAR-E	52.9	19.6

[1] "SAR" = "spawning and rearing habitat"
"R" = "rearing only habitat"
"E" = excellent; "G" = good
"F" = fair; "P" = poor

The following table summarizes the expected impact of riparian restoration on steelhead smolt capacity.

Expected impact of riparian restoration on steelhead smolt capacity.

REACH	CLASS NOW[1]	PRESENT SMOLT CAPACITY (X1000)	CLASS AFTER[1]	IMPROVED SMOLT CAPACITY (X1000)	NET SMOLT INCREASE (X1000)
Yakima: 8 miles in Wilson Creek to Taneum Creek reach.	SAR-G	57.4	SAR-E	82.0	24.6
Yakima: the 6-mile Naches R. to Wenas Creek reach.	SAR-F	31.6	SAR-E	63.2	31.6
Logy Creek: the lower 2.5 miles.	SAR-P	6.7	SAR-E	8.5	1.8
SF Cowiche Creek, ~RM 10 to ~RM 12.	SAR-F	5.9	SAR-E	6.6	0.7
NF Cowiche Creek, lower 3 miles.	SAR-P	0.8	SAR-E	2.0	1.2
Toppenish Creek, from Mud Lk. Drain to Pom Pom Rd. (RM 31.5-38.9) and ~8 miles from Wapato Irrigation Project dam (RM 44.2) to NF (RM 55.4)	R-P & SAR-F	8.4	R-F & SAR-E	17.6	9.2
Simcoe Creek, from mouth to Agency Creek (RM 9.5)	SAR-P	2.1	SAR-E	7.0	4.9
Satus Creek, from Dry Creek (RM 18.7) to High Br. (RM 30.1)	SAR-G	22.5	SAR-E	28.3	5.8

(continued)

great. However, when maintenance costs are computed at the rate of $760 per mile per year, over 90 percent of the cost of a 50-year fencing project is for maintenance alone. It would seem wise not to exclude large projects solely on the basis of future maintenance costs. Assuming the benefits to fish, wildlife and cattle production are as great as projected, it might turn out that other agencies or private landowners may be willing to assume the maintenance of projects that prove themselves. For this to happen, it may be necessary that the Bonneville Power Administration underwrite the costs only of installation and perhaps as few as 10 years' maintenance.

The areas and costs for spring chinook riparian projects are:

PROJECT LOCATION & % PUBLIC	MILES FENCING	FENCING COST ($3710/MI)	CUBIC YARDS RIPRAP	RIPRAP COST ($31/YD)	OTHER COSTS
Yakima R., Naches to Wenas; 0 % public	12	$44,520	0	0	0
Yakima R., Wilson to Taneum; 0 % public	16	$59,360	0	0	0
Logy Creek, lower 2.5 miles; 0 % public	5	$18,550	0	0	0
TOTALS	33 private 0 public	$122,430	0	0	0

PUBLIC COSTS FOR PLANNING AND OVERHEAD-----------------------0

PRIVATE COSTS FOR PLANNING AND OVERHEAD----------------$89,373

OPERATION AND MAINTENANCE COSTS (50 YRS)------------$1,254,000

TOTAL COSTS--$1,465,803

The targets for riparian restoration benefitting steelhead include the three reaches described in the spring chinook section as well as the areas described in the following table.

PROJECT LOCATION & % PUBLIC	MILES	FENCING COST ($3710/MI)	CUBIC YARDS RIPRAP	RIPRAP COST ($31/YD)	OTHER COSTS
Satus Creek, Dry Creek to High Br.;[1] 16.7 % public	22.8	$84,588	1,783	$55,287	0
Mule Dry Creek, entire utilized length; 50 % public	26.5	$98,315	0	0	0
Satus Creek, Mule Dry to Dry Creek; 15.4 % public	20.4	$75,684	0	0	0
Dry Creek, lower 10 miles;[2] 50 % public	20	$74,200	0	0	$88,000
Toppenish Creek, Mud L. Drain to Pom Pom Rd.; 22.2 % public	14.8	$54,908	0	0	0
Simcoe Creek, mouth to WIP dam;[3] 12.5 % public	28.0	$103,880	8,213	$254,613	0

(continued)

(continued)

PROJECT LOCATION & % PUBLIC	MILES	FENCING COST ($3710/MI)	CUBIC YARDS RIPRAP	RIPRAP COST ($31/YD)	OTHER COSTS
Toppenish Creek, 8 miles between WIP dam and NF; 12.5 % public	16	$59,360	0	0	0
Wide Hollow Creek, ~5 miles in patches;[4] 0 % public	5	$18,550	1,173	$36,373	0
SF Cowiche Creek, ~RM 10 to ~RM 12; 100 % public	4	$14,840	0	0	0
NF Cowiche Creek, ~RM 0.0 to ~RM 3.0; 0 % public	6	$22,260	0	0	0

[1] It was estimated that 2.8 miles of bank stabilization was needed. Assuming riprap 1 foot deep over a mean cutbank 4 foot high, [(4)(1)(2.8)(5280)]/27 = 1,783 cubic yards are needed. At $31/yd, riprap costs are $55,287.

[2] "Other costs" represent materials to pipe water to stock outside the exclosure (see text).

[3] At $31/yd for riprap and with 7 miles of 6-foot cutbank, riprap costs are $254,613.

Adjusted costs for these "exclusively steelhead" riparian projects are:

	MILES FENCING	FENCING COST	RIPRAP COST	OTHER COSTS	TOTAL COSTS
TOTALS	120 private 43 public (26.4 % public)	$606,585	$346,273	$88,000	$1,040,858

PUBLIC COSTS FOR PLANNING AND OVERHEAD--------$426,751

PRIVATE COSTS FOR PLANNING AND OVERHEAD-------$759,826

OPERATION AND MAINTENANCE COSTS (50 YRS)----$6,194,000

TOTAL COSTS--------------------------------$8,421,435

Together, the riparian projects described in this section and the spring chinook section cover all proposed riparian projects. The grand total cost of all projects is $9,887,238. As mentioned previously, most of this cost -- $7,448,000 -- is allocated to 50 years of maintenance. If BPA were to underwrite only 10 years' maintenance, hoping that in this time successful projects would be recognized and willingly perpetuated by other agencies and individuals, maintenance costs would be reduced $5,958,400.

It should also be noted that individual projects have been assigned different priorities. In the event the entire package of projects cannot be funded in a single budget cycle, the project might be phased in over a number of cycles. It is suggested that the first segment to implement would be the Dry Creek and Wide Hollow projects. Both would make excellent showpieces. The Wide Hollow project, because of its urban location and the fact Wide Hollow Creek is a Centennial Salmon Stream would receive a great deal of attention, and could have an impact out of proportion to its size and fisheries potential. The Dry Creek project is located in a fairly deep valley bottom about 0.5 mile wide. If fenced at the valley walls, it would make an excellent prototype "special use pasture" which, it is hoped, would demonstrate that badly degraded rangeland can be reclaimed to the benefit of both fish and cattle production.

APPENDIX 6

Estimation of Zero-Density Egg-to-Smolt Survival for Steelhead in the Yakima Subbasin Rearing in or Downstream of Ahtanum Creek

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The Northwest Power Planning Council's System Planning Group recently determined that zero-density egg-to-smolt survival (So) should be 0.05 for summer steelhead. However, the NPPC considered steelhead to smolt exclusively at age-II, not half at age-I and half at age-II, as steelhead do in the lower Yakima drainage. Assuming that the NPPC is right for age-II steelhead smolts, Yakima planners can use the NPPC figures and Yakima age distributions to calculate a new So:

let Ps = percent age-I steelhead that smolt;
S1 = number of age-I steelhead in a steady-state population; and
0.4 = survival rate from age-I to age-II.

Since age-I smolts = age-II smolts,

$$(S1)(Ps) = 0.4[S1-(Ps)(S1)], \text{ and } Ps = 0.28.$$

For an all age-II smolt steelhead population, letting E be the number of eggs deposited, egg to smolt survival is 0.05:

$$\frac{0.4(S1)}{E} = 0.05.$$

However, the Yakima population is:

$$\frac{[(S1)(Ps) + 0.4(S1 - (Ps)(S1))]}{E} = \frac{0.568(S1)}{E}$$

If $\frac{0.4(S1)}{E} = 0.5$, then $\frac{0.568(S1)}{E} = 0.071$.

Thus, the proper value for So in the lower Yakima Subbasin is 0.071.

APPENDIX 7

Description of Projects to Bring Potential Fall Chinook Spawning and Rearing Areas into Production

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The Yakima Subbasin Plan proposes that the natural production of fall chinook be expanded into Wanity Slough and Lateral Drain Four (collection systems in the Wapato Irrigation Project network); and the lower 10 miles of Toppenish Creek. The costs associated with bringing these areas into production are as follows.

Wanity Slough

Wanity Slough is an old, 20-mile canal on the Yakima Indian Reservation that in many reaches has assumed the character of a natural stream. This channel currently serves mainly to collect ground water from lands irrigated by the Wapato Irrigation Project and convey this water south to a pumping station for re-use. There is, however, a headgate opening on the Yakima River about one-half mile above Sunnyside Dam, and some water is diverted into the system to supply three fair-sized irrigation canals. Flows are perennial, but become quite low in the winter after the irrigation season and the inflow of Wapato Irrigation Project groundwater has subsided. Substantial flows could be maintained year-round if the Yakima Indian Nation, Bureau of Indian Affairs, and Wapato Irrigation Project agree to install new hydroelectric generators on four drops on the Wapato Irrigation Project Main Canal and continue to run water through the main Wapato Irrigation Project system in the winter to generate power. Winter flows could also be increased by the simple expedient of dredging sand bars from the upper canal and regularly maintaining the gravel berm diverting water into the headworks.

The main obstacles to establishing naturally reproducing populations of fall chinook in Wanity Slough are the existence of three unscreened diversions. A secondary consideration is the necessity of maintaining the gravel berm at the headworks or constructing a permanent concrete wing. Even if the hydroelectric project is realized, one of the latter two measures will be necessary if winter flows are to remain adequate throughout the canal. This is so because the lateral below the last drop on Wapato Irrigation Project's Main Canal enters Wanity Slough about five miles from its end; without diversions from the river, flows in the upper 15 miles would remain low.

The costs of screening the three ditches feeding off Wanity Slough are:

Screen at "Track Lateral": (120 cfs)($3200/cfs) = $384,000
Screen at "Spencer Lateral": (41 cfs)($4280/cfs) = $175,480
Screen at "Lateral 4 Extension": (140 cfs)($3200/cfs) = $448,000
(Subtotal, all new screen installation: $1,007,480)

The costs of maintaining and refurbishing screens of this size are not available at this time. However, at 1.5 percent of capital costs per year (the approximate mean O&M costs for smaller screens), operation and maintenance would come to approximately $15,000 per year.

The cost of maintaining the gravel wing at the headworks should be about $10,000 per year (K. Best, Water Resources, Yakima Indian Nation, pers. commun.). It is possible this sum could be worked into the Wapato Irrigation Project budget. A permanent, concrete wing could probably be built for about $200,000 (K. Best, YIN, pers. commun.). The latter solution is to be preferred, as it would provide more reliable service and would cost less over the long run.

Lateral Drain Four

Lateral Drain Four simply conveys Wapato Irrigation Project groundwater and operational spills to Wanity Slough and feeds no irrigation canals. If the diversions off Wanity Slough were screened, and the hydroelectric project were implemented, Lateral Four would require no modifications to serve as a fall chinook spawning area.

Lower Toppenish Creek

The lower 10 miles of Toppenish Creek appear to lack nothing as fall chinook spawning habitat. Indeed, there have been unsubstantiated reports that a few fall chinook spawn in lower Toppenish Creek even now.