4. Environmental Consequences

This chapter provides information on the environmental consequences of the Watershed Management, Anadromous Fish Mitigation, and the Instream Flow Alternatives on all elements of the affected environment as described in Chapter 3:

- Geology and Soils (Section 4.1)
- Water Quantity and Quality (Section 4.2)
- Forest Resources (Section 4.3)
- Fisheries Habitat and Resources (Section 4.4)
- Wildlife Habitat and Resources (Section 4.5)
- Cultural Resources (Section 4.6)
- Land Use (Section 4.7)
- Recreation (Section 4.8)
- Public Services (Section 4.9)
- Socioeconomics (Section 4.10)

In general, the discussion for each of these elements of the affected environment includes an analysis of individual and cumulative impacts for each alternative discussed in Chapter 2. Each section concludes with a table listing every impact evaluated for that particular element of the affected environment. Section 4.11 provides an overall summary of these "Environmental Consequences" in tabular format.

4.1 Geology and Soils

Section 3.1 set the stage for evaluating the effects of proposed Watershed Management Alternatives on the existing environment. The following section qualitatively examines each watershed management alternative for its potential impact on the four main processes discussed in Section 3.1: road-related mass-wasting; road surface erosion, hillslope erosion, and soil productivity. To evaluate these effects, the following variables will be examined: area available for timber harvest by mass wasting hazard; road maintenance and decommissioning; amount of harvest in erodible soils; and the logging systems and prescriptions used. In particular, the potential for activities on those areas to produce actual sediment delivery to streams is important.

The other proposed actions related to Anadromous Fish Mitigation and Instream Flows are not discussed in detail. Construction activities related to the Anadromous Fish Mitigation Alternatives (e.g., construction of the fish hatchery) would have localized effects on soils. However, a separate EIS, along with the site-specific permits, will address potential effects of these activities. The Instream Flow Alternatives will have no effect on soils and are not discussed further.

4.1.1 Mass Wasting

Timber Harvest-related Mass Wasting

No Action Alternative for Watershed Management (WM-1)

Under this alternative, timber harvest would be conducted in some parts of the Watershed, but at a significantly reduced rate relative to the 1960s and 1970s prior to the self-imposed harvest moratorium in 1986. Approximately 58 percent of the Watershed would be placed in an Ecological Reserve.

Timber harvest practices would be conducted under the Washington State Forest Practices Act (FPA). The FPA requires a Class IV general Special Permit subject to SEPA review for timber harvest on unstable slopes. This application undergoes a full SEPA review of the proposed forest practices including documentation of mass wasting hazard and the likely effect that the proposed forest practice would have. Proposed harvest and road building plans must demonstrate that unstable areas will be avoided or that harvest and road building plans contain adequate mitigation to offset potential adverse effects. The DNR has the responsbility to deny applications that do not meet the standards in the FPRs. Substantial buffers would be implemented on all streams as part of the Reserve, and there would be a prohibition of timber harvest in inner gorges (deeply incised stream channels) and headwall basins. The buffers would be wide enough to protect streams from most timber-harvest related effects described in the literature (see Johnson and Ryba, 1992). While a Watershed Assessment has been conducted (Technical Appendices 15

and 16), no new prescriptions for protection against mass wasting would be implemented under this alternative. It is therefore important to point out those areas that have a higher susceptibility to timber harvest-related mass wasting, and thus greater potential to affect aquatic resources.

Moderate and high mass wasting hazard areas were delineated in the Mass Wasting and Surface Erosion Assessment (Foster Wheeler Environmental Corporation, 1995b). Figure 4.1-1 shows the amount of timber harvest possible in these areas under this alternative, by subbasin. The exact timing and distribution of timber harvest are not established, although harvest operations have been modeled in some detail. However, timber harvest would probably be conducted mostly by regeneration cuts. Subbasins with a high percentage of high and moderate mass wasting hazard in non-reserve areas (matrix lands) have the greatest potential for timber harvest-related landslides. These subbasins include Damburat, Green Point, Otter, and Rack creeks (see Map 1).

However, these subbasins are relatively small in area, generally less than 1,000 acres. Each of these creeks drains into Chester Morse Lake. Typically, the mouths of the streams (at Chester Morse Lake) are the only parts of the streams that have suitable fish habitat (see Section 3.4, Fisheries Habitat and Resources), due to high stream gradients. Aerial photographs indicate that these channels can convey a landslide all the way to their mouths, as evidenced by debris flows scars. Thus, although fish habitat is limited, it could be affected by timber harvesting. Water quality would likely not be affected, since Chester Morse Lake, would trap all sediment except clay-size particles.

There are two other areas that could be affected by mass wasting: the upper portions of Rock Creek and the Taylor Creek forks. Mass wasting in these areas could effect fish habitat and water quality. Both areas have deep seated landslides that are being actively cut at the toeslope (lower end) by streams (Foster Wheeler Environmental Corporation, 1995b). While wide buffers would exclude most of the toeslopes, timber harvest on other parts of these landslides could trigger shallow landslides, which could then deliver sediment to Taylor or Rock Creeks.

However, forest practices act regulations require Class IV Special Permits and SEPA review for timber harvest activities in known landslide areas. Therefore, while most of the Watershed would not be affected by timber-harvest related landslides, there could be effects in Taylor and Rock Creeks. The significance of these effects is discussed in Section 1.2, Water Quantity and Quality, and 4.4, Fisheries Habitat and Resources.

Proposed HCP Alternative for Watershed Management (WM-2)

Under this alternative, the amount of moderate and high mass wasting area available for timber harvest would be about the same as under the No Action

Figure 4.1-1. Moderate and high mass wasting hazard in non-reserve areas (matrix lands) (matrix lands) by alternative (WM3 and WM5 omitted)

Alternative for Watershed Management (WM-1). There would be somewhat less of this area in the McClellan and Rack subbasins (see Figure 4.1-1).

However, the Proposed HCP Alternative involves several management measures that would reduce the effects of timber harvest on mass wasting to negligible levels. These include prohibition of timber harvest in inner gorges and sensitive soils (as under No Action), wide no-harvest buffers on all streams (as under No Action), and slope stability analysis for areas which are outside the Reserve but designated as moderate or high mass wasting hazard. This analysis would be applied to those areas where high mass wasting hazard is present and the slopes are greater than 30 percent, and in moderate mass wasting hazard area over 60 percent in slope.

Specifically, there are three Watershed Assessment prescriptions contained in the HCP (Technical Appendix 16) that address slope stability. The first designates initial responsibility to an interdisciplinary ("ID") team made up of qualified City personnel for site investigation prior to any management activity. The site investigation, limited to those areas that are 30 percent or greater in slope and have a moderate or high mass wasting hazard, would determine if a more detailed slope stability analysis is required.

HLP-2, which applies to those areas with potential for shallow rapid mass wasting, addresses the geotechnical investigation itself. It requires that a geotechnical or forest engineer perform the analysis to determine if the area is affected by deep seated or shallow movement. The site investigation will qualitatively and/or quantitatively characterize the site as low, moderate, or high mass wasting hazard. If it is classified as low hazard, the regular timber harvest practices—in accordance with the proposed HCP's forest management guidelines—apply. If it is classified as moderate hazard, "explicit mitigation measures" would be used in conjunction with the HCP's forest management guidelines. In these prescriptions, there are no examples of explicit mitigation measures. If the area is classified as high hazard, no harvest is allowed unless mitigation can be applied and the factor of safety (the ratio of resisting force to driving force) is 1.2 or greater.

The third prescription concerns timber harvest and road construction on deep seated landslides. Under this prescription, the actions are similar to those for shallow-rapid landslide areas, except that the factor of safety in a high hazard area must be shown to be 1.3 after timber harvest.

Some landslides could still occur within the moderate mass wasting hazard areas, where no slope stability analysis would be conducted; some landslides could occur on areas that had stability analyses performed, but weren't adequately modeled during the slope stability analysis. However, these occurrences would probably be rare because the area designated as moderate mass wasting hazard is very small and because the slope stability analysis would be conducted on a site-specific basis using standard techniques. Additionally, the buffers on type 4 and 5 streams would protect streambank

stability and decrease the potential for channel-related slides on these typically steep streams. The wide buffers on type 1, 2, and 3 streams would help reduce the runout of landslides coming from upslope and would limit the potential for a landslide to actually reach a stream. In addition, many areas classified as having a high mass wasting potential are located within rain-on-snow zones which would limit the amount that could be affected at any given time. Therefore, the effect on timber-related mass wasting would be minimal.

It is important to note that under this alternative, commercial thinning would be used on over half of the area in which there would be any timber forest. Commercial thinning would not be expected to decrease total root strength on a given hillslope, because some trees, of varying diameter, would be left standing. How many trees are left standing would depend on the individual harvest unit prescription, which would be decided during the layout of harvest units. Thus, the amount of root strength loss cannot be quantified at this level of analysis; however, there would be less risk of mass wasting within those areas commercially thinned than with those areas with retention cuts.

Long-term Sustainable Thinning Alternative (WM-3)

Under this alternative, the Reserve would be the same as that under the Proposed HCP Alternative, WM-2. The main difference between this alternative and the Proposed HCP Alternative is how logging is conducted. Because thinning would be used, like commercial thinning under WM-2, the decrease in root strength following harvest would be much less than in clearcut areas. Consequently, with the chance of triggering mass wasting substantially reduced, and other prescriptions for logging in unstable areas in place (same as the Proposed HCP Alternative), this alternative is expected to have minimal effects on timber harvest-related mass wasting. Landslides could still occur, but occurrences would be rare.

Thinning Alternative with Phased Out Commercial Timber Harvest (WM-4)

This alternative would have somewhat lower risk of mass wasting, in the short and long term, relative to the Proposed HCP Alternative.

In the short term (20 years), there would less likelihood of timber harvest-related mass wasting because only thinning would be allowed. With more trees left in a harvest unit (35 percent) the decrease in root strength following harvest would be small relative to clearcut areas. Additionally, other prescriptions for logging in unstable areas would be implemented (as under the Proposed HCP Alternative). After 20 years, 85 percent of the Watershed would be in the Reserve, and after about 50 years, all of the Watershed would be in the Reserve (the actual time for attaining 100 percent Reserve would be determined at 20 years in the HCP). Because the majority of timber harvests would be conducted as commercial thinning, loss of root strength on harvested hillslopes would not be as great as clearcut areas. Therefore, the risk of mass

wasting is lower than under Alternative 1. As the Reserve approached increases to include all of the Cedar River Municipal Watershed above Landsburg, mass wasting within the Watershed would eventually approach background levels.

The chance of triggering mass wasting would be substantially reduced, and sediment delivery would be minimized by the large buffers (as under the Proposed HCP Alternative). Consequently, this alternative is expected to have minimal effects on timber-related mass wasting. However, there could be the same effects in the Taylor and Rock Creek basins as described for alternatives WM-1, WM-2, and WM-3.

No Commercial Timber Harvest Alternative (WM-5)

Under this alternative, there would be no timber harvest of any areas, and thus there would be no effect on timber harvest-related mass wasting, although some level of background (naturally occurring) mass wasting would be present. Under this alternative, recovery from previous land management activities would occur immediately throughout the entire Watershed.

Road-related Mass Wasting

No Action Alternative for Watershed Management (WM-1)

Under this alternative, few new roads would be built. This is partially because the remaining old growth would be in the Reserve, and the second growth stands are mostly accessible by existing roads. An estimated 10 miles of new road would be constructed (Jim Kapusinski, SPU, Personal communication, March 1998). This represents less than a 2 percent increase on total road miles. Of these roads, 75 percent would be temporary, and 50 percent of the total would be on slopes less than 30 percent. Therefore, the effect of new road construction on road-related mass wasting is expected to be negligible.

However, there are many existing roads that have failed or have potential to fail. There are no explicit provisions under this alternative to address problem roads beyond what is provided by the current road maintenance program. It is expected that the existing transportation plan would dictate road management activities but funding for implementation is uncertain. Under this alternative the Applicant would continue to prepare the annual road maintenance plan required by DNR. Although roads are maintained to prevent washouts at stream crossings, undersized culverts may get plugged by water and debris during storm events, causing road crossing failures. Also, sidecast failures not associated with stream crossings may occur. Consequently, road-related mass wasting would continue to occur, as in the past.

As indicated in the Watershed Assessment (see Technical Appendices 15 and 16), the areas most affected by these types of failures are the subbasins along the north side of Chester Morse Lake. The lower reaches of these streams are

mostly Type IV, although there is fish utilization of the mouths of these streams, where they empty into Chester Morse Lake. In the past, the riparian zones along these streams have been significantly affected by road related landslides (timber harvest of the riparian zones may also have contributed to instability). It is likely that they would continue to be affected by occasional debris flows under this alternative.

Therefore, while the effects of new road construction would be minimal, road failures could occur from existing problem roads at a lesser degree than they have occurred in the recent past. This could affect fish habitat through introduction of coarse and fine sediment.

Proposed HCP Alternative Action for Watershed Management (WM-2)

Under this alternative, road-related landslides could continue to occur, but would gradually decrease over time as the road abandonment and stabilization program is implemented. Most implementation is scheduled within the first 15 years of HCP implementation. Road segments identified in the Watershed Assessment as candidates for abandonment would be addressed. There are a total of about 11.5 miles of road that would be abandoned, with a minimum of 5.6 additional miles that would be considered for abandonment. While this is a small percentage of the total miles of road, these roads are actively contributing sediment, and their decommissioning would have direct benefits.

In the short term, road-related landslides may continue to have some effect on fish habitat and water quality. The proposed road maintenance program, however, will reduce washouts, diversions, and slumping on the remaining roads.

The HCP would adopt the road construction and maintenance standards in the Washington Administrative Code (WAC 222-24). However, 10 miles of new roads would be built under guidelines adopted in the transportation plan. Impacts from these road construction miles would be basically the same as under alternatives WM-1, WM-3, and WM-4. Most non-reserve timber stands are accessible by existing roads. Therefore, the effect of new road construction on road-related mass wasting is expected to be negligible.

For the minimal roads that would be built, specific prescriptions would be followed to avoid creating road-related landslides. There are explicit mitigation measures for crossing landslide-prone areas, including the prescription which requires that a qualified scientist or engineer determine the level of shallow-rapid mass wasting hazard. If the area is determined to be high hazard for mass wasting, the road would be re-routed around the area unless it could be designed with a factor of safety of 1.3. Similarly, another prescription establishes the protocol for areas with potential for deep-seated landslides.

Because new road construction would be minimal, prescriptions to prevent mass wasting would be followed, and problem roads would be fixed over time, this alternative is expected to have minimal effects on sediment delivery from road-related mass wasting over the long term.

Long-term Sustainable Thinning Alternative (WM-3)

As under the Proposed HCP Alternative, 64 percent of the Watershed would be in reserve. Because existing road densities are already high and existing second growth timber is readily accessible, the number of new roads needed would be relatively small. Approximately 10 miles of new road would be built. These roads would be basically the same as under the No Action and Proposed HCP Alternatives.

This alternative is very similar to the Proposed HCP Alternative with respect to roads and also would have minimal effects on road-related mass wasting.

Thinning Alternative with Phased Out Commercial Timber Harvest (WM-4)

This alternative would have nearly identical effects as under the Proposed HCP Alternative, since road construction, abandonment, and maintenance would be nearly identical. Slightly more of the Watershed would initially be off-limits to harvest and thus there would fewer new logging roads. Approximately 10 miles of new road would be built. Therefore, effects to road-related mass-wasting under this alternative would be minimal.

No Commercial Timber Harvest Alternative (WM-5)

No new logging roads would be built under this alternative, and the road abandonment and maintenance program would be similar to the Proposed HCP Alternative. Therefore, this alternative would have a negligible effect on road-related mass wasting.

4.1.2 Road Surface Erosion

Under each alternative, some road surface erosion would occur because even unused roads erode during storm events. The total mileage of roads in the Cedar River Municipal Watershed does not vary significantly between the alternatives. Road surface erosion is tied closely to road use; consequently the main parameter that distinguishes potential road surface erosion between alternatives is the amount of logging and associated logging truck traffic that would occur. Road traffic related to security, maintenance, and other projects would be the same among all alternatives, and would be minimal except on the main roads.

No Action Alternative for Watershed Management (WM-1)

Under this alternative, besides background erosion of roads mentioned above, logging traffic would generate road surface erosion. Several subbasins were identified in the Watershed Assessment as having a high potential for road generated sediment (Technical Appendix 15). This determination was based mostly on the amount of traffic received, but also on surfacing and total miles of road within the subbasin.

In contrast to mass wasting potential, the subbasins with the highest road-surface erosion potential are in the lower municipal watershed, including the Lower Cedar River, Taylor Creek, and Williams Creek. Large portions of these subbasins would be open to logging; therefore it is expected that there would be sporadic episodes of road surface erosion when logging traffic occurs during rain events. Should significant portions of any subbasin be logged within a short period of time (1 to 3 years), and if operations are continued through the rainy season, sediment delivery from road surfaces could be significant. This could affect low gradient reaches of streams in the lower municipal watershed that are susceptible to fine sedimentation (see Section 4.1.4, Fisheries Habitat and Resources).

Under this alternative, there would be no specific prescriptions beyond what is required for protection under the State Forest Practices Act Regulations for minimizing road surface erosion, such as maintaining a certain thickness of surfacing on heavily traveled roads, or installing more ditch relief culverts. Re-construction and maintenance of roads associated with timber harvest specific to forest practices permits would be required to meet updated forest practices rules (WAC 222-24) designed to minimize delivery of sediment to stream channels. These rules would only apply to that system under a specific permit. Although some road abandonment and decommissioning would be implemented, this would eliminate a small fraction of the total of road surfaces contributing sediment.

Note that under this alternative, wide stream buffers would filter out most road-generated sediment before reaching streams. This would occur on roads which have frequently spaced cross drains, which empty water from roadside ditches onto hillslopes (instead of directly to streams). Based on field suveys, most roads in the Watershed are hydrologically connected to streams, resulting in a high probability of sediment delivery.

Thus, under this alternative, there could be significantly localized effects of road-generated erosion on fish habitat and water quality.

Proposed HCP Alternative for Watershed Management (WM-2)

As under the No Action Alternative, there would be no specific prescriptions for minimizing road surface erosion beyond current Forest Practices Act regulations and existing City policies. Re-construction and maintenance of roads associated with timber harvest specific to forest practices permits would

be required to meet updated forest practices rules (WAC 222-24) designed to minimize delivery of sediment to stream channels. These rules would only apply to that system under a specific permit. Although more road abandonment and decommissioning would be implemented as part of the City's annual transportation, this would eliminate only a small fraction of the total of road surfaces contributing sediment. On the other hand, the use of roads by logging trucks would be diffuse and sporadic. With a 60-year rotation increasing to 120 years during the course of the 50 year HCP, it is likely that road-generated sediment would not be significant (over the period of a year or two) within any single subbasin.

Limited road surface erosion could continue to occur on sensitive roads, such as the 100 Road, which is adjacent to Chester Morse Reservoir. However, this would not affect drinking water quality, since it is above the Masonry Dam, and most suspended sediment would settle out upon reaching the reservoir. Additionally, there is very limited fish habitat in the streams that this road crosses on the north side of the reservoir. Road 80, in the Taylor Creek drainage, in combination with other sediment sources, could affect water quality during heavy use periods. This road is used to access industrial timber lands outside the Cedar River Municipal Watershed, particularly the adjacent Green River Watershed. This road will probably continue to be used in the future. Because much of the Taylor Creek drainage is not in the Reserve, it is possible that future logging-related traffic within these subbasins could add to the sediment already generated by existing log truck traffic, creating a significant amount of localized sediment with impacts dependent upon deliverability to streams.

Note that under this alternative, wide stream buffers would filter out road-generated sediment before reaching streams. This would occur on roads which have frequently spaced cross drains, which empty water from roadside ditches onto hillslopes (instead of directly to streams). Based on field surveys, most roads in the Watershed are hydrologically connected to streams, resulting in a high probability of sediment delivery.

Therefore, it is probable that while most of the Watershed would experience a minimal, background level of sediment from unused or lightly used roads, increases in sediment could be generated in the Taylor Creek subbasins. This could have localized effects on water quality and fish habitat in these areas. These effects will be mitigated by road surfacing or suspending log truck traffic during rainy periods.

Long-term Sustainable Thinning Alternative (WM-3)

With the Reserve area and timber harvest rate similar to that under WM-2, the effects are expected to be similar. Thus, this alternative is expected to have minimal effects on road surface erosion.

Thinning Alternative With Phased Out Commercial Timber Harvest (WM-4)

Under this alternative, logging truck traffic would greatly decrease after the first few decades of implementation. Therefore, road-generated sediment would greatly decrease and would be minimal after 50 years. Furthermore, logging traffic would be infrequent and widely dispersed throughout the Watershed, diminishing the effects on water quality and fish habitat in the short term. Sediment delivery could be significant however, in the Taylor Creek subbasins, which are currently the susceptible to road surface erosion from through-going logging traffic as described under the Proposed HCP Alternative. However, in the Watershed as a whole, there would eventually be very minimal road surface-generated sediment. No significant effects to road surface erosion are expected.

No Commercial Timber Harvest Alternative (WM-5)

Because there would be no log truck traffic, there would be minimal effects on road surface erosion under this alternative.

4.1.3 Hillslope Erosion

In considering the effects of hillslope erosion, sediment delivery is a key factor. Under all of the alternatives, buffers would be greater than the typical width of 100 feet recommended by the most of the literature cited in Johnson and Ryba (1992). Although hillslope erosion may occur in non-reserve areas (matrix lands) of the Watershed, stream buffers would be sufficiently wide to filter sediment generated by this process. This is especially true because even the smallest streams (Types IV and V) would have 150 and 100 foot buffers, respectively. The effects on hillslope erosion alone vary only slightly among the alternatives while sediment delivery would be the same for each of the alternatives.

No Action Alternative for Watershed Management (WM-1)

Timber harvest would be conducted using harvest systems similar to those currently used; cable yarding has been the predominant method in the last few decades, with tractor skidding occurring on the more gentle slopes. There would be some potential for hillslope erosion, given that these practices inherently disturb some amount of soil. The amount of erosion would depend on local conditions, including soil types, slope, and percent of soil exposed.

However, due to the expected filtration of sediment by the proposed buffers mentioned above, hillslope erosion would not have a significant effect across most of the Watershed.

Proposed HCP Alternative for Watershed Management (WM-2)

Timber harvest would be conducted using harvest systems similar to those currently used; a mixture of cable and tractor yarding would be used. There would be some potential for hillslope erosion, given that these practices inherently disturb some amount of soil. The amount of erosion would depend on local conditions, including soil types, slope, and percent of soil exposed.

However, as under the No Action Alternative, filtration of sediment by the proposed buffers would protect streams from sedimentation, and hillslope erosion would not have a significant effect across most of the Watershed.

Long-term Sustainable Thinning Alternative (WM-3)

This alternative would have effects similar to Alternative WM-2 except that logging would not be phased out. While the Reserve system would be the same as under the Proposed HCP Alternative, the style of logging would be substantially different. Where tractor logging is permitted, more compaction would result compared to cable systems. Logging systems would be chosen based on slopes, soils, and season periods. Because logging would be widely dispersed across non-reserve areas (matrix lands) and the proposed buffers would filter sediment, however, this alternative would not have significant effects related to hillslope erosion.

Thinning Alternative with Phased Out Commercial Timber Harvest (WM-4)

This alternative would have effects similar to the Proposed HCP Alternative. While the Reserve system would be the same as under the Proposed HCP Alternative, the style of logging would be substantially different. Where tractor logging is permitted, more compaction would result compared to cable systems. Logging systems would be chosen based on slopes, soils, and season periods. However, because logging would be widely dispersed across non-reserve areas (matrix lands) and because wide buffers would be required, this alternative would not have significant effects on hillslope erosion. Additionally, under this alternative, logging would be phased out so the effects would be progressively eliminated as areas were added to the Reserve over time.

No Commercial Timber Harvest Alternative (WM-5)

Because no commercial timber harvest would be conducted under this alternative, there would be no effects on hillslope erosion.

4.1.4 Soil Productivity

Soil productivity is important for maintaining timber productivity and for maintaining habitat (forage, cover) for wildlife, and indirectly for maintaining water quality. The main parameters used to assess effects on soil productivity

are the type of logging used and associated prescriptions, the potential amount of soil disturbance, and the timber harvest rotation period. While prescribed burning can affect soil productivity, it is not expected to occur under any of the alternatives.

No Action Alternative for Watershed Management (WM-1)

Under the this alternative, as in the past, the type of yarding system used would be chosen by the City, and would result in the use of a variety of techniques, including rubber-tired skidders, tractors, and cable yarding . Since much of the non-reserve area is in the lower municipal watershed, skidder or tractor logging would probably be used in many of the gently sloping areas. The non-reserve area would be approximately 42 percent of the Watershed. The rotation cycle would be approximately 60 years, which in some places might not be long enough to allow soil recovery through natural processes. Thus, in areas where soils are compactable, and skidder or tractor yarding is used, there could be localized effects on soil productivity.

One management standard used in other areas for preventing effects on soil productivity is a 15 percent limit on areas of soil disturbance (Logan and Clinch, 1993). Thus, if soil disturbance in a given area (i.e., a harvest unit) is less than 15 percent, effects on soil productivity would be minimal. Aerial photographs have shown that in the past, this amount of disturbance has been exceeded in the Cedar River Municipal Watershed. However, it is not expected that greater than 15 percent soil disturbance would occur assuming that operations followed existing management policies and comply with Forest Practices Act regulations.

Notably, timber harvest would be widely dispersed across the Cedar River Municipal Watershed, since the non-reserve areas (matrix lands) are widely dispersed. In the Carey Creek Special Management Area (SMA), soils would be protected by requiring full-suspension logging, which keeps logs from dragging across the soil. Therefore, considering the Watershed as a whole, the effects on soil productivity would be minimal.

Proposed HCP Alternative for Watershed Management (WM-2)

Under this alternative, several measures would be in place to protect against soil degradation. Sensitive soils that would be protected under the proposed Reserve. The same prescriptions would be followed to minimize mass wasting and surface erosion as for the No Action Alternative. Skidder and tractor logging would be limited to slopes less than 30 percent in areas of high surface erosion hazard. This would help prevent excessive erosion, although compaction could still occur in some of tractor yarded harvest units. Timber harvest rotation would increase to 120 years or more, and processes that aerate the soil would probably be able to diminish the effects of compaction to negligible levels. In the Carey Creek Special Management Area (as in the No Action Alternative), soils would be protected by requiring full-suspension

logging. Most importantly, soil disturbance would be limited to less than 12 percent of the affected area (prescription HSEH-2). Therefore, effects to soil productivity over the long term would be negligible.

Long-term Sustainable Thinning Alternative (WM-3)

The effects under this alternative would be very similar to alternative WM-4. While the Reserve would be the same as under the Proposed HCP Alternative, the style of logging would be different. Where tractor logging is permitted, more compaction would result as compared to cable systems. Logging systems would be chosen based on slopes, soil, and seasonal periods. However, because soil disturbance would be limited to less than 12 percent of the affected area, the effect on soil productivity would be minimal under this alternative (Watershed Assessment Prescription HSEH-2).

Thinning Alternative with Phased Out Commercial Timber Harvest (WM-4)

While the Reserve would be the same as under the Proposed HCP Alternative, the style of logging would be different. However, because soil disturbance would be limited to less than 12 percent of the affected area, the effect on soil productivity would be minimal under this alternative (Watershed Assessment Prescription HSEH-2) and because logging would be phased out over 50 years, the effect on soil productivity would be negligible under this alternative.

No Commercial Timber Harvest Alternative (WM-5)

Because there would be no commercial timber harvest of any kind, there would be no effect on soil productivity under this alternative.

4.1.5 Anadromous Fish Mitigation Alternatives

Environmental review for this programmatic EA/EIS did not identify any potential impacts to geology and soils from the Anadromous Fish Mitigation Alternatives. Specific projects implemented as part of the HCP may require further SEPA analysis at the time of construction, depending upon what permits are required. Hydraulic Permit Approvals and Shoreline Substantial Development Permits may be required for facilities at Landsburg Dam, the pipeline crossing, or construction of the hatchery. Site-specific measures for mitigating any temporary impacts to geology and soils from erosion related to construction activities will be addressed as part of the permit process.

4.1.6 Instream Flow Alternatives

Environmental review did not identify any potential impacts to geology and soils from the Instream Flow Alternatives.

4.1.7 Summary

A summary of environmental consequences for geology and soils is presented in Table 4.1-1. These consequences are summarized here individually for each of the watershed management alternatives. As discussed earlier, environmental review did not identify any potential impacts to geology and soils from the Anadromous Fish Mitigation and Instream Flow Alternatives.

No Action Alternative for Watershed Management (WM-1)

Under this alternative, there would be minimal effects on timber harvest related mass wasting across most of the Cedar River Municipal Watershed. There could be effects, however, in the Taylor and Rock Creek subbasins, where deep-seated landslides could contribute sediment to streams from shallow landslides that might occur outside the buffers. Landslides from roads could have localized effects on fish habitat. Overall, very few new roads would be built and road-related mass wasting would occur mostly from existing roads. Limited road decommissioning would occur which would slightly reduce existing levels of road-related mass wasting.

The effects on road surface erosion could occur in the Lower Cedar River, Taylor Creek, and Williams Creek subbasins where road surface erosion potential is high, if high usage occurred without proper road maintenance and road surfacing. Hillslope erosion would not have significant effects on streams because buffers would be sufficiently wide to filter out the sediment. In addition, effects of hillslope erosion on streams would not be significant because buffers would be sufficiently wide to filter out the sediment.

Effects on soils productivity would be minimal because of widely dispersed timber harvest areas, and Special Management Areas which protect soils.

Proposed HCP Alternative for Watershed Management (WM-2)

This alternative would have minimal effects on timber harvest related mass wasting throughout the Watershed because of restrictions on timber harvest in unstable areas, prescriptions to protect against landslides, and a large Reserve which includes wide stream buffers. Prescriptions would also be implemented to prevent road-related mass wasting and a program to decommission or repair all currently identified problem roads would be implemented. Therefore this alternative would reduce road-related landslides significantly and road related landslides from new roads would be minimal.

This alternative would have minimal effects on road surface erosion due to long rotation cycles and dispersed timber harvest units which would spread out logging truck traffic over time and space. Some localized effects could occur in the Taylor Creek subbasin because it is a mainline road with high erosion potential. This effect will be mitigated by rainy period traffic restrictions. Hillslope erosion would not have significant effects on streams because buffers would be sufficiently wide to filter out the sediment.

Effects on soils productivity would be minimal because of widely dispersed timber harvest areas, and Special Management Areas (SMAs) which protect soils. In addition, special prescriptions which minimize soil disturbance would prevent effects on soil productivity.

Long-term Sustainable Thinning Alternative (WM-3)

Under this alternative, prescriptions would be the same as under the Proposed HCP Alternative. The Reserve would be identical and there would be no clearcutting which would help maintain root strength for slope stability. Therefore, this alternative would have minimal effects on timber harvest related mass wasting. This alternative would treat road-related landslides in the same way as under the Proposed HCP Alternative and would thus have minimal effects.

This alternative would have minimal effects on road surface erosion due to long rotation cycles and dispersed timber harvest units which would spread out log truck traffic over time and space. Some localized effects could occur in the Taylor Creek subbasins. Hillslope erosion would not have significant effects on streams because buffers would be sufficiently wide to filter out the sediment.

The Reserve, SMAs, and timber harvest prescriptions would be the same as under the Proposed HCP Alternative, and thus effects on soil productivity would be minimal.

Thinning Alternative with Phased Out Commercial Timber Harvest (WM-4)

Because this alternative has the same prescriptions for timber harvest as the Proposed HCP Alternative, has a slightly larger Reserve, and would phase out logging in the long-term, it is expected to have minimal effects on timber harvest related mass wasting. This alternative would treat road-related landslides in the same way as under the Proposed HCP Alternative, and would thus have minimal effects.

This alternative would have minimal effects on road surface erosion due to long rotation cycles and dispersed timber harvest units which would spread out the log truck traffic over time and space. In the long-term, there would be negligible effects because logging (and related log truck traffic) would be phased out. Hillslope erosion would not have significant effects on streams because buffers would be sufficiently wide to filter out the sediment.

The Reserve, SMAs, and timber harvest prescriptions would be the same as under the Proposed HCP Alternative; consequently, effects on soil productivity would be minimal.

Table 4.1-1 Summary of Environmental Consequences Evaluated for Geology and Soils (page 1 of 3)

Potential Impact Evaluated	Environmental Consequences					Comments
	Watershed Management Alternatives					
	WM-1	WM-2	WM-3	WM-4	WM-5	
Potential for causing mass wasting from timber harvesting activities	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	The alternatives would have minimal potential for contributing to mass wasting problems generated by timber harvesting activities because of the large reserve areas, related buffers and management constraints . Even WM-1 which represents the alternative with the highest level of timber harvesting would not have much of an effect because any harvesting on unstable slopes would be subject to a Class IV General Permit under the Forest Practices Act Regulations
Potential to trigger shallow landslides in the Taylor and Rock Creek basin from timber harvesting activities	Negative Effects	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Only Alternative WM-1 has the potential to cause localized sedimentation impacts in the Taylor and Rock Creek subasins from shallow landslides triggered by timber harvest activities. This potential could be mitigated by implementing the Watershed Assessment Prescriptions proposed for the other alternatives.
Potential effect on road-related mass wasting from new road construction	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	No Effects	Alternatives WM-1, WM-2, WM-3 and WM-4 are estimated to result in approximately 10 miles of new road over the duration of the 50-year time period of the HCP. This level of new road construction would be conducted according to current road standards in the Cedar River Municipal Watershed and is estimated as having at most a minimal effect on mass wasting. New roads would not be built as part of WM-5 and, therefore, would have no effect on mass wasting.

Table 4.1-1 Summary of Environmental Consequences Evaluated for Geology and Soils (page 2 of 3)

Potential Impact Evaluated	Environmental Consequences					Comments
	Watershed Management Alternatives (cont.)					
	WM-1	WM-2	WM-3	WM-4	WM-5	
Potential effect on road-related mass wasting from road maintenance	Negative Effects	Positive Effects	Positive Effects	Positive Effects	Positive Effects	Under WM-1, mass wasting events related to road failure would be expected to continue to occur at a similar or slightly lesser degree than they have occurred in the recent past. Although the City's transportation plan would dictate road management activities on an annual basis, funding for implementation is uncertain. All of the other alternatives will result in reducing the risk of mass wasting because of funding commitments for road maintenance activities.
Potential for surface erosion from road use and maintenance	Negative Effects	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Under all the alternatives, some surface erosion from roads would occur because even unused roads erode during storm events. Road traffic related to security, maintenance and other projects would be the same amongst all alternatives and would be minimal except possibly on the main roads. The highest potential for surface erosion from roads exists in the lower watershed. Under rainy conditions during heavy logging traffic, surface erosion in the lower watershed could be significant under WM-1. The proposed reserve areas, related buffers, and proposed road maintenance prescriptions will minimize the surface erosion potential of the other alternatives.

Table 4.1-1 Summary of Environmental Consequences Evaluated for Geology and Soils (page 3 of 3)

Potential Impact Evaluated	Environmental Consequences					Comments
	Watershed Management Alternatives (cont.)					
	WM-1	**WM-2**	**WM-3**	**WM-4**	**WM-5**	
Potentitial for hillslope erosion	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Although hillslope erosion could occur in non-reserve areas of the watershed, stream buffers would be sufficiently wide under all of the alternatives to filter out sediment generated by this process. Even the smallest streams, Types 4 and 5, would have buffers of 150 and 100 feet, respectively. The effects on hillslope erosion alone vary only slightly among the alternatives while sediment delivery would remain the same.
Potential effect on soil productivity within the Cedar River Municipal Watershed	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	The effect on soil productivity is considered minimal for all of the alternatives evaluated.
	Anadromous Fish Mitigation Alternatives					
	AFM-1	**AFM-2**	**AFM-3**	**AFM-4**	**AFM-5**	
Environmental review did not identify any potential impacts to Geology and Soils from the Anadromous Fish Mitigation Alternatives						
	Instream Flow Alternatives					
	IF-1			**IF-2**		
Environmental review did not identify any potential impacts to Geology and Soils from the Instream Flow Alternatives						

Table 4.6-1 Summary of Environmental Consequences Evaluated for Cultural Resources (page 1 of 3)

Potential Impact Evaluated	Environmental Consequences					Comments
	Watershed Management Alternatives					
	WM-1	WM-2	WM-3	WM-4	WM-5	
Potential effects on cultural resources from regeneration or retention harvesting	Negligible Effects	Negligible Effects	No Effects	No Effects	No Effects	Effects on these resources would be negligible because in all cases SPU would implement the Cultural Resources Management Plan to mitigate potential impacts from incidental activities related to timber harvesting. There are no effects expected for alternatives WM-3, WM-4 and WM-5 because regeneration and retention harvesting are not components of these alternatives
Potential effects on cultural resources from thinning applications, including PCT, commercial, restoration and ecological thinning	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Effects on these resources would be negligible because in all cases SPU would implement the Cultural Resources Management Plan to mitigate potential impacts from incidental activities related to thinning applications.
Potential effects on cultural resources from road maintenance, construction and decommissioning activities	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Effects on these resources would be negligible because in all cases SPU would implement the Cultural Resources Management Plan to mitigate potential impacts from incidental activities related to road maintenance, construction and decommissioning activities.
Potential effects on hunter-fisher-gatherer archaeological sites	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Potential effects on hunter-fisher-gatherer archaeological sites would be negligible because of implementation of the Cultural Resources Management Plan to mitigate potential impacts from incidental activities.

Table 4.6-1 Summary of Environmental Consequences Evaluated for Cultural Resources (page 2 of 3)

Potential Impact Evaluated	Environmental Consequences					Comments
	Watershed Management Alternatives (cont.)					
	WM-1	WM-2	WM-3	WM-4	WM-5	
Potential effects on historic archaeological sites	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Potential effects on historic archaeological sites would be negligible because of implementation of the Cultural Resources Management Plan to mitigate potential impacts from incidental activities.
Potential effects on traditional cultural properties	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Potential effects on traditional cultural properties would be negligible because of implementation of the Cultural Resources Management Plan to mitigate potential impacts from incidental activities.
Potential effects on historic trails	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Potential effects on historic trails would be negligible because of implementation of the Cultural Resources Management Plan to mitigate potential impacts from incidental activities.
Potential effects on traditional use areas	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Potential effects on traditional use areas would be negligible because of implementation of the Cultural Resources Management Plan to mitigate potential impacts from incidental activities.
	Anadromous Fish Mitigation Alternatives					
	AFM-1	AFM-2	AFM-3	AFM-4	AFM-5	
Potential effects on cultural resources from excavation and other construction activities from the installation of fish passage facilities, fish screening facilities and the hatchery at Landsburg	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Effects on these resources would be negligible because in all cases SPU would implement the Cultural Resources Management Plan to mitigate potential impacts from incidental activities related to the installation of fish passage facilities, fish screening facilities and the hatchery at Landsburg.

Table 4.6-1 Summary of Environmental Consequences Evaluated for Cultural Resources (page 3 of 3)

Potential Impact Evaluated	Environmental Consequences					Comments
	Anadromous Fish Mitigation Alternatives (cont.)					
	AFM-1	AFM-2	AFM-3	AFM-4	AFM-5	
Potential effects on cultural resources from excavation and other construction activities from the installation habitat restoration projects downstream of Landsburg	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Effects on these resources would be negligible because in all cases SPU would implement the Cultural Resources Management Plan to mitigate potential impacts from incidental activities related to the installation of downstream habitat restoration projects.
	Instream Flow Alternatives					
	IF-1			**IF-2**		
Potential effects on cultural resources in the Cedar River downstream of Landsburg from the management of instream flows	No Effects			No Effects		No archeological resources are expected to be affected from the management of flows within the Cedar River downstream of Landsburg from either flow regime.
Potential effects on cultural resources from fluctuations in reservoir operations caused by supplemental steelhead flows by the use of temporary pumping plants or reduced instream flows to recover water	Negligible Effects			Negligible Effects		Potential effects are considered negligible because the incremental impact of IF-2 averages 0.41 feet less during fall (when the difference would be expected to be the largest) and the applicant has procedures in place to conduct archeological investigations on the shoreline of Chester Morse Lake if temporary pumping is utilized.
Potential effects on cultural resources from the use of dead storage on a permanent basis	Does Not Apply			Unknown Effects		Potential effects on cultural resources from the use of dead storage is not known at this time. IF-2 does not commit to use dead storage. Instead, the proposed HCP alternative would provide the funding to conduct a feasibility study to evaluate the project, including potential environmental impacts to cultural resources and other elements of the affected environment.

4.2 Water Resources

This section considers the environmental consequences of the Water Management, Anadromous Fish Mitigation, and Instream Flow Alternatives on water resources in the Cedar River. Additional discussion and analysis of water quantity and quality issues are found in the following sections: Section 4.4.2 Anadromous Fish Mitigation Alternatives and Section 4.4.3 Effects of Instream Flow Alternatives (under Section 4.4 Fisheries Habitat and Resources); Section 4.8.4 Instream Flow Alternatives (under Section 4.8 Recreation); and Section 4.9 Public Services.

4.2.1 Watershed Management Alternatives

Water Quantity

Presented below is a discussion of the environmental consequences of the Water Management Alternatives on water quantity and water quality.

Land management activities can change the patterns and magnitude of stream runoff. These linkages were discussed in Section 3.1. Timber harvest can influence stream flows by increasing the amount of snow accumulation. Loss of vegetation decreases snow interception and consequent evaporation, thereby increasing the amount of snow available for runoff. This snow is especially important during rain-on-snow (ROS) events. Of most concern are increases in flood, or peak, flows.

Increases in peak flow can also occur as a result of road building. Roads can gather and transmit rainfall faster than the natural landscape, altering basin hydrology and extending the drainage network. Effects of roads on peak flows have been documented in small watersheds in which roads occupy more than 6 percent of the surface area (see Section 3.2.1). This value may be used as a rough indicator of potential for peak flow increases due to roads.

The existing sensitivity of subbasins in the Cedar River Municipal Watershed to ROS events was established in Section 3; many subbasin were identified in the Watershed Assessment as being susceptible to increased peak flows

(Technical Appendix 15). Therefore the protection of hydrologic maturity and road construction and decommissioning are important parameters to consider.

The following section addresses the effects of the Water Management Alternatives on streams upstream from Landsburg. Section 4.4.3, which address the effect on instream flow mitigation, discusses effects downstream of Landsburg.

No Action Alternative for Watershed Management (WM-1)

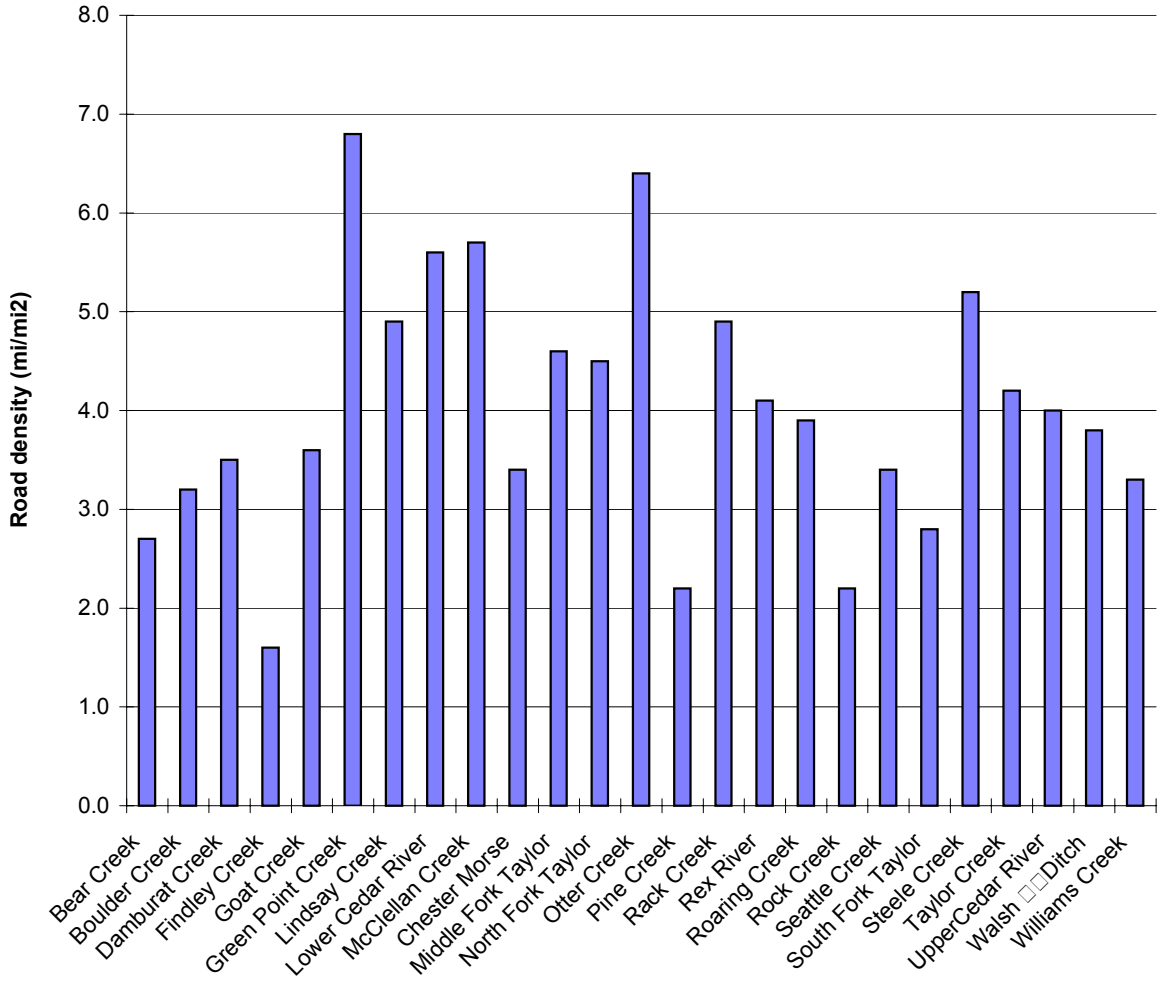
Under this alternative, timber harvest would be conducted at some level on the 38,000 acres of non-reserve areas (matrix lands). The rate of timber harvest would be low, relative to the harvest rates on adjacent, privately owned lands, and relative to historical harvest rates of the 1960s and 1970s. Current peak flows in many of the subbasins were calculated using the Washington State standard methodology for Watershed Analysis (Foster Wheeler Environmental Corporation, 1995c). While there is evidence that this method overestimates peak flows, many of the subbasins showed significant (greater than 25 percent) increases under current (1995) conditions. Therefore, additional timber harvest could maintain or increase this effect. Increased peak flows could cause streambed scour, streambank erosion, and channel incision. Each of these effects could degrade fish habitat (see Section 4.4, Fisheries Habitat and Resources).

The effects of roads on peak flows can be evaluated by considering road density. A threshold of 6.3 mi/mi^2 of roads, based on Jones and Grant (1996), was presented in Section 3.1. Only two of the subbasins (Green Point, Lower Cedar, and Otter creeks) have a road density greater than 6 mi/mi^2. A few other subbasins have road densities approaching 6 mi/mi^2 (Figure 4.2-1). Notably, increased peak flows in small subbasins (including Green Point and Otter creeks) draining directly into Chester Morse Lake are probably attenuated due to the flood storage capacity of the reservoir. In addition, the relatively high existing road densities indicate that new road construction for timber harvest would be minimal. The proposed new roads were estimated at 10 miles, which is small compared to the existing road network. Road reconstruction is more likely and would not increase effects on peak flows above existing conditions. The minor additional road building expected under this alternative would not cause significant increases in peak flows.

Proposed HCP Alternative for Watershed Management (WM-2)

The Proposed HCP Alternative, WM-2, would have somewhat less overall harvest than the No Action Alternative since 6 percent more of the Watershed would be in the Reserve and because rotation ages would increase from an average of 60 years to 120 to 140 years. In addition, a timber harvest standard for protection of hydrologic maturity within each subbasin would be in effect.

Figure 4.2-1 Existing road density by subwatershed



Therefore there would be minimal effect of timber harvest on ROS related peak flows.

As under the No Action Alternative, existing road-related effects are estimated to be minimal. Furthermore, the relatively high existing road densities indicate that new road construction would be minimal. The proposed new roads were estimated at 10 miles, which is small compared to the existing road network. Road reconstruction is more likely and would not increase effects on peak flows above existing conditions. The minor additional road building expected under this alternative would not cause significant increases in peak flows.

Because peak flows are not likely to be affected by this alternative, alteration of the floodplain on tributaries to the Cedar River are unlikely to occur. In addition, no significant construction in the floodplains of these tributaries is proposed; floodplain capacity above Landsburg would be unaffected by this alternative.

Long-term Sustainable Thinning Alternative (WM-3)

This alternative would have effects similar to those under the Proposed HCP Alternative. Because timber harvest would be designed to maintain appropriate levels of hydrologically mature forest, there would be no effect on ROS events. Additionally, no clearcutting would occur and thinning would leave much more of the canopy in harvest units than under the Proposed HCP Alternative. Treatments for roads would be the same as under the Proposed HCP Alternative; therefore road-related effects on runoff would be the same, and their would be no significant effect on peak flows.

Thinning Alternative with Phased Out Commercial Timber Harvest (WM-4)

Under this alternative, increases in peak flows due to roads and timber harvest would be even less likely than under the Proposed HCP Alternative because timber harvest would be phased out over time. Likewise, effects on floodplains would be insignificant. In the near term, because the timber harvest program would be conducted to retain adequate amounts of hydrologically mature forest, no effect on peak flows due to timber harvest is expected. The effect on runoff due to roads would minimal, as under the Proposed HCP Alternative.

No Commercial Timber Harvest Alternative (WM-5)

Because there would be no harvest of any portion of the Watershed and because the amount of roads would not increase, there would be no effects on water quantity under this alternative. The effect on runoff due to roads would be the same as under the No Action Alternative, minimal.

Water Quality

As discussed in Section 3.2, suspended sediment, turbidity, and temperature are the primary variables affecting water quality that are associated with land management activities.

Temperature plays an integral role in the biological productivity of streams. Aquatic life uses are the beneficial uses of the water most sensitive to water temperatures. Salmonids and some amphibians appear to be the most sensitive to water temperatures and are used as indicator species regarding water temperature and water quality (see Section 3.8). As discussed in Section 3.2, stream temperatures in the upper Cedar River in the past have been within the state limits.

No Action Alternative for Watershed Management (WM-1)

Under this alternative, there would not be significant effects on water quality, because current watershed management has kept the Cedar River rated as exceptional water quality by the State of Washington. While timber management could occasionally cause increases in turbidity and suspended sediment during storms, these would be sporadic and short-lived, and wide stream buffers would prevent most sediment from reaching streams. While parts of the Taylor Creek and Rock Creek subbasins may experience some timber-harvest-related mass wasting (see Section 4.1.1), delivery of significant amounts of fine sediment to streams would be unlikely. At the Landsburg Diversion, the drainage area is large, and the area being logged at any time is small in comparison that there would be negligible effects on turbidity and suspended sediment (see Section 4.1.1). There could be localized, short term increases in suspended sediment in stream adjacent to logging operations, particularly tractor logging on steep slopes (greater than 30 percent). Additionally, log truck traffic could cause road-generated erosion in the Taylor Creek Subbasin which could be significant depending upon deliverability when combined with existing truck traffic (see Section 4.1).

Over the long term, stream temperature would be unchanged in areas where it is within state standards. Shade would increase in previously harvested riparian zones, eliminating any existing temperature effects. Stream buffers are wide enough that shade requirements for all stream types (1 through 5) would be met. In a summary of existing literature, Johnson and Ryba (1992) indicated that a buffer of 100 feet was typically recommended for protecting stream temperature. The buffers, which would apply to the horizontal distance away from the water's edge under the Proposed HCP Alternative, are a minimum of 300 feet on fish bearing streams, 150 feet on non-fish bearing perennial streams, and 100 feet on intermittent streams. Because all of the proposed buffer widths exceed the amount deemed necessary by existing literature (Johnson and Ryba, 1992) for stream temperature protection, no effect on stream temperature is expected. Water temperature, where currently elevated in the summer, would decrease to near natural levels as harvested

riparian zones recover from past logging and buffer requirements (via the Forest Practices Act and Watershed Assessment) (see Technical Appendices 13 and 15) are implemented in future timber harvests.

In addition to the 300-foot buffer around Type 1 streams, a Special Management Area (SMA) has been established for additional protection of water quality. This SMA includes the area under City ownership within a 1-mile circle of Landsburg and an additional 300-foot buffer around the mainstems of the Cedar River and Taylor Creek. Timber harvest will be constrained within the SMA to inhibit ungulate use of the area in order to minimize pathogen loading to the City's drinking water supply.

Proposed HCP Alternative for Watershed Management (WM-2)

Under this alternative, the effects on turbidity and suspended sediment conditions would be minimal because of restrictions on the timing, amount, and style of logging, including prescriptions designed to prevent erosion and sedimentation (see Section 4.1). Longer rotations would mean that a subbasin would be less susceptible to erosion at any given time; more trees would be left standing in each harvest unit, and limits on tractor yarding would reduce potential erosion. Additionally, SPU would have the option of shutting down the diversion, as in the past, if turbidity levels are too high. Therefore there would be no significant effect on turbidity and suspended sediment, and thus no effect on the water supply.

Under this alternative, water temperature would be maintained or improved as indicated under the No Action Alternative. The stream buffer widths would be sufficient for stream temperature protection. Although some smaller streams may currently have elevated temperatures in the summer as a result of past timber harvest in the riparian zone, no data are available to demonstrate this. Nevertheless, riparian zones would grow back and be protected by buffers in the future. Thus any existing elevated temperatures would revert to background levels over time.

Long-term Sustainable Thinning Alternative (WM-3)

Because timber harvest would be selective, and prescriptions (as under the Proposed HCP Alternative) would be implemented to prevent erosion and sedimentation, the potential effects on suspended sediment and turbidity would be minimal. In addition, since the buffers would be same as under the No Action alternative, the effect would be to maintain or improve stream temperature.

Thinning Alternative with Phased Out Commercial Timber Harvest (WM-4)

The effects of this alternative would be virtually identical to those under WM-3. The localized effects on suspended sediment and turbidity related to

timber harvest would eventually cease altogether, since logging would be phased out in 50 years. Therefore there would no significant effects on water quality under this alternative.

No Commercial Timber Harvest (WM-5)

Effects on water quality under this alternative would be negligible, since there would be no logging, very little truck traffic, and wide buffers on all streams.

4.2.2 Anadromous Fish Mitigation Alternatives

Water Quality

Impact Mechanisms Related to Water Quality

Because the Cedar River Municipal Watershed is a managed by the City as a regional water supply, water quality has two aspects in this analysis of alternatives: effects on drinking water, which is limited to effects on surface water above the Landsburg water intake, and effects on water quality in general, which is considered both above the water intake and in the Cedar

The drinking water quality parameters most germane to the alternatives evaluated were introduced in Section 3.2 and are briefly summarized below:

Nutrients	Nitrogen and phosphorous are nutrients that stimulate growth of algae. Most species of algae do not pose health hazards themselves, but contribute to smell and odor problems that are not easily ameliorated in drinking water. Algae also contain organic chemicals that can interact with chlorine to produce disinfection by-products (see below).
TOC/DBPs	Organic carbon, characterized by Total Organic Carbon (TOC), can combine with chlorine used in the disinfection process to create disinfection by-products (DBPs), which are potentially harmful to human health.
Pathogens	Ungulates (deer and elk) and predators and scavengers on salmon carry viruses and parasites of concern for human health, such as *Giardia lamblia* and *Cryptosporidium*, and can cause increases in these pathogens by deposition of fecal matter in or near streams. Fecal coliform bacteria are also regulated pathogens transmitted by animals, but coliform bacteria are completely inactivated by standard chlorination.
Turbidity	Turbidity is a measure of the relative clarity of water, which is affected by material in suspension in the water. High turbidity reduces the effectiveness of disinfection by chlorine.

Two measures in the Anadromous Fish Mitigation Alternatives could result in drinking water quality impacts: (1) construction of facilities to allow passage of chinook and coho salmon, and steelhead trout above the Landsburg Diversion Dam, and (2) construction of screens on the raw water intake at Landsburg.

The concern with fish passage above the raw water intake is the potential effects on water quality of the carcasses of spawned-out salmon and consequent increases in nutrients, TOC, and pathogens from scavengers and predators on the salmon. A risk assessment performed by CH2M HILL (Appendix 5) was the basis for the decision that passage of steelhead, chinook, and coho above Landsburg would not pose a risk to drinking water quality, as long as water quality is carefully monitored, but that passage of the mass-spawning sockeye would pose an unacceptable human health risk. There is little concern with passing steelhead above the intake for three reasons: (1) steelhead spawn after coho and chinook, so do not overlap; (2) steelhead spawn at low densities, and (3) most adult steelhead do not die after spawning, and thus few carcasses are left. For these reasons, passage of steelhead above the water intake is not an issue of concern for drinking water quality.

The concern with the screens is the risk of turbidity events during construction or operation that could increase human health risks. Because the raw drinking water compliance point is now at the Landsburg water intake, material deposited or stirred up during construction or operation of the screens could cause an increase in turbidity event in excess of regulatory standards, with no opportunity to shut the system down prior to the turbid water entering the pipeline. When the planned ozone treatment plant at Lake Youngs is completed, expected in 2004, the raw water compliance point will be moved to Lake Youngs, and the above concerns will not apply. The effects of any short episodes of turbid water caused by the screens at Landsburg would be greatly reduced by dilution in the large Lake Youngs reservoir prior to treatment by chlorine for drinking water purposes. In addition, The City anticipates that the frequency and magnitude of short term turbidity events associated with construction activities will be minimized or avoided by implementation of protective measures during construction. Operations of the screening and passage facilities after construction are not expected to effect turbidity.

Although not of concern with respect to drinking water, operation of the sockeye salmon hatchery could impact surface water downstream of Landsburg through discharge of water used for incubators. This potential impact is discussed in Section 4.4.2. It is concluded in Section 4.4.2 that such impact are insignificant, largely because sockeye fry are not reared for protracted periods, as in many hatcheries, with concomitant accumulation of food material and metabolic waste products from fry and juvenile fish. In addition, permits required by the state to operate the hatchery facility would limit nutrient loading to within acceptable levels. Therefore, these potential impacts will not be discussed further in this section.

Effects by Alternative

No Action Alternative (AFM-1)

Fish currently cannot migrate above the Landsburg Diversion Dam, and the No Action Alternative would not provide for fish passage above the blockage. Therefore, there would be no additional impacts on drinking water related to TOC, phosphorous, nitrogen, or pathogens associated with anadromous salmonids.

Additionally, potential for increase in pathogens would be reduced under all alternatives by the establishment of areas of the Ecological Reserve along all streams and around the reservoir complex, within which no timber harvest for commercial purposes would be allowed, and establishment of Special Management Areas (SMAs) in key areas of the Cedar River Municipal Watershed outside the Reserve where timber harvest activities could affect drinking water. Most of the SMAs were established expressly to protect drinking water, and no timber harvest would be allowed that would encourage the build-up of mammals that could carry human pathogens. This would be accomplished largely by avoiding thinning operations that would open the canopy enough to develop high densities of forage plants in the understory, thus attracting such animals as deer, elk, and voles. Relevant SMAs include a one mile radius circle around the Landsburg intake and an additional 300 ft strip outside the 300-ft Reserve buffers on all state Type 1 streams below Masonry Dam and around the reservoir complex itself. A comparison of the effects of the different Watershed Management Alternatives on turbidity and other water quality variables is provided in Section 4.2.1.

Proposed HCP Alternative for Anadromous Fish Mitigation (AFM-2)

Water quality upstream from Landsburg Diversion

Under this alternative, coho, chinook, and steelhead would be allowed to spawn upstream of the diversion. Decaying salmon carcasses along and in streams could attract other animals (such as black bear, raccoons) to decaying salmon along stream banks. These animals may in turn contribute fecal coliform and other pathogens to surface water. However, the number of fish that would be spawning would make a relatively small contribution to production of TOC and nutrients, and would attract relatively few scavengers and predators that carry human pathogens of concern (Appendix 5).

The timing of spawning of chinook and coho salmon overlap somewhat (mid-October through November), while that of the anticipated few hundred steelhead would not overlap with either species, occurring later in the winter and early spring (March through early June). The peak effects on water quality would be expected during the period that encompasses both coho and chinook spawning, from mid-September through mid-February.

A nutrient-loading scenario was evaluated by SPU consultants for a hypothetical run of 1,000 chinook and 4,500 coho (46,500 pounds of carcasses; CH2M HILL, 1996), greater than the expected escapement goals for these species. It was estimated that, during a "typical" water year, the increase in phosphorous at the Lake Youngs reservoir would be about 0.79 percent, while TOC would increase by about 0.12 percent. During a dry year, the increase in phosphorous and TOC would be 1.36 and 0.22 percent, respectively. These amounts would not be statistically detectable or significant in terms of drinking water quality (Appendix 5). Because the target goals for spawning are likely even less than those in the study, no significant effect on nutrients or TOC would be expected. Consequently, there would be no significant increase in DBPs, and water taste and odor at Lake Youngs would be similar to existing conditions.

Data on carcass consumption and scavenger species composition are insufficient to characterize the potential effects of salmon spawning upstream. However, the salmon spawning targets are low, which diminishes the likelihood of a significant increase in fecal coliform and other pathogens related to scavengers. In addition, any increase in fecal coliform related to salmon carcasses would occur well after the existing seasonal peak in fecal coliform, which occurs in June and July (CH2M HILL, 1996). Background fecal coliform concentrations are typically low during the spawning period, from early October to late February. However, should fecal coliform levels rise above the 20 colonies/100 ml regulatory standard (current peak geometric mean monthly is about 11 colonies/100 ml) at a frequency in excess of the standard, this increase would represent a three-fold increase in the average October fecal coliform (the month with the highest historical fecal coliform during the spawning season). This magnitude of increase is unlikely to occur, although any increase in fecal coliform is of concern (CH2M HILL, 1996).

As discussed in Section 4.4.2, construction of the screens on the water intake is expected to occur after the ozone treatment plant is on line, and the raw water regulatory compliance point is moved to Lake Youngs. Because the large volume of water in the Lake Youngs reservoir would dilute any turbidity spikes that might occur at Landsburg during construction or operation of the screens, there is little concern for human health. In addition, there should be no risk of turbidity events that could trigger the need to construct a water filtration plant.

Potential for increase in fecal coliform and other pathogens from herbivorous mammals as a result of forest management upstream of Landsburg would be reduced by the establishment of Reserve stream buffers and SMAs, as under the No Action Alternative.

Concurrent with anadromous fish mitigation, an extensive water quality monitoring program would be implemented, tailored to parameters of concern regarding salmon carcasses. SPU would have the option of restricting spawning if it appears to be degrading water quality to unacceptable levels.

Water quality downstream of Landsburg Diversion

The addition of up to 260,000 returning sockeye to the lower Cedar River could result in significant increases in phosphorous and TOC, as indicated by the Taylor Creek study (Ebasco Services, 1988). However, the Cedar River below Landsburg is not used as a source of drinking water. Since the main concern of TOC is related to the DBPs created during drinking water treatment, there would be no adverse effect, because this surface water is not treated for human use.

Phosphorous loading in the lower Cedar River could be a concern because of the link between phosphorus and algal blooms (CH2M HILL, 1996; Walher, 1983). However, because salmon carcasses would be decaying primarily during the winter-early spring months, there would be less chance of algal blooms, because of cooler weather. Furthermore, an increase in phosphorous loading during the winter months could be a positive effect; several studies in the Lake Tahoe basin (Richey et al., 1975; Goldman, 1970; Goldman, 1974) have shown that decaying land-locked salmon contribute to maintaining fertility of fish-rearing habitat, and similar benefits occur as anadromous salmon import nutrients from the marine environment into the freshwater environment (Bilby et al., 1996).

Down-sized Sockeye Hatchery Alternative with Savings Going Towards Downstream Habitat Restoration (AFM-3)

Because fish passage measures are the same as for the Proposed HCP Alternative (AFM-2), the effects of alternative AFM-3 on water quality upstream of Landsburg would be similar to those under the Proposed HCP Alternative. Because a combination of reduced hatchery fish production and habitat improvements would be used, it is difficult to predict what actual run sizes (thus water quality effects) would be downstream of Landsburg (for a more detailed discussion, see Section 4.4.2). However, given the timing of spawning, as discussed above, effects of spawning are likely to be limited to an increase in nutrients, which may be beneficial for many species.

Deferred Hatchery Construction Alternative Contingent on Evaluation of More Information (AFM-4)

Because fish passage measures are the same as for the Proposed HCP Alternative (AFM-2), the effects of alternative AFM-4 on water quality upstream of Landsburg would be similar to those under the Proposed HCP Alternative. This alternative presents the possibility of many different scenarios in the future regarding downstream water quality. While the means of fish production would be achieved through a combination of downstream habitat enhancement and hatchery production, the effects on water quality would be similar to those under the Proposed HCP Alternative. This is primarily because while the actual number of fish may vary, the overriding factor is the timing of spawning and the downstream water uses. Because

spawning would occur in the cooler months of the year, the likelihood of algal blooms would be small. Pathogens associated with salmon carcass scavengers would be of minimal concern, because there are no water supply intakes below Landsburg.

All Downstream Habitat Restoration and Protection Alternative (AFM-5)

Because fish passage measures are the same as for the Proposed HCP Alternative (AFM-2), the effects of alternative AFM-5 on water quality upstream of Landsburg would be similar to those under the Proposed HCP Alternative. Under this alternative no hatchery would be constructed, and the hatchery funding would be used to construct, maintain, and monitor downstream habitat restoration and protection projects. Under this alternative, there might be minor, but not significant, effects on water quality. Spawning could occur at greater levels than occur now, but spawning would take place during the cooler months of the year, which would minimize potential algal blooms. There would be no hatchery discharge to contribute nutrients over background levels related to natural fish production, but the habitat enhancements would have a similar effect ultimately, as with the other alternatives.

There are approximately 30 instream construction projects that could be funded under this alternative. These projects would be permitted under a series of Hydraulic Project Approvals, to be issued by the WDFW. Construction effects of these projects would be reviewed by WDFW, and any potential negative effects would have either mitigation requirements or be deemed acceptable by WDFW. With fewer of potential habitat projects in the other alternatives, the other alternatives would have the potential for less impact during construction.

4.2.3 Instream Flow Alternatives

Water Quantity

Impact Mechanisms

Much analysis of the effects of instream flow alteration has been done as part of the instream flow negotiations. The reasons behind the proposed flows, and their effects on aquatic life are discussed in detail in Section 4.4, Fisheries Habitat and Resources. Figure 4.2-2 shows streamflow statistics for the Cedar River at Renton as measured by USGS Stream Gage No. 12119000, and includes the 1979 normal minimum instream flow regime and the proposed HCP instream flow regime for reference.

This section will briefly discuss the potential effects on the channel itself. The primary concern is the effect of project operations on sediment transport and floodplains. These impact mechanisms are briefly summarized below:

Sediment transport	Flow diversions can affect sediment transport in the bypass (if flow is returned downstream) or downstream reach (if flow is not returned). With less stream power, sediment can accumulate, or aggrade. Below dams, increased stream power often results in coarsening of the streambed, which can effect fish habitat.
Floodplains	Floodplains can be affected by changes in the flood flows. A reduction in the flood volume and/or timing can cause aggradation (sediment deposition), which tends to make the floodplain more widespread, If a river has a limited sediment supply, the floodplain width can decrease downstream of a diversion, as the vegetation encroaches on the stream channel.

The proposed construction of fish passage and hatchery facilities calls for extensive alteration of the floodplain at Landsburg. Effects from this construction are discussed in the EIS for the activities at Landsburg.

Effects of the Alternatives

No Action Alternative (IF-1)

Under this alternative, there would be no significant change in sediment transporting flows (i.e., flood flows) from existing conditions. Although there is some indication that operations have affected the floodplain of the lower Cedar River in the past, continued operation under current instream flows would not be expected to affect sediment transport or floodplains.

Because Chester Morse Lake is on the site of a natural lake, and the reach downstream of the lake is a bedrock canyon, neither streambed degradation nor

Figure 4.2-2. Cedar River at Renton, Washington - Streamflow Statistics

armoring can occur downstream of Masonry Dam. In addition, the Landsburg diversion is a low diversion which does not trap significant amounts of sediment. Sediment that does build up behind the diversion dam is flushed downstream yearly. Therefore, continued operation of the dam and diversion under the No Action Alternative would not cause degradation or stream armoring at Cedar Falls. Reductions in flow may affect sediment transport because decreases in the available stream power may result in aggradation. However, in the case of the Landsburg Dam, diversions are halted during peak flow events to protect drinking water quality. Even if diversions were not curtailed during peak flow events, they would represent a relatively minor proportion of total stream flow.

Most of the work that forms and maintains channel form and shape in gravel-bedded streams such the Cedar River is done during large storm events. In western Washington, these have been estimated as occurring roughly every 1.5 years (Booth, 1989). The flood frequency table for the Cedar River as measured at the USGS Stream Gage No. 12117500, located above Landsburg at river mile 23.4, is shown in Table 4.2-1. IF-1 would not alter current flood management practices and therefore would have no effect on peak flow frequency, sediment transport, channel morphology, or floodplain configuration.

Table 4.2-1. Flood Frequency Table for Cedar River as measured at the USGS Stream Gage No. 12117500, located above Landsburg at river mile 23.4 (Raytheon, 1998)

Return Period (years)	Peak Flow (cfs)
2	2,400
5	3,900
10	5,100
25	7,000
50	8,700
100	10,700
200	13,000
500	16,000
1,000	18,500

Proposed HCP Alternative for Instream Flows (IF-2)

The new instream flow rules contained in the Proposed HCP Alternative are the result of years of analysis and negotiation. They are intended to maintain a reliable supply of high quality water while maintaining beneficial habitat conditions for aquatic life. Streamflows that provide beneficial conditions for aquatic life are typically well below peak flow levels that mobilize sediment and alter the channel and floodplain. Thus, the flow commitments provided by IF-2 are well below the peack flow levels.

As in the No Action Alternative, operations at Masonry Dam would not be changed. Therefore there would be no effects on sediment transport or floodplains below Cedar Falls.

4.2.4 Summary

A summary of environmental consequences for water resources is presented in Table 4.2-2. These consequences are summarized here individually for each of the Watershed Management, Anadromous Fish Mitigation, and Instream Flow Alternatives.

No Action Alternative for Watershed Management (WM-1)

This alternative could cause streambed scour in some of the subbasins because of increased peak flows. However, roads would not contribute to increased peak flows.

Suspended sediment and turbidity could be affected by log truck traffic in the Taylor Creek Watershed; however, most of the Cedar River Municipal Watershed would have minimal effects. There would be minimal effects on stream temperature, and no effects over the long term.

Proposed HCP Alternative for Watershed Management (WM-2), Long-term Sustainable Thinning Alternative (WM-3), Thinning Alternative with Phased Out Commercial Timber Harvest (WM-4)

Because hydrologic maturity would be more protected than under the No Action Alternative, this alternative would have minimal effects on peak flows. Roads would not contribute to increased peak flows.

There would be minimal effects on suspended sediment, turbidity, or stream temperature, and no effects over the long-term.

No Commercial Timber Harvest Alternative (WM-5)

There would be no effect on ROS peak flows, and roads would not contribute to increased peak flows.

There would be minimal effects on suspended sediment, turbidity, or stream temperature, and no effects over the long-term.

No Action Alternative (AFM-1)

Because there would be no passage of salmon above the Landsburg Diversion, there would be no effects to drinking water quality with regard to nutrients, TOC/DBPs, or pathogens.

Proposed HCP Alternative for Anadromous Fish Mitigation (AFM-2)

No significant effect on drinking water quality would be expected under this alternative. An assessment has shown that the number of potential fish that would be allowed to spawn above Landsburg would be too low to cause water quality problems; monitoring would occur to establish that no drinking water problems exist; and the Applicant would have the authority to reduce fish passage if any adverse conditions developed. Construction of the fish screen would not occur while the raw water regulatory compliance point was still at Landsburg, and thus there would be no risk of turbidity events during construction or operation of the screens that might constitute a risk to human health. Effects of water quality downstream of Landsburg are also expected to be minimal. Although there would be an increased chance of algal blooms in the Cedar River, this would occur during the wet season, and would not have significant effects.

Down-sized Sockeye Hatchery Alternative with Savings Going Towards Downstream Habitat Restoration (AFM-3)

Upstream of Landsburg, the effects of this alternative on drinking water quality would be similar to those under the Proposed HCP Alternative, and would be minimal. Downstream of Landsburg, there would a somewhat diminished risk of algal blooms, relative to the Proposed HCP Alternative, which is not expected to have significant effects.

Deferred Hatchery Construction Alternative Contingent on Evaluation of More Information (AFM-4)

This alternative presents a wide array of options for enhancing sockeye salmon runs. Although the hatchery size, and thus production, could be smaller by some (as yet undetermined) amount, the enhancement projects built downstream could increase fish production separately. The effects on downstream water quality would be similar to, or less than, those under the Proposed HCP Alternative, because the main factor influencing nutrient impact is the timing of carcass build up in the river, as discussed above.

All Downstream Habitat Restoration and Protection Alternative (AFM-5)

The effects of alternative AFM-5 on water quality upstream of Landsburg would be similar to those under the Proposed HCP Alternative. Under this alternative no hatchery would be constructed, and the hatchery funding would be used to construct, maintain, and monitor downstream habitat restoration and protection projects. Increased spawning downstream of Landsburg would be expected to have a minimal effect on water quality. No significant adverse effects of the higher number of fish habitat restoration projects are anticipated, because each project would be permitted under a Hydraulic Project Approval and any potentially negative effects would require mitigation or deemed acceptable by the regulatory agency.

No Action Alternative (IF-1)

Under this alternative, there would be no significant effects on sediment transport or floodplains. The operation of Masonry Dam would not cause modification of the channel downstream, because the downstream reach is underlain by resistant bedrock. Existing modifications to the floodplain downstream of Landsburg confined the channel and have altered the floodplain beyond the level attributable to flow diversions.

Proposed HCP Alternative for Instream Flows (IF-2)

There would be no significant effects to sediment transport or floodplains under this alternative. As under the No Action Alternative, operations at Masonry Dam would not affect sediment transport or floodplains.

Table 4.2-2 Summary of Environmental Consequences Evaluated for Water Resources (page 1 of 4)

Potential Impact Evaluated	Environmental Consequences					Comments
	Watershed Management Alternatives					
	WM-1	WM-2	WM-3	WM-4	WM-5	
Potential effects on peak flows from timber harvesting activities	Negative Effects	Negligible Effects	No Effects	No Effects	No Effects	Overall, there is not expected to be much impact on peak flows from timber harvesting or other silvicultural activities as part of any of the Watershed Management alternatives. However, negative effects may occur under the No Action Alternative, WM-1, if timber harvesting were to occur in subbasins with increases in peak flows above current conditions. These increases in peak flows could potentially cause streambed scour, streambank erosion and channel incision resulting in localized degradation of fisheries habitat. Drinking water quality would not be affected from these potential increases in peak flows under WM-1. Potential effects on peak flows under the proposed HCP alternative, WM-2, are considered negligible because of the proposed retention harvests and implementation of watershed assessment prescriptions. No effects on peak flows are expected from alternatives WM-3 and WM-4, which involve thinning applications. No commercial timber harvest is proposed under WM-5.
Potential effects on peak flows from changes in road density	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Effects on peak flows from changes in road density are expected to be negligible for all alternatives. For all alternatives except WM-5, it is estimated that 10 miles of new road will be built. This number is small in comparison to existing road densities. In addition, all of the alternatives except WM-1 have funding commitments for road decommissioning which would offset any new construction by reducing road densities.

Table 4.2-2 Summary of Environmental Consequences Evaluated for Water Resources (page 2 of 4)

Potential Impact Evaluated	Environmental Consequences					Comments
	Watershed Management Alternatives (cont.)					
	WM-1	WM-2	WM-3	WM-4	WM-5	
Potential for increasing levels of turbidity and suspended sediment	Negligible Effects	No Effects	No Effects	No Effects	No Effects	Suspended sediment and turbidity levels could be affected under WM-1 because of log traffic in the Taylor Creek subbasin. None of the other Watershed Management alternatives are expected to have an effect on turbidity and suspended sediment because of the large stream buffers included as part of the ecological reserves and the relatively low level of timber harvest activity for each alternative.
Potential effects on water temperatures	No Effects	No Effects	No Effects	No Effects	No Effects	None of the Watershed Management alternatives are expected to have an effect on water temperatures because of the large stream buffers included as part of the ecological reserves for each alternative.
Potential for increasing pathogen loading	No Effects	No Effects	No Effects	No Effects	No Effects	None of the Watershed Management alternatives are expected to increase pathogen levels because of the large stream buffers included as part of the ecological reserves for each alternative.

Table 4.2-2 Summary of Environmental Consequences Evaluated for Water Resources (page 3 of 4)

Potential Impact Evaluated	Environmental Consequences					Comments
	Anadromous Fish Mitigation Alternatives					
	AFM-1	AFM-2	AFM-3	AFM-4	AFM-5	
Potential effects on drinking water quality caused by decaying salmon carcasses occurring from the passage of chinook salmon, coho salmon, and steelhead trout over the Landsburg Diversion Dam	Unknown	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	It is possible that decaying salmon carcasses resulting from the passage of chinook, coho, and steelhead could increase levels of nutrients, organic carbon and pathogens in the water column. The potential environmental consequences are unknown for the No Action Alternative (AFM-1) because the timing of passage, if provided at all under this alternative, is uncertain. Fish passage would be provided as part of all other anadromous fish mitigation alternatives. Effects on water quality from the attraction of scavengers is expected to be negligible due to the relatively small number of fish that would be passed above the diversion dam. Monitoring will be implemented to ensure that drinking water quality is not compromised.
Potential effects on drinking water from pathogens introduced by the attraction of scavengers, such as bear, mink or raccoon, to the mainstream of the Cedar River from the passage of chinook salmon, coho salmon, and steelhead trout over the Landsburg Diversion Dam	Unknown	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	It is possible that scavengers will be attracted to the mainstream of the Cedar River from decaying salmon carcasses resulting from the passage of chinook, coho, and steelhead. The potential environmental consequences are unknown for the No Action Alternative (AFM-1) because the timing of passage, if provided at all under this alternative, is uncertain. Fish passage would be provided as part of all other anadromous fish mitigation alternatives. Effects on water quality from the attraction of scavengers is expected to be negligible. Monitoring will be implemented to ensure that drinking water quality is not compromised.

Table 4.2-2 Summary of Environmental Consequences Evaluated for Water Resources (page 4 of 4)

Potential Impact Evaluated	Environmental Consequences					Comments
Potential Impact Evaluated	**Environmental Consequences**					**Comments**
Anadromous Fish Mitigation Alternatives (cont.)						
	AFM-1	**AFM-2**	**AFM-3**	**AFM-4**	**AFM-5**	
Potential effects on water quality downstream of Landsburg from discharges from hatchery operations	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Nutrient loadings from hatchery discharges containing metabolites is expected to be minimal. Permits required for hatchery operations would limit nutrient loading below deleterious levels. Effects are unknown for Alternative AFM-1 because the timing of hatchery construction, if it occurs at all under this alternative, is uncertain. Effects on water quality from hatchery operations are considered negligible for alternatives AFM-2, AFM-3, and AFM-4. Hatchery facilities would not be operated under Alternative AFM-5.
Potential effects on water quality from the construction of fish passage facilities, fish screening facilities, the hatchery facility, or downstream habitat restoration projects	Unknown	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	The potential exists for temporary localized sedimentation during the construction of fish facilities at Landsburg and also downstream habitat restoration projects. Effects on water quality are expected to be minimal. Regardless, permitting requirements at the time of construction are expected to mitigate for any potential effect.
Instream Flow Alternatives						
	IF-1			**IF-2**		
Potential effects on water quality from the instream flow alternatives	No Effects			No Effects		No effect on water quality is expected from implementation of either instream flow alternative.
Potential effects on peak flow frequency, sediment transport or on floodplains	No Effects			No Effects		No effects on peak flow frequency, sediment transport or on floodplains are expected from the two instream flow alternatives. Collaborative instream flow studies demonstrate that bedland mobilization begins to occur at approximately 2000 cfs, a flow level well above those provided by the two flow regimes. The frequency of flow events that will mobilize bedload and alter channel morphology (i.e., greater than 2000 cfs) is not expected to be affected by either alternative.

Table 4.4-6 Summary of Environmental Consequences Evaluated for Fisheries Habitat and Resources (page 1 of 10)

Potential Impact Evaluated	Environmental Consequences					Comments
	Watershed Management Alternatives					
	WM-1	WM-2	WM-3	WM-4	WM-5	
Potential effects on resident fisheries resources from timber harvesting within the Cedar River Municipal Watershed	Unknown Effects	Positive Effects	Positive Effects	Positive Effects	Positive Effects	In general, the large reserve areas with extensive stream buffers found as part of every alternative are expected to provide a great deal of protection to fisheries resources. Localized sedimentation within the Taylor subbasin could have a slight effect on fisheries resources depending on deliverability.
Potential effects on resident fisheries resources from road maintenance and decommissioning	Unknown Effects	Positive Effects	Positive Effects	Positive Effects	Positive Effects	The road maintenance and decommissioning activities proposed for every alternative are expected to provide a positive effect on fisheries resources. The effects for WM-1 are listed as unknown because funding for road maintenance and decommissioning under the No Action Alternative is uncertain.
Potential effects on resident fisheries resources from stream and riparian restoration projects (large woody debris placement, stream bank armoring, stream bank revegetation, etc.)	No Effects	Positive Effects	Positive Effects	Positive Effects	Positive Effects	Stream and riparian restoration projects (large woody debris placement, stream bank armoring, stream bank re-vegetation, etc.) are expected to have a positive effect on fisheries resources for alternatives WM-2, WM-3, WM-4 and WM-5. These projects are not proposed as part of WM-1, the No Action Alternative.

Table 4.4-6 Summary of Environmental Consequences Evaluated for Fisheries Habitat and Resources (page 2 of 10)

Potential Impact Evaluated	Environmental Consequences					Comments
	Anadromous Fish Mitigation Alternatives					
	AFM-1	AFM-2	AFM-3	AFM-4	AFM-5	
Effects on current runs of chinook, coho, and steelhead	Unknown Effects	Positive Effects	Positive Effects	Positive Effects	Positive Effects	Chinook and coho salmon, and steelhead trout will gain access to available spawning habitat through passage over the Landsburg Diversion Dam under alternatives AFM-2, AFM-3, AFM-4, and AFM-5. The effects from AFM are unknown because it is not certain that passage would be provided under the No Action Alternative.
Effects on genetics and domestication of sockeye salmon in the Cedar River	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Fish produced by the interim and replacement hatcheries are intended to be genetically, physiologically, behaviorally, and ecologically similar to those produced naturally and cannot be distinguished by appearance from naturally reproducing fish. Because the sockeye stocks in Lake Washington managed as a single stock, there are risks of domestication to the Cedar River stock. Risks of domestication are considered to be negligible or low, because the primary objective of the sockeye hatchery program is to minimize domestication effects; changes in genetics, fish characteristics, and return rates will be monitored; the hatchery will be operated adaptively to minimize such impacts; and the hatchery program can be abandoned by agreement of the parties to the Landsburg Mitigation Agreement if such problems cannot be solved.

Table 4.4-6 Summary of Environmental Consequences Evaluated for Fisheries Habitat and Resources (page 3 of 10)

Potential Impact Evaluated	Environmental Consequences					Comments
	Anadromous Fish Mitigation Alternatives (cont.)					
	AFM-1	AFM-2	AFM-3	AFM-4	AFM-5	
Effects of disease on sockeye	Positive Effects	Positive Effects	Positive Effects	Positive Effects	Negligible Effects	The production of IHN-free sockeye fry in the hatchery, plus the concept of a composite population, has the potential to reduce the incidence of IHN infection throughout the watershed. It is possible that IHN could build up in groundwater-fed side channels, which are not flushed by storm flows, but this risk is considered negligible for the population as a whole.
Effects of straying to naturally reproducing fish stocks	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Unknown Effects	The available evidence from Hendry et al. (1996) suggests that no substantial introgression has occurred to date between Cedar River and the naturally reproducing stocks in Bear and Cottage Creeks. The effects of straying on non-Cedar sockeye stocks in the basin are expected to be negligible, because straying will be monitored; procedures for detecting and minimizing impacts will be followed; and hatchery operations will be altered too if such problems occur. Because sockeye produced from the Cedar River by habitat restoration will not be otolith-marked, and their straying cannot be easily monitored, effects of increased production from the Cedar by natural means are not known.
Effects of sockeye harvest on naturally reproducing stocks	Negligible Effects	Uncertain Effects	Uncertain Effects	Uncertain Effects	Uncertain Effects	According to the Wild Salmonid Policy, enhanced production that could lead to increased harvest might negatively effect native stocks. This was noted to be especially true for systems such as the Lake Washington System where all anadromous stocks are already depressed. Overall, it is expected the negative effects of harvest to naturally reproducing stocks will be minimized as a result of the implementation of an

Table 4.4-6 Summary of Environmental Consequences Evaluated for Fisheries Habitat and Resources (page 4 of 10)

Potential Impact Evaluated	Environmental Consequences					Comments
						appropriate
	Anadromous Fish Mitigation Alternatives (cont.)					
	AFM-1	AFM-2	AFM-3	AFM-4	AFM-5	
						harvest management strategy by WDFW and the Muckleshoot Indian Tribe, including monitoring during and after the sport harvest. In addition, evidence suggests that harvest of stocks from the north end of Lake Washington can be segregated from harvest of Cedar River stock by restricting timing and site of allowed fishing in the lake.
Competition with naturally reproducing fish for limited resources above Landsburg	No Effects	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	After passage of chinook, coho, and steelhead above the Landsburg Diversion Dam, competition can be expected to occur with cutthroat and rainbow trout. The magnitude of these effects is unknown. However, because these three anadromous species were present historically in the reach above Landsburg before the diversion dam was constructed, the effects on resident trout, and other native fish in this area of the watershed, are considered to be acceptable. The potential effects are considered negligible because providing passage would restore fish communities closer to their natural structure before Landsburg was constructed.
Effect of broodstock collection practices on reproductive success of naturally reproducing salmonids	Neglible Effects	Negligible Effects	Negligible Effects	Negligible Effects	No Effects	The sockeye broodstock collection program has two primary objectives: i) to capture an adequate number of adult sockeye salmon in a manner that provides a representative subset of the entire Cedar River sockeye population and ii) to avoid and minimize any impacts the program may have on naturally reproducing salmonids in the Cedar River. The City believes that the potential risks associated with installation, operation, and

Table 4.4-6 Summary of Environmental Consequences Evaluated for Fisheries Habitat and Resources (page 5 of 10)

Potential Impact Evaluated	Environmental Consequences					Comments
						removal of interim and long-term broodstock
	Anadromous Fish Mitigation Alternatives (cont.)					
	AFM-1	AFM-2	AFM-3	AFM-4	AFM-5	
						collection facilities can be minimized and avoided through the development of rigorous broodstock collection protocol and implementation of improved broodstock collection practices beginning in Year 1 of the HCP. The design and implementation of sockeye broodstock collection facilities and practices will be addressed during the development of sockeye mitigation program guidelines in Year 1 of the HCP. Under AFM-2, AFM-3, or AFM-4, ongoing evaluation, analyses and design activities will determine the precise method of broodstock collection for the final sockeye fry production program. Interim and long-term broodstock collection facilities will be designed and operated in a manner that avoids and minimizes potential negative impacts on naturally reproducing fish in the Cedar River. Specific aspects of the long-term broodstock collection program will be further addressed during project specific environmental review prior to initiating construction of a final facility.

Table 4.4-6 Summary of Environmental Consequences Evaluated for Fisheries Habitat and Resources (page 6 of 10)

Potential Impact Evaluated	Environmental Consequences					Comments
	Anadromous Fish Mitigation Alternatives (cont.)					
	AFM-1	AFM-2	AFM-3	AFM-4	AFM-5	
Competition with naturally reproducing fish for limited resources below Landsburg	Unknown Effects	Unknown Effects	Unknown Effects	Unknown Effects	Unknown Effects	Any measures, artificial production facility or habitat improvements, that increase production of sockeye could lead to increased competition with naturally reproducing stocks in the basin. An important assumption implicit to the hatchery proposal is that sockeye fry from the hatchery will not limit naturally reproduced fry production from the Cedar River or the northern Lake Washington tributaries through competition for resources (e.g., space or food) in the lake. Ongoing and proposed investigations are designed to test this assumption and are an important component to the adaptive management strategy pursued in the HCP.
Other ecological effects of increased sockeye production on other salmonid species	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Waples (1998) has suggested that spawning female sockeye could affect the redds (nests) of other species (by excavating), and that sockeye could transfer diseases to other species. Note that the potential for these effects is independent of the kind of measures used to increase production of sockeye. Because hatchery produced fish are expected to be more disease-free than naturally produced fish, there is little risk of disease transfer as a result of the artificial production program. The effects of spawning competition from increased sockeye are expected to be negligible, because harvest is expected to keep sockeye populations within escapement goals; steelhead and many coho spawn after sockeye; chinook are aggressive at redds, and are much larger than sockeye; and chinook mostly spawn in deeper water than sockeye, and place their eggs deeper in the gravel than sockeye.

Table 4.4-6 Summary of Environmental Consequences Evaluated for Fisheries Habitat and Resources (page 7 of 10)

Potential Impact Evaluated	Environmental Consequences					Comments
	Anadromous Fish Mitigation Alternatives (cont.)					
	AFM-1	**AFM-2**	**AFM-3**	**AFM-4**	**AFM-5**	
Effects on egg-to-fry survival in sockeye	No Effects	Positive Effects	Positive Effects	Positive Effects	Positive Effects	The natural mortality of incubating eggs in the gravel can be considerable. Egg-to-fry sockeye survival rates are typically below 20 percent and averaged near 10.5 percent for six Alaska populations reported by Foerster (1968), but can be substantially higher or lower in a given year or river. In contrast, egg-to-fry survival within a hatchery can exceed 90 percent. Because redds in groundwater-fed side channels will be protected from flood flows, egg-to-fry survival can be also expected to be relatively higher than in the mainstem of the Cedar River.
	Instream Flow Alternatives					
	IF-1			**IF-2**		
Instream Flows Below the Landsburg Division Dam						
Salmon spawning flows in the fall and winter	Positive and Negative Effects			Positive Effects		Target species are sockeye and chinook spawning. During this period WUA is higher or flows are higher than IF-1. Cumulative habitat and edge habitat for sockeye spawning is greater than in IF-1.
Salmon incubation flows in the winter and spring	Positive and Negative Effects			Positive Effects		Target species chinook, sockeye, and coho. Based on the effective spawning analysis IF-2 flows remain elevated to ensure that most of the available spawning area remains inundated until emergence.
Sockeye outmigration flows in the spring	Negative Effects			Positive Effects		IF-2 contains provisions for 40% higher minimum flows at least 70% of the time during the peak of sockeye outmigration.

Table 4.4-6 Summary of Environmental Consequences Evaluated for Fisheries Habitat and Resources (page 8 of 10)

Potential Impact Evaluated	Environmental Consequences		Comments
	Instream Flow Alternatives (cont.)		
	IF-1	IF-2	
Chinook rearing and outmigration flows in the spring	Uncertain	Uncertain	IF-2 provides up to 213 cfs more flow than the IF-1 during this period to benefit sockeye outmigration. Chinook outmigration may be benefited under IF-2. As a consequence of higher flows, chinook rearing WUA is diminished under the IF-2.
Supplemental Steelhead spawning and incubation flows in the spring and summer with option to recover water by using temporary pumps or by reducing instream flows	Negative Effects	Positive and Negative Effects	From early March through mid-May, higher flows under IF-2 reduce WUA for steelhead spawning. After mid-May, IF-2 flows provide more WUA for steelhead spawning and reduce the risk of subsequent redd stranding. For steelhead incubation, IF-2 provides an additional block of water to be allocated as directed by the Commission in normal years when the need exists for increased steelhead incubation protection.
Instream Flows Below the Landsburg Diversion Dam			
Steelhead and coho rearing flows year round	Positive Effects	Positive Effects	Under IF-2, WUA or instream flows are equal to or greater than IF-1.
Instream Flows Upstream of Landsburg Diversion Dam			
Landsburg to Lower Cedar Falls	No Effects	Positive Effects	IF-2 flows or WUA are equal to or greater than that under IF-1.
Lower Cedar Falls to Masonry Dam	Negative Effects	Positive Effects	IF-2 provides a minimum flow through this reach for resident trout and rearing salmon and steelhead whereas IF-1 does not.
Reservoir fish populations potentially impacted by reservoir operations	Negligible Effects	Negligible Effects	The minor changes in reservoir pool elevations necessary to meet the IF-2 flow commitments will have negligible effects on bull trout and pigmy whitefish habitat.

Table 4.4-6 Summary of Environmental Consequences Evaluated for Fisheries Habitat and Resources (page 9 of 10)

Potential Impact Evaluated	Environmental Consequences		Comments
	Instream Flow Alternatives (cont.)		
	IF-1	IF-2	
Additional Flow Management Provisions			
Oversight of instream flow management	Does Not Apply	Positive Effects	Commission monitoring of instream flows and certain instream flow related studies of the HCP will assure that the full effect of SPU's flow commitments are realized by Cedar River fish populations.
Juvenile and fry stranding	Negative Effects	Positive Effects	Under IF-2 ramping rates will protect against stranding of fry and juveniles throughout the Cedar River below Masonry Pool. Under IF-1 there are no ramping rate requirements.
Additional Flow Management Provisions			
Relocating compliance point	Does Not Apply	Positive Effects	Under IF-1 the measurement point at Landsburg will improve SPU's ability to reregulate and meet instream flows throughout the lower Cedar River.
New criteria and procedures for switching	Does Not Apply	Positive Effects	New switching criteria and procedures will help ensure that critical instream flow regimes are implemented only when warranted.
Flow management during favorable hydrologic conditions	Does Not Apply	Positive Effects	Supplemental flows under IF-2 will provide additional biological benefits for anadromous fish that are not provided under IF-1.

Table 4.4-6 Summary of Environmental Consequences Evaluated for Fisheries Habitat and Resources (page 10 of 10)

Potential Impact Evaluated	Environmental Consequences		Comments
	Instream Flow Alternatives (cont.)		
	IF-1	IF-2	
Emergency flow continuation at Cedar Falls powerhouse	Negative Effects	Positive Effect	Under IF-2, installation of flow continuation capabilities at Cedar Falls powerhouse will reduce the impacts of rapid flow fluctuations on aquatic resources downstream.
Water conservation program	Positive Effects	Positive Effect	An addition of $30,000 would go towards the City's current conservation program.
Use of Cedar dead storage on a permanent basis for instream flows and water supply	No Effects	Negative Effect	Under IF-2 the SPU will investigate the feasibility of reliable options for utilizing water stored below the natural gravity outlet of Chester Morse Lake. Potential benefits exist for augmentation of both stream flows for anadromous fish and water supply from this source. Potential small negative effects on bull trout, pigmy whitefish, and loons.
Additional Flow Management Provisions			
Improve passage and water efficiency at the Chittenden Locks	No Effects	Positive Effect	Under IF-2 the applicant proposes to provide up to $625,000 toward the estimated costs of improving fish passage at the locks. The applicant also proposes to provide up to $1.25 million for improvements to the salt-water drain at the locks. Both these initiatives will benefit fisheries resources in the Cedar River as well as in the Lake Washington Basin.

4.3 Forest Resources

4.3.1 Introduction

The following section describes the environmental consequences on the forest resources within the Watershed with respect to the Watershed Management Alternatives. The effects on successional stages, commercial timber volumes, rare plants, and noxious weeds are discussed for each alternative. The Anadromous Fish Mitigation alternatives will generally not affect forest resources. Hatchery construction near Landsburg will convert a small area of trees to buildings, roads, and parking areas. These effects are discussed in detail in the separate EIS dealing with Landsburg Diversion construction. The Instream Flow alternatives are related to minimum instream flows in the Cedar River below Landsburg Diversion and will have no effect on forest resources.

This section uses a forest growth and yield model to estimate both future timber harvest and future successional stage conditions within the Watershed. It also discusses how the proposed management activities influence the vegetative or successional stage conditions both inside and outside the Reserve. The timber volumes that would be expected from timber harvest under Alternatives WM-1 to WM-4 are also presented. The successional stages that occur at years 2000, 2020, and 2050 that are described in this section provide wildlife habitat that is discussed in Section 4.5 Wildlife Resources. Similarly, the timber volumes that that are described in this section provide the basis for the revenue estimates and socioeconomic effects that are discussed in Section 4.10 Socioeconomics.

4.3.2 Vegetation Modeling Assumptions and Limitations Common to All Alternatives

To assess future timber stand and wildlife habitat conditions and to predict costs and revenues associated with each alternative, a regionally developed and validated tree growth and yield model called a Forest Projection System (FPS) (Arney, 1997) was used in coordination with the Watershed's GIS

database. This allows the model to "grow" the trees while the GIS shows their distribution on the landscape decades into the future. For an in-depth discussion of the use of the FPS model to portray the Watershed over time and the limitations placed on it (City of Seattle, 1998).

The estimation of future yields from regenerated stands is important for developing the estimates of potentially available timber resources in the future. The FPS harvest scheduler simulates the various timber harvest regimes associated with each of the alternatives into the future. Harvest levels can be set to optimize yields or they can be regulated by various constraints such as rotation age, maximum number of acres harvested, or ROS limitations.

The FPS operates with numerous constraints as it calculates solutions that satisfy the objectives of each alternative. These constraints track retention levels, stand conditions, when to thin, how much to thin, stand age, stocking in the ROS and snow zones, and breakage and defect in the trees. Table 4.3-1 summarizes the constraints that were applied to management of the commercial zone for each alternative. Where possible, these modeling constraints were developed to reflect the management constraints that would be applied on the ground during harvest under any one of the Watershed Management Alternatives. Please note that a 40-acre maximum was used in the projections rather than the 120-acre maximum allowed under the proposed HCP guidelines because it is the Applicant's intent to limit the size of retention harvest units to generally less than 120 acres. It was decided that the 40 acre maximum provided a more realistic representation of what would actually happen on average across the landscape under the proposed HCP Alternative (WM-2). However, the 120-acre maximum being proposed could be applied if the effects were determined to be ecologically or silviculturally beneficial while having no negative impacts on water quality.

4.3.3 Effects on Successional Stages and Commercial Timber Volumes

No Action Alternative for Watershed Management (WM-1)

Under the No Action Alternative, a core forested Reserve of 51,657 acres (58 percent of the Watershed) would be established and the remaining 36,806 acres (42 percent of the Watershed) would be utilized as a commercial timber base. This alternative continues the present management direction established by the Applicant's 1989 Secondary Use Policy (Technical Appendix 12). Commercial timber harvest would consist of regeneration cuts only on an even flow, sustained yield basis. Timber harvest would occur in stands at least 60 years old. The maximum size of regeneration cuts would be 120 acres. Beyond the mapped Reserve elements and buffers outlined in Chapter

Table 4.3-1. Summary of timber harvest modeling constraints by alternative

	WM-1	WM-2	WM-3	WM-4	WM-5
Reserve (Acres)	51,657	56,223	56,223	60,019[1/]	88,328
Commercial Base (Acres)	36,671	32,105	32,105	28,309	NA
Minimum Age for Harvest in Regeneration Cuts	60	60	NA	NA	NA
Tree Retention Levels in Regeneration Cuts (%)[2/]	2	10	NA	NA	NA
Known Riparian zones & Wetlands (%)[2/]	0	0	0	0	NA
Unmapped Riparian zones & wetlands (%)[2/]	0[3/]	5	5	5	NA
Legacies (%)[2/]	0	1	0	NA	NA
Inoperable (%)[2/]	4	4	4	5	NA
Breakage and Defect (% Volume)	Douglas-fir - 2 Red Alder - 10 Other - 6	Douglas-fir - 2 Red Alder - 10 Other - 6	Douglas-fir - 2 Red Alder - 10 Other - 6	Douglas-fir - 2 Red Alder - 10 Other - 6	NA
Max. Harvest Unit Size (Acres)	Regeneration Cut - 120	Retention Cut - 40	None	None	NA
Rotation Ages (Years)	60	1st Rotation - 60 2nd Rotation - Douglas -fir 120 True firs 140 Hardwoods CMAI	NA	NA	NA
Crown Competition Factor (CCF)	NA	300	300	None	NA
Rain-on-Snow Constraint	NO	YES	NO	NO	NA
Special Management Area	YES	YES	YES	YES	NA
Minimum Harvestable Volume for Commercial Thinning (Bf/Ac)	5000	5000	5000	5000	NA
Diameter Limit	NONE	NONE	NONE	21”/24” dbh[4/]	NA

1/ Under Alternative WM-4, all forested acres would become part of the Reserve after 50 years.

2/ Reduction in percent of commercial tree count reflects effect of resource protection by attribute.

3/ Under the No Action Alternative (WM-1), State buffers would apply to all unmapped streams.

4/ Stands whose quadratic mean diameter is at least 21-inch DBH will be removed from the commercial zone and no trees over 24-inch DBH would be cut.

2, timber harvest constraints are limited to Washington State Forest Practices Rules (FPRs) and currently unmapped Reserve elements would be buffered according to FPRs. Within the Reserve, ecological thinning and restoration treatments would not take place as part of this alternative.

In the areas available for timber harvest, a tree retention level of 2 percent (calculated as a tree count reduction in the FPS projections) was used to simulate the minimum number of green trees and wildlife recruitment trees that FPRs require. An additional 4 percent of the harvestable trees in the commercial base was subtracted to reflect the likelihood that there will be some forested areas that are inoperable due to financial or physical constraints, such as unstable slopes or areas too small or inaccessible to harvest economically. No commercial thinning was modeled because of the short rotations.

Under the No Action Alternative (WM-1), as well as Alternatives WM-2 to WM-4, the SMAs would be treated with timber management practices designed to keep canopy cover more than 70 percent. This level of canopy cover would reduce the amount of understory vegetation which would discourage concentrated use by ungulates and other mammal species known to carry human pathogens. The general effects of these management practices on the residual stands in the SMAs would be to create 300 foot to 1 mile buffers or protection zones around sensitive hydrologic areas.

Forest successional stages inside and outside the Reserve and commercial timber harvest acreages and volumes for the five Watershed Management Alternatives are shown in Tables 4.3-2 and 4.3-3, respectively. Inside the Reserve the successional stages are the result of natural tree growth while outside the Reserve they reflect the type and amount of commercial timber harvest activity that occurs. Restoration thinning and ecological thinning that will occur within the Reserve for alternatives WM-2 through WM-4 are not modeled in the FPS; consequently, their effects on stand structure and growth are not reflected in Table 4.3-2.

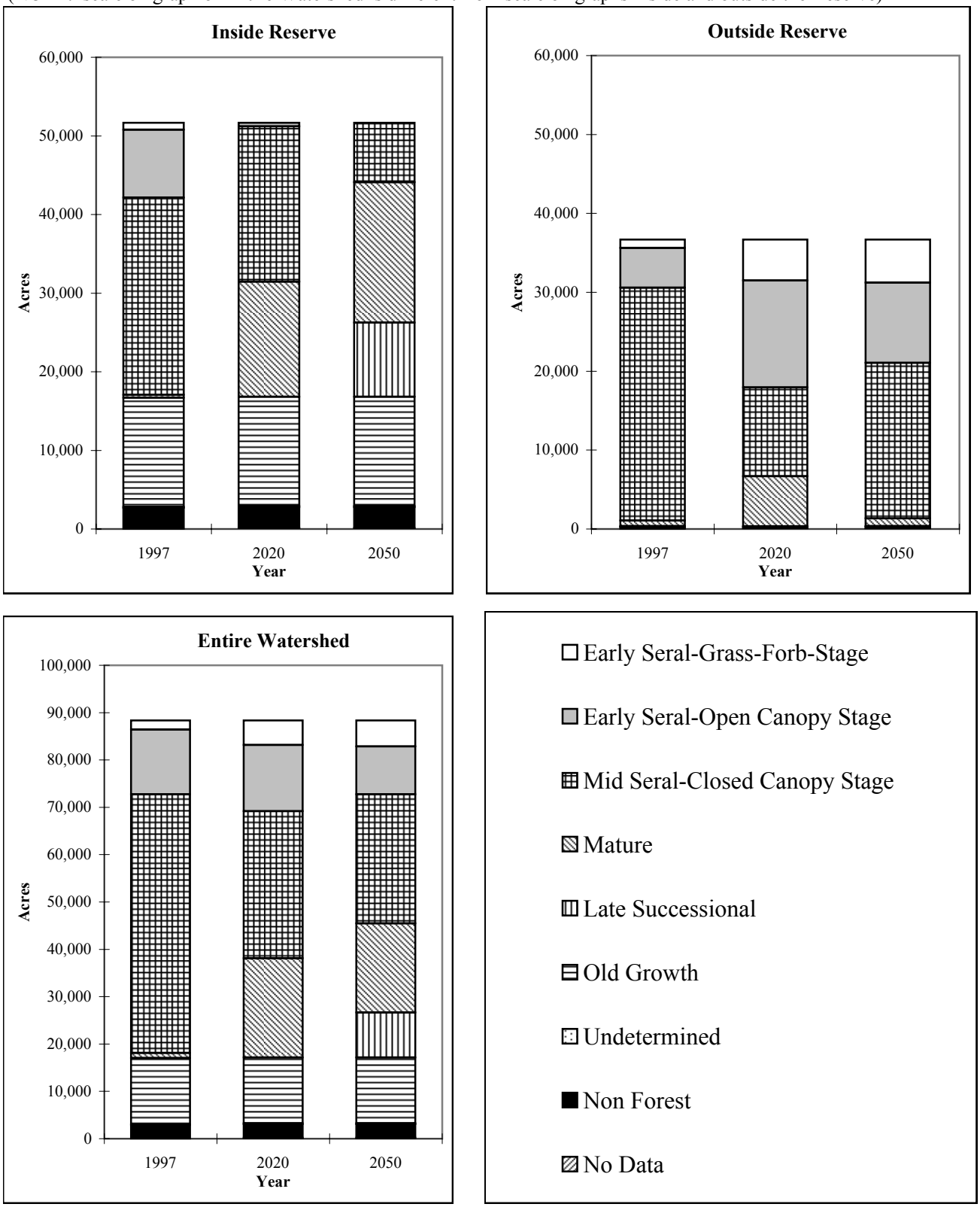
Successional Stages

The successional stages that would result on non-reserve lands from implementation of vegetative management practices under this alternative would result in a mosaic of homogeneous, even-aged stands similar to those present under existing conditions. There would be small numbers of remnant Reserve trees in regeneration units scattered throughout the non-reserve portion the Watershed. The distribution of stand ages would reflect the rotation age of 60 years and maintain the majority of land managed for timber production in early seral and mid seral age classes (See Figure 4.3-1).

At Year 0, Alternative WM-1 would include the following successional stages on non-reserve lands: 6,109 acres of early seral, 29,491 acres of mid seral, 713 acres of mature, and 91 acres of late successional forest (Table 4.3-2).

Figure 4.3-1. Seral stage projections for WM-1

Forest seral stages inside and outside the Reserve for the years 1997, 2020, and 2050, under Alternative WM-1
(NOTE: scale on graph of Entire Watershed is different from scale on graphs inside and outside the Reserve)



G:\WP\1162\SPU\GRAPH97.XLS Figure 4.3-1 7/28/2004

Table 4.3-2. Forest seral stages (in acres) for the years 1997, 2020, and 2050 both inside and outside the Reserve for the Watershed Management Alternatives.

		Alternative WM-1			Alternative WM-2			Alternative WM-3			Alternative WM-4			Alternative WM-5		
	Seral Stage	**1997**	**2020**	**2050**	**1997**	**2020**	**2050**	**1997**	**2020**	**2050**	**1997**	**2020**	**2050**	**1997**	**2020**	**2050**
Inside	Early Seral-Grass-Forb Stage	877	0	0	1,165	0	0	1,165	0	0	1,226	0	0	1,937	0	0
Reserve	Early Seral-Open Canopy Stage	8,624	442	0	9,682	542	0	9,682	579	0	9,757	843	0	13,673	1,164	0
	Mid Seral-Closed Canopy Stage	25,102	19,764	7,544	28,139	22,097	8,599	28,139	22,059	8,716	31,368	26,339	12,331	54,592	34,009	12,331
	Mature	360	14,629	17,861	485	16,686	19,946	485	16,686	19,829	859	31,589	34,933	1,074	35,819	34,933
	Late Successional	0	12	9,442	0	12	10,790	0	12	10,790	54	162	23,918	91	190	23,918
	Old Growth	13,889	13,889	13,889	13,889	13,889	13,889	13,889	13,889	13,889	13,889	13,889	13,889	13,889	13,889	13,889
	Undetermined	151	151	151	193	193	193	193	193	193	193	221	222	222	222	222
	Non Forest	2,655	2,655	2,655	2,670	2,670	2,670	2,670	2,670	2,670	2,672	2,673	2,695	2,855	2,855	2,855
	No Data	0	116	116	0	136	136	0	136	136	0	162	176	0	184	184
Total in Reserve		**51,657**	**51,657**	**51,657**	**56,223**	**56,223**	**56,223**	**56,223**	**56,223**	**56,223**	**60,019**	**75,878**	**88,164**	**88,331**	**88,331**	**88,331**
Outside	Early Seral-Grass-Forb Stage	1,060	5,187	5,456	771	2,456	2,059	771	0	0	711	0	0	0	0	0
Reserve	Early Seral-Open Canopy Stage	5,049	13,551	10,156	3,991	5,520	3,469	3,991	670	0	3,916	321	0	0	0	0
	Mid Seral-Closed Canopy Stage	29,491	11,266	19,725	26,454	11,362	11,107	26,454	11,865	3,842	23,224	7,670	0	0	0	0
	Mature	713	6,332	957	588	12,426	10,718	588	19,133	14,877	214	4,230	0	0	0	0
	Late Successional	91	0	41	91	82	4,493	91	179	13,128	37	28	0	0	0	0
	Undetermined	71	71	71	28	28	28	28	28	28	28	1	0	0	0	0
	Non Forest	200	200	200	184	184	184	184	184	184	182	182	159	0	0	0
	No Data	0	68	68	0	48	48	0	48	48	0	22	8	0	0	0
Total outside Reserve		**36,674**	**36,674**	**36,674**	**32,108**	**32,107**	**32,107**	**32,108**	**32,108**	**32,108**	**28,312**	**12,453**	**167**	**0**	**0**	**0**
Watershed	Early Seral-Grass-Forb Stage	1,937	5,187	5,456	1,937	2,456	2,059	1,937	0	0	1,937	0	0	1,937	0	0
Total	Early Seral-Open Canopy Stage	13,673	13,993	10,156	13,673	6,061	3,469	13,673	1,249	0	13,673	1,164	0	13,673	1,164	0
	Mid Seral-Closed Canopy Stage	54,592	31,029	27,269	54,592	33,458	19,706	54,592	33,924	12,558	54,592	34,009	12,331	54,592	34,009	12,331
	Mature	1,074	20,961	18,818	1,074	29,112	30,664	1,074	35,819	34,706	1,074	35,819	34,933	1,074	35,819	34,933
	Late Successional	91	12	9,483	91	94	15,284	91	190	23,918	91	190	23,918	91	190	23,918
	Old Growth	13,889	13,889	13,889	13,889	13,889	13,889	13,889	13,889	13,889	13,889	13,889	13,889	13,889	13,889	13,889
	Undetermined	222	222	222	222	222	222	222	222	222	222	222	222	222	222	222
	Non Forest	2,855	2,855	2,855	2,855	2,855	2,855	2,855	2,855	2,855	2,855	2,855	2,855	2,855	2,855	2,855
	No Data	0	184	184	0	184	184	0	184	184	0	184	184	0	184	184
	Open Water	2,214	2,214	2,214	2,214	2,214	2,214	2,214	2,214	2,214	2,214	2,214	2,214	2,214	2,214	2,214
Total for the Entire Watershed		**90,546**	**90,546**	**90,546**	**90,546**	**90,545**	**90,545**	**90,546**	**90,546**	**90,546**	**90,546**	**90,546**	**90,546**	**90,546**	**90,546**	**90,546**

Table 4.3-3. Commercial timber harvest average acres and average volumes per year by alternative for decades 1 to 5

	WM-1	WM-2	WM-3	WM-4	WM-5
Decade 1					
Stand Age (Yr.)	75	72	86	60	0
Bd. Ft./Ac. (MBF)	33.5	18.3	10.7	8.0	0
Regeneration Cut Ac./Yr.	623	0	0	0	0
Retention Cut Ac./Yr.	0	110	0	0	0
Com. Thinning Ac./Yr.	0	369	348	1138	0
Total Bd. Ft./Yr. (MMBF)	20.9	8.8	3.4	9.5	0
Total Harvest Acres	623	479	348	1138	0
Decade 2					
Stand Age (Yr.)	76	79	0	0	0
Bd. Ft./Ac. (MBF)	39.8	36.3	0	0	0
Regeneration Cut Ac./Yr.	524	0	0	0	0
Retention Cut Ac./Yr.	0	242	0	0	0
Com. Thinning Ac./Yr.	0	0	0	0	0
Total Bd. Ft./Yr. (MMBF)	20.9	8.8	0	0	0
Total Harvest Acres	524	242	0	0	0
Decade 3					
Stand Age (Yr.)	82	86	0	0	0
Bd. Ft./Ac. (MBF)	45.8	40.7	0	0	0
Regeneration Cut Ac./Yr.	457	0	0	0	0
Retention Cut Ac./Yr.	0	215	0	0	0
Com. Thinning Ac./Yr.	0	0	0	0	0
Total Bd. Ft./Yr. (MMBF)	20.9	8.8	0	0	0
Total Harvest Acres	457	215	0	0	0
Decade 4					
Stand Age (Yr.)	87	87	90	80	0
Bd. Ft./Ac. (MBF)	42.4	14.0	10.3	8.7	0
Regeneration Cut Ac./Yr.	511	0	0	0	0
Retention Cut Ac./Yr.	0	45	0	0	0
Com. Thinning Ac./Yr.	0	588	1618	959	0
Total Bd. Ft./Yr. (MMBF)	21.7	8.9	15.0	8.1	0
Total Harvest Acres	511	633	1618	959	0
Decade 5					
Stand Age (Yr.)	96	109	0	0	0
Bd. Ft./Ac. (MBF)	47.2	44.0	0	0	0
Regeneration Cut Ac./Yr.	467	0	0	0	0
Retention Cut Ac./Yr.	0	199	0	0	0
Com. Thinning Ac./Yr.	0	0	0	0	0
Total Bd. Ft./Yr. (MMBF)	22.1	8.8	0	0	0
Total Harvest Acres	467	199	0	0	0

Early seral habitats would continue to be created in the short term and long term through commercial regeneration harvest on non-reserve lands. Harvest would be structured to create an uneven stand age distribution across the landscape. At Year 20 under this management scenario there would be 18,738 acres of early seral, 11,266 acres of mid seral, 6,332 acres of mature, and 0 acres of late successional forest on non-reserve lands. At Year 50 there would be 15,612 acres of early seral, 19,725 acres of mid seral, 957 acres of mature, and 41 acres of late successional forests on non-reserve lands. Because no pre-commercial or commercial thinning would take place under this alternative, there would be no acceleration of the development of late successional like characteristics in second-growth forests on non-reserve lands.

Combining Reserve and non-reserve lands into a single total for Alternative WM-1 gives the following acreages: (1) 15,610 acres of early seral forest habitat at Year 0, 19,180 acres at Year 20, and 15,612 acres at Year 50; (2) 54,592 acres of mid seral forest habitat at Year 0, 31,029 acres at Year 20, and 27,269 acres at Year 50; (3) 1,074 acres of mature forest habitat at Year 0, 20,961 acres at Year 20, and 18,818 acres at Year 50; and (4) 91 acres of late successional forest habitat at Year 0, 12 acres at Year 20, and 9,483 acres at Year 50 (Table 4.3-2).

Overall, the effects of Alternative WM-1 over the 50 years on successional stages would result in the highest levels of early to mid seral stage acres and the lowest levels of mature and late successional forest acres over the entire Watershed of all the alternatives. Old growth forest acres remain the same under all the alternatives.

Vegetation Composition

On non-reserve lands, regeneration harvest methods such as regeneration cuts with green Reserve trees (approximately 5 per acre) would create open conditions and expose some bare mineral soil. Leaving this small number of Reserve trees dispersed or in groups would encourage the establishment and growth of shade intolerant species, e.g., Douglas-fir and red alder at elevations below about 2,000 feet and lesser amounts of Douglas-fir above 2,000 feet.

The No Action Alternative for Watershed Management (WM-1) would maintain the current species composition in the lower municipal watershed, outside the Reserve, by favoring Douglas-fir and western hemlock in both pure and mixed species stands. In the upper municipal watershed watershed, Alternative WM-1 would maintain the current species mix dominated by Pacific silver fir, western hemlock, and mountain hemlock. Mixed coniferous and deciduous stands would also be present and distributed across the landscape, mostly in forested wetlands and riparian habitats.

Commercial Timber

Table 4.3-3 summarizes the projected harvest acres by stand treatment (i.e., regeneration cut or commercial thinning) and the volume harvested per year for each decade over a 50 year period for each alternative. The No Action Alternative for Watershed Management (WM-1) provides the highest level of commercial timber harvest and revenues per decade of all the alternatives (Table 4.3-3) (for the economic effects of the alternatives see Section 4.10 Socioeconomics). The commercial timber volume harvested under the No Action Alternative is estimated at approximately 20.9 MMBF per year during the first decade. The total volume harvested in the next 50 years would be approximately 1,064 MMBF. This volume is probably close to but less than the maximum timber volume that could be achieved under Washington FPRs.

The timber volume produced under this alternative would be generated by an average of 623 acres of regeneration cut and 0 acres of commercial thinning per year in the first decade (Table 4.3-3). The total area of regeneration cut and commercial thinning would be 25,820 and 0 acres, respectively in the next 50 years (Table 4.3-4). The average stand age harvested would be 75 years in the first decade and would increase to 96 years in the fifth decade.

Table 4.3-4. Total acres harvested by silvicultural system over the next 50 years by alternative

Method	Alt. WM-1	Alt. WM-2	Alt. WM-3	Alt. WM-4	Alt. WM-5
Regeneration Cut (WA FPR)[1/]	25,820				0
Retention Harvest (Additional Green Tree Retention)[2/]		8,110			0
Com. Thin[3/]		9,570	19,660		0
Com. Thin[4/]				20,970	0
Commercial Harvest in Reserves[5/]	None	None	None	None	None
Total Acres	25,820	17,680	19,660	20,970	0

1/ Regeneration unit size is limited by constraints under the Washington State Forest Practices Act, e.g., 120-acre maximum size with a 2% green tree and wildlife tree retention level.

2/ Retention units are limited to 120 acres maximum size with an additional 10% green tree and wildlife tree retention level.

3/ Commercial thinning units are designed to leave dominant and codominant trees and develop multi-layered stands using a Crown Competition Factor of 300.

4/ Commercial thinning units are designed to harvest a volume allocation in a given timeframe from each of four zones. Only stands whose quadratic mean diameter is at least 21-inch DBH will be removed from the commercial zone and no trees over 24-inch DBH would be harvested.

5/ Harvest treatments within the Ecological Reserve will consist of ecological and restoration thinnings designed to accelerate watershed function for water quality, fisheries, and wildlife populations.

Under this alternative, silvicultural and stand manipulation practices produce stand conditions that provide a high degree of protection against agents detrimental to forest health such as windthrow and windsnap, and damage (wounding) of residual trees from harvest operations. In general, less residual stand degradation would occur because the utilization of traditional regeneration cut treatments versus the higher Reserve tree retention and commercial thinning treatments under alternatives WM-2 to WM-4. Leaving fewer Reserve trees exposes less trees to windthrow conditions and leaves less trees damaged during harvest operations.

Proposed HCP Alternative for Watershed Management (WM-2)

The Proposed HCP Alternative for Watershed Management (WM-2) consists of a forested Reserve of 56,223 acres (64 percent of the Watershed) and a commercial base of 32,105 acres (36 percent of the Watershed). Commercial timber harvest outside the Reserve would consist of retention cuts in timber stands at least 60 years old and commercial thinning could occur in timber stands where at least 5,000 board feet/acre could be removed. Timber removal over the proposed 50 year HCP permit is designed to transition to long term rotations of 120 to 140 years. Timber harvest would be on an even flow, sustained yield basis.

Studies have shown that conifer growth in young stands can be accelerated through silvicultural treatments such as thinnings which control conifer stocking, reduce competing vegetation, and reduce the threat of insects and diseases (e.g., Curtis et al., 1997). Treatments may shorten the time spent in the closed canopy phase of mid seral stand development and offer other resource benefits. Carey et al. (1995) concluded that young-growth forests actively managed for structural diversity could support virtually all species occurring in western Washington. Carey et al. (1995) proposed a biodiversity pathway for forest management based on comparisons of biotic communities in old growth, young natural, and managed forests. These management practices are based on 1) conservation of biological legacies (e.g., snags and downed wood) during harvest and regeneration, 2) minimizing time in the closed canopy stage of mid seral stand development, 3) ensuring diversity and niche diversification in later stages through thinnings and coarse woody debris management (e.g., downed logs and cavity trees), 4) using extended rotations on a significant part of a given land base. Several of these goals are also achieved by using variable density commercial thinning rather than conventional commercial thinning. Variable density commercial thinning is much heavier than conventional commercial thinning and is intended to maintain tree growth, promote understory development, and add coarse woody debris to the forest floor (Carey and Curtis, 1996).

Outside the Reserve, under the Proposed HCP Alternative for Watershed Management (WM-2) commercial thinnings would be tailored to develop late

successional like habitat structure by leaving the dominant and co-dominant (i.e., larger) trees, while removing some of the smaller or less vigorous trees. These thinnings would be designed to develop multi-layered stands that would provide structural and species diversity prior to final harvest. Thinnings would be scheduled by stand conditions, rather than age, using crown competition factor (CCF). Thinning levels would maintain crown closure between the level where minimal natural mortality occurs and the level where some mortality exists but growth still exceeds mortality. The extent of thinning would also be designed on a site specific basis (i.e., for individual stands) so as not to exceed levels that would result in widespread windthrow of the remaining trees.

Final harvest areas (retention cuts) utilizing a biodiversity pathways approach would be limited to a maximum of 120 acres. Approximately 10 percent of the stand volume in the form of green recruitment trees and wildlife Reserve trees would be left. Though this increase reflects only an additional three trees per acre above State requirements, the Applicant intends to retain dominant and co-dominant trees, while the State requirements can be met with much smaller trees. These larger trees provide more habitat benefits during all successional phases of subsequent stand development (see Section 4.5 Wildlife Resources).

Newly identified streams, wetlands, and other special habitats in the non-reserve areas would be buffered with the wider buffers provided for Reserve elements. In the projections of growth over time and to establish a realistic management strategy based on existing stand conditions, an initial final harvest age in the first rotation of more than equal to 60 years was used. Some existing stands have already passed the point where they can respond to thinning by increasing growth because of stocking and age. However, one objective of this alternative is to move, in the second rotation, to longer rotation ages. These longer rotations are 120 years for Douglas-fir and 140 years for true firs. Over time, timber volume would be generated on a sustained yield basis for this longer rotation period.

Within the Reserve ecological thinning and restoration management treatments would be designed to accelerate watershed functions for water quality, fisheries, and wildlife populations. Restoration of forest habitat in the Reserve would include restoration planting, ecological thinning, and restoration thinning of some stands to facilitate the development of late successional habitat or to restore natural function in riparian forest. This would involve cutting trees inside the Reserve from which some revenue in excess of cost may be incidentally derived.

Under Alternative WM-2, in subbasins within the ROS and snow zones, forests will be managed so that no more than one third of the forested acres will be hydrologically immature (less than 70 percent canopy cover and less than 9 inches dbh).

Successional Stages

On forested areas outside the Reserve the stand condition created by leaving higher green tree standards in retention cuts would also promote habitat conditions favorable to species dependent on uneven-aged stand age distribution. The transition to harvest rotation ages of 120 to 140 years would create conditions favorable late successional habitat dependent species (see Section 4.5 Wildlife Resources). Over the 50 year life span of the proposed HCP, less retention cuts combined with greater commercial thinnings designed to develop multi-layered stands would create more late successional habitat conditions compared to the No Action Alternative for Watershed Management (WM-1). This will prepare the stand age structure to transition toward longer rotation lengths prior to final harvest (See Figure 4.3-2).

At Year 0, the Proposed HCP Alternative for Watershed Management (WM-2) would include the following successional stages as part of the Reserve: 10,847 acres of early seral, 28,139 acres of mid seral (mid seral includes closed canopy forest classifications), 485 acres of mature, and 0 acres of late successional forest (Table 4.3-2). Through natural forest maturation at Year 20 there would be 542 acres of early seral including grass-forb and open canopy stages, 22,097 acres of mid seral, 16,686 acres of mature, and 12 acres of late successional forest in the Reserve. At Year 50 there would be 0 acres of early seral, 8,599 acres of mid seral, 19,946 acres of mature, and 10,790 acres of late successional forests in the Reserve. Restoration thinning or ecological thinning would take place in some of these second-growth forests, thus accelerating the development of late successional or old growth characteristics.

At Year 0, the Proposed HCP Alternative for Watershed Management (WM-2) would include the following successional stages on non-reserve lands: 4,762 acres of early seral, 26,454 acres of mid seral closed canopy, 588 acres of mature, and 91 acres of late successional forest (Table 4.3-2). Early seral habitats, including grass-forb and open canopy stages, would continue to be created in the short term and long term through retention timber harvest outside the Reserve. Harvest would be structured to create an uneven stand age distribution across the landscape. The Proposed HCP Alternative would create approximately 45 to 242 acres of early seral habitat annually through regeneration timber harvest methods. Under this management scenario there would be 7,976 acres of early seral, 11,362 acres of mid seral, 12,426 acres of mature, and 82 acres of late successional forest on non-reserve lands at Year 20. At Year 50 there would be 5,528 acres of early seral, 11,107 acres of mid seral, 10,718 acres of mature, and 4,493 acres of late successional forests on non-reserve lands. Pre-commercial and commercial thinning under this alternative would accelerate the development of late successional or old growth characteristics in second-growth forests on non-reserve lands.

Figure 4.3-3. Seral stage projections for WM-3

Forest seral stages inside and outside the Reserve for the years 1997, 2020, and 2050, under Alternative WM-3. (NOTE: scale on graph of Entire Watershed is different from scale on graphs inside and outside the Reserve)

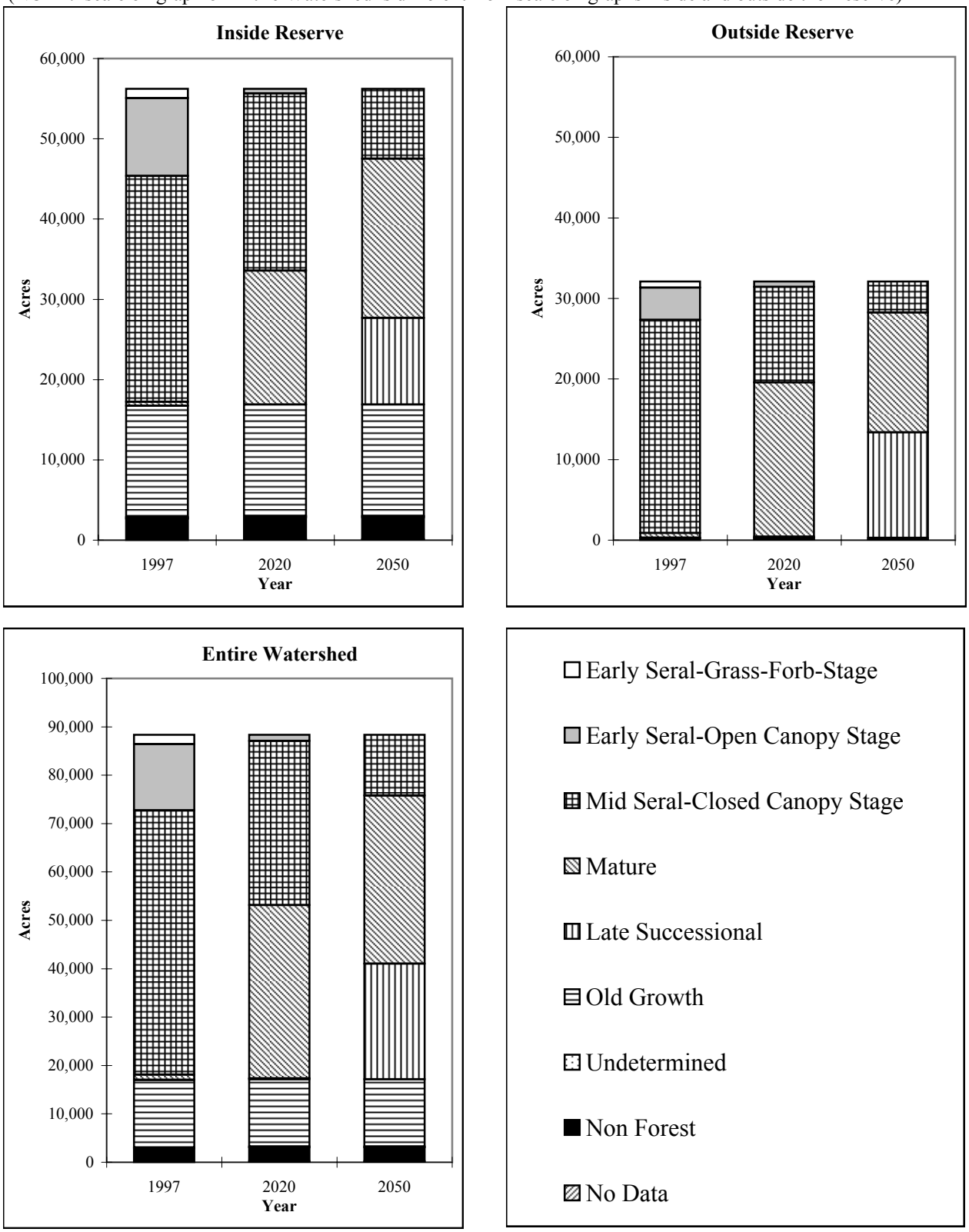


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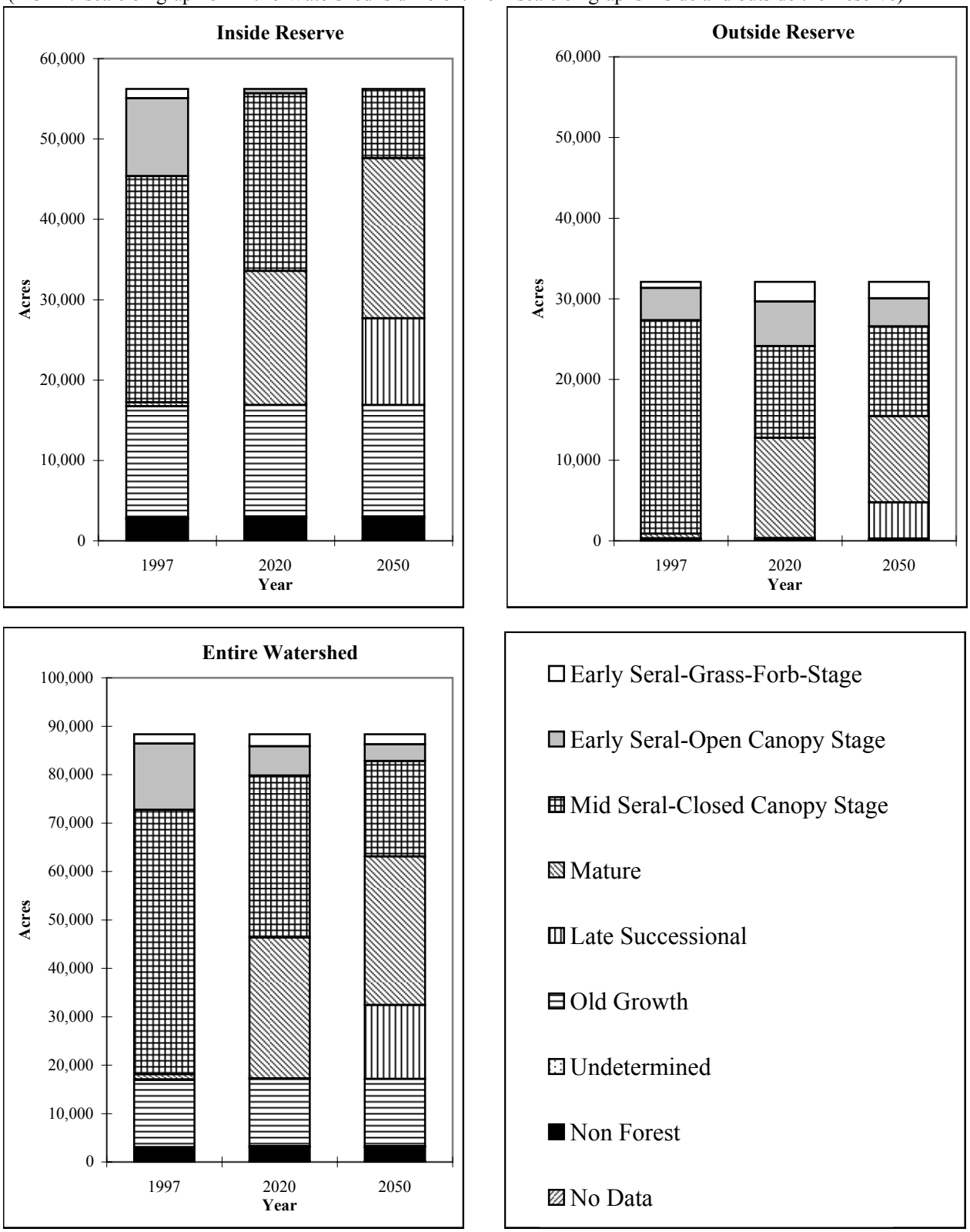
Figure 4.3-2. Seral stage projections for WM-2

Forest seral stages inside and outside the Reserve for the years 1997, 2020, and 2050, under Alternative WM-2. (NOTE: scale on graph of Entire Watershed is different from scale on graphs inside and outside the Reserve)



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Combining Reserve and non-reserve lands into a single total for the Proposed HCP Alternative for Watershed Management (WM-2) gives the following acreages: (1) 15,610 acres of early seral forest habitat at Year 0, 8,518 acres at Year 20, and 5,528 acres at Year 50; (2) 54,592 acres of mid seral forest habitat at Year 0, 33,458 acres at Year 20, and 19,706 acres at Year 50; (3) 1,074 acres of mature forest habitat at Year 0, 29,112 acres at Year 20, and 30,664 acres at Year 50; and (4) 91 acres of late successional forest habitat at Year 0, 94 acres at Year 20, and 15,284 acres at Year 50 (Table 4.3-2).

Vegetation Composition

Retention harvest methods would be applied to approximately 25 percent of land available for timber harvest outside of the Reserve. These regeneration units would retain approximately 10 percent of the stand volume in any given harvest unit. These tree retention standards, if met by clumping trees in groups, would create conditions favorable to shade intolerant species as discussed under Alternative WM-1. If the additional leave trees under the Proposed HCP Alternative for Watershed Management (WM-2) were dispersed evenly over a harvest area they would create shade conditions more favorable to shade tolerant species and less favorable to shade intolerant species.

Silvicultural practices that create less ground disturbance and smaller openings in the canopy would encourage the establishment and growth of shade tolerant species such as Pacific silver fir, and lesser amounts of western hemlock, western red cedar, mountain hemlock, and subalpine fir, respectively, with increasing elevation. These practices include single tree selection, smaller sized groups in group selection, overstory removals, commercial thinning (including ecological and restoration thinning), and treatments in SMAs with many Reserve trees

Intermediate harvest methods, such as commercial thinning treatments with the majority of the stand retained after harvest would be applied to approximately 77 percent of land available for timber harvest outside of the Reserve. These thinning treatments would encourage the establishment and growth of shade tolerant species, e.g., Pacific silver fir, mountain hemlock, and subalpine fir, respectively, with increasing elevation.

An example of a vegetative change that could occur is when late seral tree species representative of the climax vegetation stage in the lower municipal watershed could become established in the understory of stands subject to light partial removal treatments, such as commercial thinning and small group selection cuts. These forest stands currently dominated by shade-intolerant, early seral species, e.g., Douglas-fir when treated by uniform low-stem removal treatments, such as commercial thinnings, could become dominated with an understory of shade tolerant, late-seral species, such as western hemlock, western redcedar, and true firs.

Mixed coniferous and deciduous stands would also be present and distributed across the landscape, mostly in forested wetlands and riparian habitats.

Commercial Timber

The Proposed HCP Alternative for Watershed Management (WM-2) provides the second to the highest level of timber harvest and consequently of revenues per decade (Table 4.3-3) (see Section 4.10 for further discussion of revenues). The commercial timber volume harvested under the Proposed HCP Alternative is estimated at approximately 8.8 MMBF per year during the first decade. The total volume harvested in the proposed 50 year HCP period would be approximately 440 MMBF. This volume is approximately a 59 percent reduction from the total potential timber volume available under the No Action Alternative for Watershed Management (WM-1).

The timber volume produced under this alternative would be generated by an average of 110 acres of regeneration cut and 369 acres of commercial thinning per year in the first decade. The total area of retention cut and commercial thinning would be 8,110 and 9,570 acres, respectively, over the proposed 50 year HCP (Table 4.3-4). The average stand age harvested would be 72 years in the first decade and would increase to 109 years in the fifth decade. This increase in stand age reflects the transition to longer term 120 year and 140 year rotations that are not yet reached at the end of the fifth decade.

Under this alternative, silvicultural treatments produce stand conditions that provide a moderate degree of protection against agents detrimental to forest health. However, damage to residual trees (wounds) from light harvest operations such as commercial thinning can result in losses due to windthrow and windsnap, insects, and disease. The potential for damage caused by windthrow under this alternative would be minimized by scheduling thinning by stand condition and utilizing the CCF to guide tree removal. Windthrow damage is usually a result of several factors including, exposure of trees in openings, high soil moisture content, position of the stand on the mountain slope, tree health and vigor, snow load on the tree canopy, and the probability that the stand will be exposed to several of these factors at the same time. Commercial thinning could increase the potential for windthrow damage if stand treatments create these detrimental conditions. However, commercial thinning under this alternative would be designed to minimize these effects.

Long-term Sustainable Thinning Alternative (WM-3)

Alternative WM-3 consists of a forested Reserve of 56,223 acres (64 percent of the Watershed) and a commercial base of 32,105 acres (36 percent of the Watershed). Timber harvest, consisting of commercial thinnings only in stands where at least 5000 board feet/acre could be removed would be allowed outside the Reserve. Timber harvest would be on an even flow, sustained yield basis. An additional 10 percent of the commercial trees was subtracted from the estimated volume to account for unmapped stream and wetland buffers and

inoperable ground. Commercial thinning treatments outside the Reserve, ecological thinning and restoration management treatments in the Reserve, and SMAs would be implemented as under the Proposed HCP Alternative for Watershed Management (WM-2).

Successional Stages

On commercial forest lands outside the Reserve, the structural diversity that would result from implementation of Alternative WM-3 would be the same as described in Alternative WM-2, for the proposed commercial thinning treatments. The main difference in the two alternatives is that regeneration and retention harvests are not considered in this alternative. Stand structure would therefore advance similar to natural successional processes at a generally more rapid rate rather than being converted to early seral conditions initiated by complete timber removal (See Figure 4.3-3).

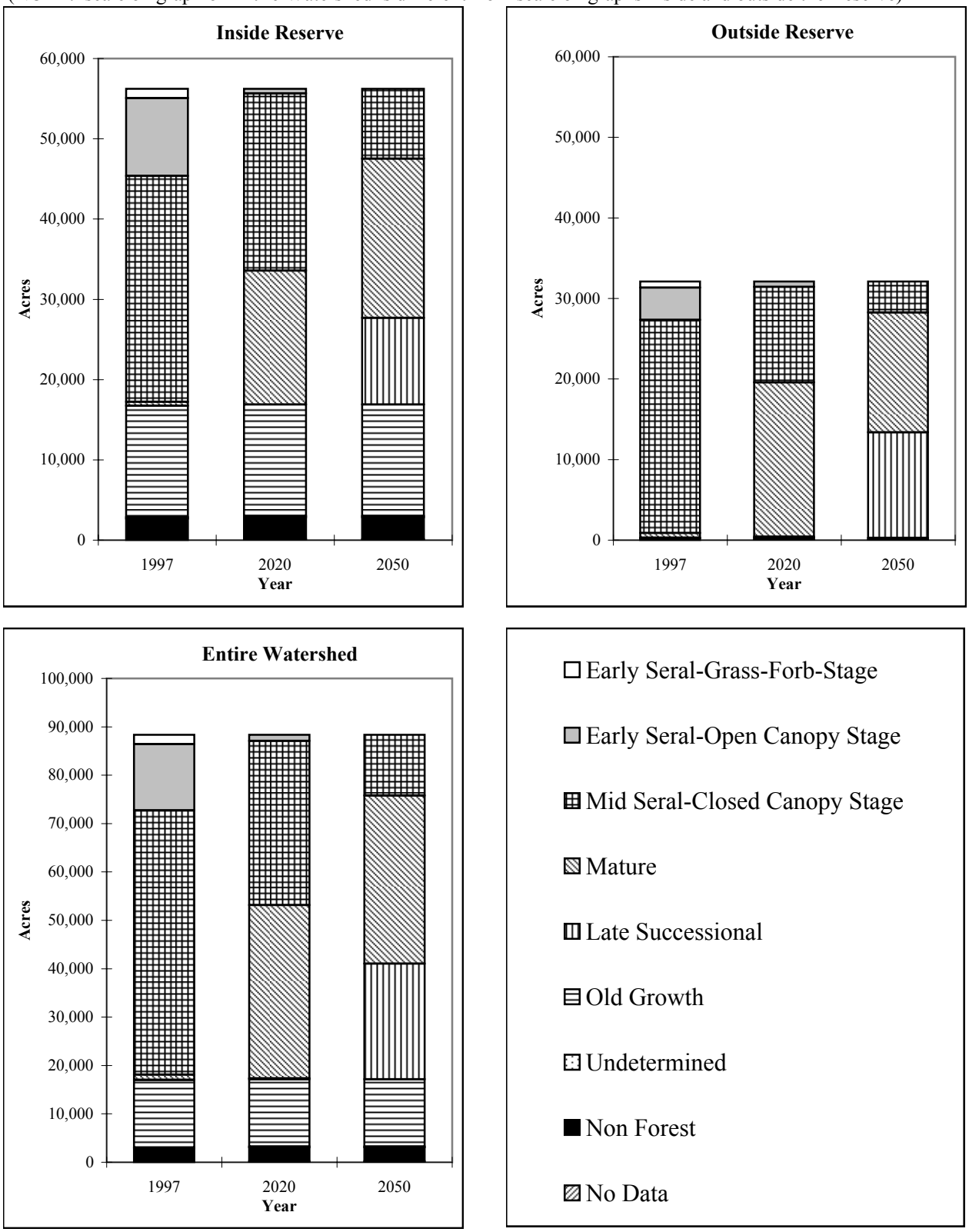
At Year 0, Alternative WM-3 would include the following successional stages as part of the Reserve: 10,847 acres of early seral, 28,139 acres of mid seral, 485 acres of mature, and 0 acres of late successional forest (Table 4.3-2). Through natural forest maturation there would be 579 acres of early seral, 22,059 acres of mid seral, 16,686 acres of mature, and 12 acres of late successional forest in the Reserve at Year 20. At Year 50 there would be 0 acres of early seral, 8,716 acres of mid seral, 19,829 acres of mature, and 10,790 acres of late successional forests in the Reserve. Restoration thinning or ecological thinning would take place in some of these second-growth forests, thus accelerating the development of late successional or old growth characteristics.

At Year 0, Alternative WM-3 would include the following successional stages on non-Reserve lands: 4,762 acres of early seral, 26,454 acres of mid seral, 588 acres of mature, and 91 acres of late successional forest (Table 4.3-2). No new early seral habitats would be created under Alternative WM-3. Under this management scenario there would be 670 acres of early seral, 11,865 acres of mid seral, 19,133 acres of mature, and 179 acres of late successional forest on non-reserve lands at Year 20. At Year 50 there would be 0 acres of early seral, 3,842 acres of mid seral, 14,877 acres of mature, and 13,128 acres of late successional forests on non-reserve lands. Pre-commercial and commercial thinning under this alternative would accelerate the development of late successional or old growth characteristics in second-growth forests on non-Reserve lands.

Combining Reserve and non-reserve lands into a single total for Alternative WM-3 would yield the following acreages: (1) 15,610 acres of early seral forest habitat at Year 0, 1,249 acres at Year 20, and 0 acres at Year 50; (2) 54,592 acres of mid seral forest habitat at Year 0, 33,924 acres at Year 20, and 12,558 acres at Year 50; (3) 1,074 acres of mature forest habitat at Year 0,

Figure 4.3-3. Seral stage projections for WM-3

Forest seral stages inside and outside the Reserve for the years 1997, 2020, and 2050, under Alternative WM-3. (NOTE: scale on graph of Entire Watershed is different from scale on graphs inside and outside the Reserve)



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35,819 acres at Year 20, and 34,706 acres at Year 50; and (4) 91 acres of late successional forest habitat at Year 0, 190 acres at Year 20, and 23,918 acres at Year 50 (Table 4.3-2).

Vegetation Composition

On all the lands available for timber harvest outside of the Reserve, commercial thinning treatments that retain the majority of the stand would encourage the establishment and growth of shade tolerant species. These species are indicators of the climax vegetation series found in the Watershed , e.g., western hemlock, Pacific silver fir, mountain hemlock, and subalpine fir, respectively, with increasing elevation.

Mixed coniferous and deciduous stands would also be present and distributed across the landscape, mostly in forested wetlands and riparian habitats.

Commercial Timber

Alternative WM-3 provides the third to the highest level of harvest and consequently of revenues per decade of all the alternatives (Table 4.3-3) (see Section 4.10 for socioeconomic effects). The commercial timber volume harvested under Alternative WM-3 is estimated as 3.4 MMBF per year during the first decade. The total volume harvested in the next 50 years is estimated as 184 MMBF. No harvest would occur in the second, third, and fifth decades because stands appropriate for commercial thinning would not exist. The total volume represents approximately 17.4 percent of the total available volume as indicated in the No Action Alternative for Watershed Management (WM-1).

The timber volume produced under this alternative would be generated by no regeneration harvest and 348 acres of commercial thinning per year in the first decade (Table 4.3-3). The total area of regeneration harvest and commercial thinning would be 0 and 19,660 acres, respectively, over the next 50 years (Table 4.3-4). The average stand age harvested would be 86 years in the first decade and 90 years in the fourth decade. As noted above, no harvest would occur in the second, third, and fifth decades. Under this alternative, silvicultural and stand manipulation practices produce stand conditions that provide a moderate degree of protection against agents detrimental to forest health. However, damage to residual trees (wounds) from light to moderate harvest operations, such as commercial thinning, can result in low to moderate losses due to windthrow or windsnap, insects, and disease. The potential for damage caused by windthrow under this alternative would be minimized by the implementation of thinning prescriptions that would be developed on a site specific basis utilizing CCF and other site specific factors, as discussed under the Proposed HCP Alternative for Watershed Management (WM-2).

Thinning Alternative with Phased Out Commercial Timber Harvest (WM-4)

Alternative WM-4 consists of a forested Reserve which includes the Alternative WM-2 Reserve acreage (56,223 acres) plus an additional 3,795 acres, for a total of 60,019 acres (68 percent of the Watershed) and a beginning commercial base of 28,309 acres (32 percent of the Watershed). The commercial base was divided into four zones with corresponding periods when each zone is available for commercial thinning (Table 4.3-4). These zones also have a specified percent volume removal over a specified time frame (Table 4.3-4). These zones are shown in Map 20. All stands must be capable of producing at least 5,000 board feet/acre at the time of entry.

From the initial commercial base, stands whose quadratic mean diameter is more than or equal to 21 inches dbh would automatically become part of the Reserve. In the remaining commercial base, no trees over 24 inches dbh could be harvested for commercial purposes. These constraints are carried through time as the growth model grows the trees. Additional commercial tree count reductions of 10 percent were subtracted from the commercial zone to account for unmapped streams and wetlands as well as inoperable ground. Alternative WM-4 would end commercial timber harvest by the end of 50 years, therefore there was no attempt to produce sustainable, even flow timber volumes. Currently unidentified features would be buffered as described in the Proposed HCP Alternative for Watershed Management (WM-2).

This alternative only utilizes commercial thinning as a harvest method. Additionally there are specified zones in which to harvest and each zone has a specified percent volume removal over a given time frame (Table 4.3-5). These constraints preclude establishment of appropriate retention levels and managed sustained growth projections over time. Similarly, because there would be no final harvest, there is no maximum limit on commercial thinning harvest unit size. Rotation ages are not applicable because the timber stands are never harvested with the intent to regenerate the entire stand.

Table 4.3-5. Commercial base zones, acreage, prescribed volume removal, and period available for commercial thinning under Alternative WM-4 (see Map 20)

Zone	Acres	Volume Removal (percent)	Years available
A	2,320	15	2000-2005
B	4,008	25	2000-2010
C	9,531	50	2000-2020
D	12,286	65	2000-2050
E (developed acres)	167	N/A	N/A

Within the Reserve, ecological thinning and restoration management treatments would take place, as described under the Proposed HCP Alternative for Watershed Management (WM-2). SMAs as described in the No Action Alternative for Watershed Management (WM-1) are also a part of this alternative. This alternative did not contain a CCF constraint because the suggested volume removals could not be achieved if this constraint was imposed.

Successional Stages

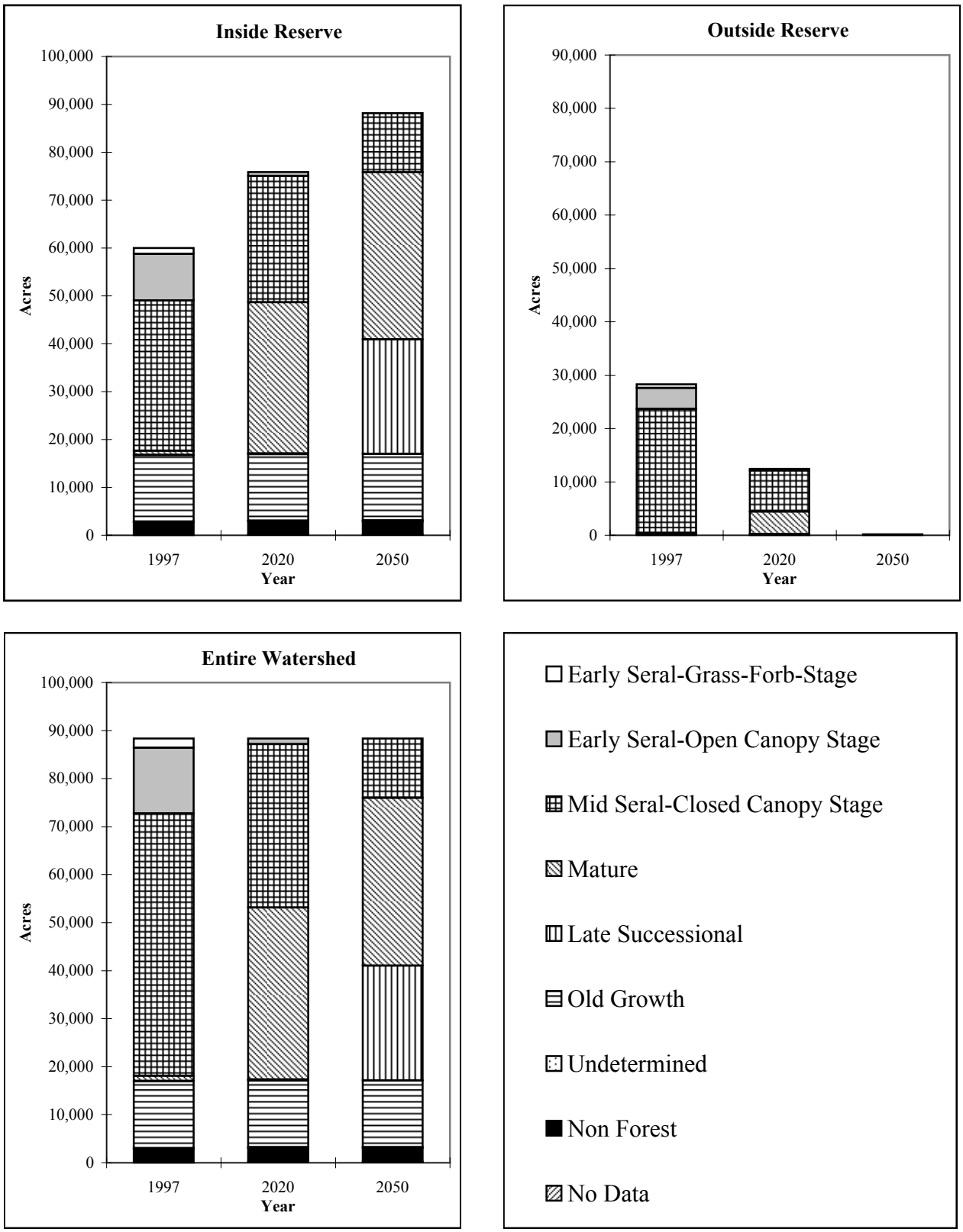
Timber harvest by commercial thinning only would be designed to remove 15, 25, 50, and 65 percent of the trees in zones A to D, respectively, while retaining the larger trees (over 24 inches dbh) and stands with larger average diameters (greater than 21 inches dbh) (Table 4.3-4). The effects of commercial thinning treatments on structural diversity in the four areas scheduled for harvest would be dependent on the age class and location of stands being thinned. Those stands receiving the highest volume removal levels, e.g., zone D and containing the least number of Reserve trees (over 24 inches dbh) would probably have a high percent of the existing trees removed prior to the end of commercial harvest operations in fifty years. This would create conditions suitable for the regeneration and dense stocking of shade tolerant species, e.g.., western hemlock, Pacific silver and subalpine firs. Overtime these thinning regimes would develop multi-layered stands and create late successional habitat conditions (See Figure 4.3-4).

At Year 0, Alternative WM-4 would include the following successional stages in the Reserve: 10,983 acres of early seral, 31,368 acres of mid seral, 859 acres of mature, and 54 acres of late successional forest (Table 4.3-2). Through natural forest maturation and the inclusion of more lands, there would be 575 acres of early seral, 22,207 acres of mid seral, and 20,255 acres of mature, and 66 acres of late successional forest in the Reserve at Year 20. At Year 50 there would be 0 acres of early seral, 8,709 acres of mid seral, 20,069 acres of mature, and 14,325 acres of late successional forests in the Reserve. Restoration thinning or ecological thinning would take place in some of these forests, thus accelerating the development of late successional or old growth forest characteristics.

At Year 0, Alternative WM-4 would include the following successional stages on non-reserve lands: 4,627 acres of early seral, 23,224 acres of mid seral, 214 acres of mature, and 37 acres of late successional forest (Table 4.3-2). No new early seral habitats would be created under WM-4. Under this management scenario there would be 321 acres of early seral, 7,670 acres of mid seral, 4,230 acres of mature, and 28 acres of late successional forest on non-reserve lands at Year 20. At Year 50 there would be 0 acres of early seral, 0 acres of mid seral, 0 acres of mature, and 0 acres of late successional forests on non-reserve lands. Pre-commercial and commercial thinning under this

Figure 4.3-4. Seral stage projections for WM-4

Forest seral stages inside and outside the Reserve for the years 1997, 2020, and 2050, under Alternative WM-4.



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alternative would accelerate the development of late successional or old growth characteristics in second-growth forests outside the Reserve.

Combining Reserve and non-reserve lands into a single total for WM-1 would yield the following acreages: (1) 15,610 acres of early seral forest habitat at Year 0, 1,164 acres at Year 20, and 0 acres at Year 50; (2) 54,592 acres of mid seral forest habitat at Year 0, 34,009 acres at Year 20, and 12,331 acres at Year 50; (3) 1,073 acres of mature forest habitat at Year 0, 35,819 acres at Year 20, and 34,993 acres at Year 50; and (4) 91 acres of late successional forest habitat at Year 0, 190 acres at Year 20, and 23,918 acres at Year 50 (Table 4.3-2).

Vegetation Composition

On the majority of land available for timber harvest outside of the Reserve, commercial thinning only treatments would be applied at high intensities of tree removal and the four schedules of the harvest will create conditions that would encourage change to a mixture of shade-tolerant and shade-intolerant species. Over time, the Watershed would develop late successional forest characteristics and favor tree species and vegetation representative of the three climax plant associations found in the Watershed (USFS, 1992).

Mixed coniferous and deciduous stands would also be present and distributed across the landscape, mostly in forested wetlands and riparian habitats.

Commercial Timber

Alternative WM-4 provides the lowest level of harvest, and consequently of revenues, per decade of all the alternatives that allow timber harvest (Table 4.3-3) (see Section 4.10 for socioeconomic effects). The commercial timber volume harvested under Alternative WM-4 is estimated at 9.5 MMBF per year during the first decade. The total volume harvested in the next 50 years is estimated at 176 MMBF. No harvest would occur in decades two, three, and five because stands appropriate for commercial thinning would not exist. The total volume represents approximately 17.0 percent of the total available volume as indicated in the No Action Alternative (WM-1).

The timber volume produced under this alternative would be generated by no regeneration harvest and 1,138 acres of commercial thinning per year in the first decade (Table 4.3-3). The total area of regeneration harvest and commercial thinning would be 0 and 20,970 acres, respectively, over the next 50 years (Table 4.3-4). The average stand age harvested would be 60 years in the first decade and 80 years in the fourth decade. As noted above, no harvest would occur in the second, third, and fifth decades.

Under this alternative, silvicultural and stand manipulation practices produce stand conditions that provide a moderate degree of protection against agents detrimental to forest health. However, damage to residual trees (wounds) from

light harvest operations such as commercial thinning can result in low to moderate losses due to windthrow or windsnap, insects, and disease.

This alternative would create windthrow damage problems on many sites due to the increased exposure of the residual stands to high intensity windstorm events. Increased windthrow or blowdown of trees can result from commercial thinnings that open a closed canopy stand. Trees that grow in closed canopy conditions have not been individually exposed to wind and therefore have not developed root and mainstem structures that minimize the potential for them to be blown down. Being exposed to open conditions can result in substantial windthrow of the trees that are retained after commercial thinning. Other conditions that increase susceptibility to windthrow include high soil moisture content, stand position on a mountain slope, effects of root and bole diseases, and wind direction. The thinning prescriptions identified for Alternative WM-4 do not consider these windthrow susceptibility factors but rather prescribe specific volume removal per zone that would have to be applied on all stands in order to meet the volume estimates. For example, zone D prescriptions require 65 percent volume removal on approximately 44 percent of the available commercial lands for this alternative. Consequently, there would be a substantial risk of windthrow under Alternative WM-4. By comparison, the commercial thinning regime under Alternative WM-3 generates its projected timber volume while providing flexibility for individual stand treatments that explicitly considers individual stand susceptibility to blowdown.

No Commercial Timber Harvest Alternative (WM-5)

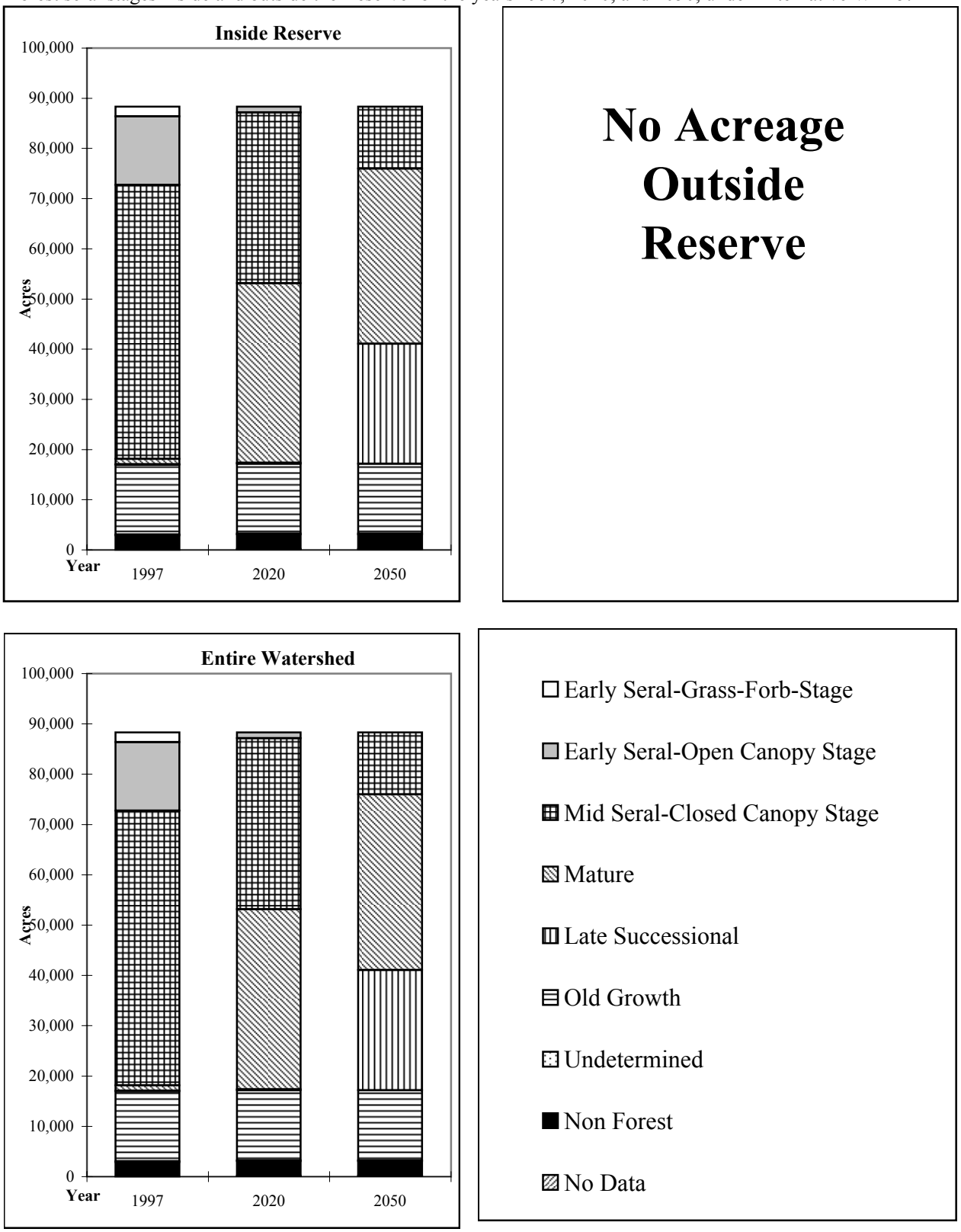
Under this alternative, the entire Watershed would become Reserve (88,328 forested acres) and no timber harvest would occur. Consequently, there would be 0 acres of regeneration harvest and 0 acres of commercial thinning over the next 50 years (Table 4.3-4). ecological and restoration treatments would occur in the Reserve, as described under the Proposed HCP Alternative for Watershed Management (WM-2). Some removal of windthrow on roads, and cutting of trees encroaching on roads would be part of a routine road maintenance program. Some tree removal could also occur during emergencies to prevent catastrophic impacts to municipal waters. Some trees would also be cut for road access as part of a flood and fire control prevention plan.

Successional Stages

Under Alternative WM-5 structural diversity would develop by natural processes. Stands throughout the Watershed would mature at natural rates and would develop mature and late successional conditions over time. Natural processes would take an estimated one hundred years or perhaps longer to develop late successional conditions than if treatment designed to develop these characteristics were implemented. Fragmentation would be lowest over time and because there would be less roads and created openings there would be the least risk from wind damage (See Figure 4.3-5).

Figure 4.3-5. Seral stage projections for WM-5

Forest seral stages inside and outside the Reserve for the years 1997, 2020, and 2050, under Alternative WM-5.



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At Year 0, Alternative WM-5 would include the following other habitats on Reserve lands: 15,610 acres of early seral, 54,592 acres of mid seral, 1,074 acres of mature, and 91 acres of late successional forest (Table 4.3-2). No early seral forest habitats would be created by timber harvest under Alternative WM-5. Under this management scenario there would be 1,164 acres of early seral, 34,009 acres of mid seral, 35,819 acres of mature, and 190 acres of late successional forest in the Reserve at Year 20. At Year 50 there would be 0 acres of early seral, 12,331 acres of mid seral, 34,933 acres of mature, and 23,918 acres of late successional forests in the Reserve. Restoration thinning or ecological thinning would take place in these second-growth forests, thus accelerating the development of late successional or old growth forest characteristics in some areas.

Vegetation Composition

In the next 50 years the majority of lands in the Watershed would maintain the current species composition but would begin the evolution to the tree species and vegetation representative of the three main climax vegetation series and their respective forest plant associations that cover the forested stands in the Watershed (USDA Forest Service, 1992). Over an extended period, the major coniferous tree species that would be represented in climax vegetation stages include western hemlock, Pacific silver fir, and mountain hemlock, with smaller amounts of Douglas-fir and western red cedar. Subalpine fir would be a component of the climax vegetation at the highest elevations in the Watershed.

Mixed coniferous and deciduous stands would also be present and distributed across the landscape, mostly in forested wetlands and riparian habitats.

Commercial Timber

Alternative WM-5 postpones indefinitely the commercial timber harvest and related revenues from the sale of timber from watershed lands. Natural growth and mortality would occur without being captured by prescribed silvicultural treatments that provide commercial thinning, mortality salvage, and other commercial harvest operations during the life span of the HCP.

Under this alternative, natural agents detrimental to forest health, such as, wildfire, windthrow, insect and disease epidemics would be allowed to affect forest stands up to a degree that prevention of catastrophic impacts to municipal waters is considered necessary.

4.3.4 Effects on Rare Plants

No Action Alternative for Watershed Management (WM-1)

There are no known populations and there is no known high probability habitat of the two Federally listed endangered plant species in the Watershed. There is

only one Federally listed threatened plant species that is known to occur in portions of King County, golden Indian-paintbrush (*Castilleja levisecta*). It generally occurs in lower elevation areas around Puget Sound. Therefore, it is unlikely to occur in the Watershed.

There are eighteen state sensitive plant species that could be found in the Watershed plus four state listed threatened and endangered species. A search of the Washington State Department of Natural Resources Natural Heritage Program database indicated no locations inside the Watershed. There is some minor risk of affecting these species because 25,820 acres of timber harvest would occur over the next 50 years.

Proposed HCP Alternative for Watershed Management (WM-2)

Under the Proposed HCP Alternative (WM-2) the potential effects to rare plants would be the same as described under Alternative WM-1 though the risk would be proportionally reduced because of the lesser acreage of timber harvest that would occur over the next 50 years (i.e., 17,680 compared to 25,820). ecological and restoration thinning within the Reserve would also create a slight risk of affecting these plants.

Long-term Sustainable Thinning Alternative (WM-3)

Under Alternative WM-3 the potential effects to rare plants would be the same as described under Alternative WM-1 though the risk would be proportionally reduced because of the lesser acreage of timber harvest that would occur over the next 50 years (i.e., 19,660 compared to 25,820). ecological and restoration thinning within the Reserve would also create a slight risk of affecting these plants.

Thinning Alternative with Phased Out Commercial Timber Harvest (WM-4)

Under Alternative WM-4 the potential effects to rare plants would be the same as described under Alternative WM-1 though the risk would be proportionally reduced because of the lesser acreage of timber harvest that would occur over the next 50 years (i.e., 20,970 compared to 25,820). ecological and restoration thinning within the Reserve would also create a slight risk of affecting these plants.

No Commercial Timber Harvest Alternative (WM-5)

Alternative WM-5 would have the least likelihood of affecting rare plants because it does not have disturbance from commercial timber harvest. ecological and restoration thinning within the Reserve would create a slight risk of affecting these plants.

4.3.5 Effects on Noxious Weeds

No Action Alternative (WM-1)

Any ground disturbing activity would increase the potential incidence of noxious weeds. The general effects of the No Action Alternative (WM-1) would create regeneration cut areas that cause some ground disturbance through timber harvest and road construction activities. This would cause a greater risk than those alternatives which create less or no disturbance. These conditions would gradually decrease over time as forests occupying these sites mature, however, mature forests that are harvested in the future will become new habitats for noxious weeds. Since noxious weeds are currently not a major problem in the Watershed, they are not anticipated to be s a significant problem under this alternative.

Proposed HCP Alternative for Watershed Management (WM-2)

Under the Proposed HCP Alternative (WM-2) the potential effects of increasing noxious weeds would be the same as described under Alternative WM-1 though the risk would be proportionally reduced because of the lesser acreage of timber harvest that would occur over the next 50 years (i.e., 17,680 compared to 25,820). ecological and restoration thinning within the Reserve would not increase noxious weeds because the amount of disturbance and shade would minimize the potential for their establishment.

Long-term Sustainable Thinning Alternative (WM-3)

Under Alternative WM-3 the potential effects of increasing noxious weeds would be the same as described under Alternative WM-1 though the risk would be proportionally reduced because of the lesser acreage of timber harvest that would occur over the next 50 years (i.e., 19,660 compared to 25,820). The risk would also be reduced because commercial thinning has less site disturbance and provides more shade which minimizes the potential for noxious weed establishment. ecological and restoration thinning within the Reserve would not increase noxious weeds because the amount of disturbance and shade would minimize the potential for their establishment.

Thinning Alternative with Phased Out Commercial Timber Harvest (WM-4)

Under Alternative WM-4 the potential effects of increasing noxious weeds would be the same as described under Alternative WM-1 though the risk would be proportionally reduced because of the lesser acreage of timber harvest that would occur over the next 50 years (i.e., 20,970 compared to 25,820). The risk would also be reduced because commercial thinning has less site disturbance and provides more shade which minimizes the potential for noxious weed establishment. ecological and restoration thinning within the

Reserve would not increase noxious weeds because the amount of disturbance and shade would minimize the potential for their establishment.

No Commercial Timber Harvest Alternative (WM-5)

Alternative WM-5 would have the least likelihood of increasing noxious weeds because it does not have disturbance from commercial timber harvest. ecological and restoration thinning within the Reserve would not increase noxious weeds because the amount of disturbance and shade would minimize the potential for their establishment.

4.3.6 Anadromous Fish Mitigation Alternatives

Environmental review did not identify any potential impacts to forest resources from the Anadromous Fish Mitigation Alternatives because the activities described for these alternatives do not take place within or have an effect on the forest lands of the Cedar River Municipal Watershed.

4.3.7 Instream Flow Alternatives

Environmental review did not identify an potential impacts to forest resources from the Instream Flow Alternatives. However, please refer to Section 4.5.6 for information concerning the effects of instream flow alternatives on delta vegetation communities which include deciduous and coniferous resources.

4.3.8 Summary

A summary of environmental consequences for forest resources is presented in Table 4..3-6. These consequences are summarized here individually for each of the Watershed Management Alternatives. As discussed earlier, environmental review did not identify any potential impacts to forest resources from the Anadromous Fish Mitigation and Instream Flows Alternatives.

The environmental consequences on successional stages and commercial timber volumes result directly from the amount of area Reserved from harvest and the amount of area scheduled for timber harvesting, the timing of that harvest, the silvicultural prescriptions allowed, and the types of harvest systems used.

Under the No Action Alternative (WM-1) the resulting seral stages would be similar to the current mosaic of early, mid seral, and mature age class stands outside of the Reserve due to the 40 to 80 year rotation. Harvest prescriptions under minimum Washington FPA standards would retain the least number of Reserve trees under the alternatives that allow timber harvest. Precommercial or commercial thinnings would not take place outside the Reserve and ecological thinning and restoration treatments to accelerate late successional habitat characteristics inside the Reserve would not take place under Alternative WM-1.

The Proposed HCP Alternative for Watershed Management (WM-2) would create a greater structural diversity within the mid seral and mature stages through implementation of the proposed biodiversity pathways approach to forest management in second growth forests outside the Reserve. Early and mid seral habitat conditions would decrease over time as compared to Alternative WM-1. Late successional habitat conditions would increase through commercial thinnings designed to accelerate late successional habitat and the conversion to longer rotation ages. It would accelerate the development of late-seral conditions through ecological thinning and restoration treatments in the Reserve.

Alternative WM-3 would effect seral stages as described in the Proposed HCP Alternative (WM-2), except that no new early seral habitat conditions would be created by regeneration harvest. Over the 50 year HCP, early and mid seral habitats would be eliminated in their entirety and decrease in a substantial manner, respectively. Treatments inside the Reserve would be the same as described under the Proposed HCP Alternative for Watershed Management (WM-2).

Alternative WM-4 would effect seral stages the same as described for Alternative WM-3 during the next 50 years. At that time, all commercial timber harvest would stop and seral stage conditions would be influenced by the natural processes of succession, as described in Alternative WM-2.

Alternative WM-5 would eliminate commercial timber harvest completely and seral stages would be influenced by the natural processes of succession outside the Reserve, as described in Alternative WM-3. Inside the Reserve, ecological and restoration treatments would occur as discussed under Alternative WM-2.

Based on factors presented, Alternative WM-1 would have the greatest effect on vegetation. It would result in more early seral to mature aged stands, less structural diversity, and more fragmentation than the other Alternatives.

Alternative WM-2 would affect vegetation to a somewhat lesser degree by the larger size of the Reserve and retaining approximately 10 percent of the volume in green and wildlife trees from regeneration harvest and by using commercial thinning designed to develop multi-layered stands that would provide some degree of structural and species diversity while moving to longer (120 to 140 year) rotation lengths.

Alternative WM-3 would utilize only commercial thinning treatments designed to develop multi-layered stands that would provide some degree of structural and species diversity, while capturing mortality, e.g., the harvest of diseased, windthrown, or less vigorous, understory trees that normally succumb to competition.

Alternative WM-4 would utilize only commercial thinning treatments on four selected areas over a 50 year period, after which commercial harvest would end. The general effects on the Watershed's forest resources would be that the

majority of commercial timber stands would receive low to moderate impacts due to lesser intensity harvest treatments.

Alternative WM-5 would preclude commercial timber harvest and the entire Watershed would become a Reserve. There would be no opportunities to create multi-layered stand structure and restore habitats outside the Reserve through active management practices, except through restoration and ecological thinnings.

Alternative WM-1 would produce the highest timber harvests of approximately 21.3 MMBF per year, Alternative WM-2 would produce approximately 8.8 MMBF per year or an approximate reduction of 59 percent from the No Action Alternative. Alternative WM-3 would produce approximately 3.7 MMBF per year or an approximate reduction of 83 percent from the No Action Alternative. Alternative WM-4 would produce 3.5 MMBF per year, an approximate reduction of 83 percent from the No Action Alternative, due to having the highest harvest limitations among the action alternatives. Alternative WM-4 would phase out harvest after 50 years and Alternative WM-5 would eliminate commercial timber harvest.

Potential Impact Evaluated	Environmental Consequences					Comments
	Watershed Management Alternatives					
	WM-1	WM-2	WM-3	WM-4	WM-5	
Potential effects on structural diversity within timber stands and overall successional development	Positive Effects	Positive Effects	Positive Effects	Positive Effects	Positive Effects	Successional development on reserve lands for all of the alternatives would increase over the life of the HCP. Because of the large size of the reserve areas, each alternative is considered to have a positive effect on structural diversity and successional development on forest lands. The restoration and ecological thinning applications would help to facilitate the development of late-successional characteristics on stands within reserve areas. On non-reserve matrix lands for the No Action alternative, WM-1, the distribution of stand ages would reflect the rotation age of 60 years and maintain a majority of these areas in early seral and mid-seral age classes. As a result, commercial harvest under this alternative would result in a mosaic of homogenous, even-aged stands similar to those under existing conditions. Under WM-2, more late successional habitat conditions with greater structural diversity would be developed compared to WM-1. For alternatives WM-3 and WM-4, stand structure on non-reserve matrix lands would advance similar to natural successional processes but at a more rapid rate as a result of thinning applications.
Potential effects on species composition, including pure and mixed species stands, mixed conifer stands and deciduous stands	Negligible Effects	Positive Effects	Positive Effects	Positive Effects	Positive Effects	In general, the No Action alternative WM-1 would maintain the current species composition in the watershed on non-reserve matrix lands because regeneration harvest methods would create open conditions encouraging the development of shade intolerant species, such as Douglas-fir and red alder. For alternatives WM-2, WM-3 and WM-4, retention harvesting

Potential Impact Evaluated	Environmental Consequences					Comments
	Watershed Management Alternatives (cont.)					
	WM-1	WM-2	WM-3	WM-4	WM-5	
						and/or thinning applications. Retaining existing stand characteristics would tend to promote the growth of shade-tolerant species depending on how retention is applied across a particular harvest unit.
Potential to provide a sustainable harvest of commercial timber	Positive Effects	Positive Effects	Positive Effects	Does Not Apply	Does Not Apply	Sustainable commercial harvests of timber on non-reserve, matrix lands, are possible under alternatives WM-1, WM-2 and WM-3 with total volumes harvested over the 50 years of the HCP reaching 1,064, 440 and 184 MMBF, respectively. Alternatives WM-4 and WM-5 were not designed to provide a sustainable level of commercial harvest. Under the No Action alternative, WM-1, the distribution of stand ages would reflect the rotation age of 60 years and maintain a majority of the non-reserve, matrix lands, in early seral and mid-seral age classes. Under WM-2, more late successional habitat conditions would be developed compared to WM-1 and the distribution of stand ages would reflect the desired target of a sustainable harvest with a rotation age of 120 to 140 years at the end of the 50 year life of the HCP. Under WM-3, overall stand age across the landscape would increase.
Potential to create conditions that would contribute to windthrow damage problems	Positive Effects	Positive Effects	Positive Effects	Negative Effects	Negative Effects	Alternatives WM-1, WM-2 and WM-3 are not expected to create conditions that would contribute to windthrow. Thinning alternative WM-4 is expected to create windthrow damage problems on many sites due to the increased exposure of residual stands to high intensity windstorm events. Under the No Commercial alternative, WM-5, the potential for windthrow would increase above existing conditions.

Potential Impact Evaluated	Environmental Consequences					Comments
	Watershed Management Alternatives (cont.)					
	WM-1	WM-2	WM-3	WM-4	WM-5	
Potential to create conditions that would be detrimental to forest health, including insect and disease epidemics	Positive Effects	Positive Effects	Positive Effects	Positive Effects	Negative Effects	Alternatives WM-1, WM-2, WM-3 and WM-4 are expected to provide a moderate degree of protection against insect and disease epidemics. Under WM-5, the No Commercial Harvest alternative, natural agents detrimental to forest health, including not only windthrow but also insect and disease epidemics, would be expected to occur to the extent that intervention to prevent catastrophic impacts to the municipal water supply would be necessary.
Potential to create conditions that would increase the risk of forest fires within the watershed	Positive Effects (meaning risk would be minimized)	Positive Effects	Positive Effects	Positive Effects	Negative Effects (meaning risk would increase)	Proposed silvicultural activities under alternatives WM-1, WM-2, WM-3 and WM-4 would minimize the risk of forest fires within the watershed during the 50-year life of the HCP. Under WM-5, the No Commercial Harvest alternative, the potential for wildfires would be expected to increase to the point where intervention as part of a fire control plan would be needed to prevent catastrophic impacts to the municipal water supply.
Potential effects on rare plants	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Plant species listed as sensitive, threatened or endangered by either the State of Washington or the Federal government are not known to occur in the Watershed and are not expected to be found in the habitats subject to commercial timber harvesting or thinning applications within the Reserve areas.

	Watershed Management Alternatives (cont.)					
	WM-1	WM-2	WM-3	WM-4	WM-5	
Potential to increase the incidence of noxious weeds in the watershed	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Any ground disturbing activity has the potential to increase the incidence of noxious weeds. However, since noxious weeds are not currently a problem in the watershed, they are not anticipated to be a significant concern for any of the alternatives.
	Anadromous Fish Mitigation Alternatives					
	WM-1	WM-2	WM-3	WM-4	WM-5	
Environmental review did not identify any potential impacts to Forest Resources from the Anadromous Fish Mitigation Alternatives						
	Instream Flow Alternatives					
	IF-1			IF-2		
Environmental review did not identify any potential impacts to Forest Resources from the Instream Flow Alternatives						

Table 4.7-1 Summary of Environmental Consequences Evaluated for Land Use

Potential Impact Evaluated	Environmental Consequences					Comments
	Watershed Management Alternatives					
	WM-1	**WM-2**	**WM-3**	**WM-4**	**WM-5**	
Environmental review did not identify any potential impacts to Land Use from Watershed Management Alternatives						
	Anadromous Fish Mitigation Alternatives					
	AFM-1	**AFM-2**	**AFM-3**	**AFM-4**	**AFM-5**	
Environmental review did not identify any potential impacts to Land Use from the Anadromous Fish Mitigation Alternatives						
	Instream Flow Alternatives					
	IF-1			**IF-2**		
Environmental review did not identify any potential impacts to Land Use from the Instream Flow Alternatives						

4.4 Fisheries Habitat and Resources

This section considers the environmental consequences of the Watershed Management, Anadromous Fish Mitigation, and Instream Flow Alternatives on fisheries habitat and resources in the Cedar River Municipal Watershed.

4.4.1 Effects of Watershed Management Alternatives on Fish Habitat

Effects of the five Watershed Management Alternatives on fish habitats depends on how each alternative would protect or restore upslope and fluvial processes that create and maintain a diversity of fish habitats. The alternatives may influence sediment delivery, flow regimes, and riparian functions (see the discussion on the role of disturbance in shaping fish habitat in Section 3.4.2 on Fish Habitat). These functions may be altered by timber harvest and roading, as well as hillslope, road, and channel restoration efforts proposed for each alternative.

Conservation Features Common to All Watershed Management Alternatives

In considering the effects of the Watershed Management Alternatives on fish habitat, it is important to note that under all alternatives in which timber harvest occurs, stream buffers would be implemented on all streams and other bodies of waters as part of the Ecological Reserve, where no commercial timber harvest would be allowed (see Map 12). All riparian areas along rivers, streams, wetlands, lakes, and ponds within the Watershed are included in Ecological Reserves in all alternatives, including the No Action Alternative. The Ecological Reserve strategy was designed to incorporate all elements of the riparian ecosystem necessary to protect or restore the natural processes important in the creation and maintenance of complex stream channels that provide a diversity of fish habitats. The Ecological Reserves on fish-bearing waters are wide enough (minimum 300 feet both sides of channel) to provide a full array of ecological functions by including floodplains, wetlands, and unstable inner gorges that may deliver sediment and wood to the stream. Reserve widths on the perennial, non fish-bearing streams and on intermittent

channels are at least 100 feet horizontal distance on each side of the channel providing for the recruitment of Large Woody Debris (LWD), vegetation to supply food for macro-invertebrates, and shade to keep stream temperatures cool.

The stream buffers would include all known inner gorges, which represent an inherently high likelihood of delivering coarse sediment and wood from landslides. These buffers would prevent harvest-related landslides from initiating within the inner gorge. In the event of a naturally occurring landslide, retention of trees within stream buffers assure that woody debris could be incorporated into the stream system.

A minimum of a 100-foot-wide no commercial harvest buffer on both sides of Type 5 waters would also be established. The upstream head of steep Type 5 channels are common initiation sites of debris flows and debris slides. Mature streamside conifers can serve as a lateral barrier to landslides and channel barriers to debris flows, which limit the distance debris flows and dam break floods may travel from their point of origin. Without this functional capacity in the convergent "starting zones," these events may affect greater stream lengths and produce larger volumes of sediment delivered at terminal deposits.

In addition to the proposed Ecological Reserves, alternatives WM-1, WM-2, and WM-3 also include land designated as Special Management Areas (SMA) with constraints on timber harvest. Lands around Carey Creek have been designated as an SMA in order to minimize the potential for erosion and sedimentation to this anadromous fish-bearing stream.

The Ecological Reserves and SMAs in themselves protect fish habitat from most impacts associated with new timber harvest activities. In addition, new road construction would be very limited, primarily consisting of only short spur roads to access landings or for use of ground-based equipment in gentle terrain. New roads would rarely be constructed across any stream channel of any size. Construction of primary and secondary arterial roads would be done only where reconstruction of existing roadbeds are determined to pose more of a risk to deliver sediment to streams than alternative relocation.

Because of this, the risk of adverse effects to fish habitat is very minimal under any of the alternatives, as the dynamic fluvial and upslope processes that create and maintain fish habitat would be allowed to progress naturally. As described in Section 4.1 Soils and Geology, mass wasting associated with timber harvest and surface erosion due to logging traffic use of existing roads are the primary potential impacts to fish habitat from forest practices under all of the alternatives except for the No Commercial Timber Alternative (WM-5).

Under all of the alternatives except for the No Action Alternative, the Applicant would commit to a program of watershed restoration targeted at rehabilitation of significant ecological processes. Projects will be prioritized based on the ability to restore natural stream and fish habitat attributes, with

the highest priorities for projects which will enhance resources for threatened, endangered, or candidate species.

The anticipated effects to fish habitat from future timber harvest would vary only slightly among all alternatives. The primary difference between the No Action Alternative and the remainder of the alternatives is the watershed restoration programs that would be implemented under Alternatives WM-2, WM-3, WM-4 and WM-5.

No Action Alternative for Watershed Management (WM-1)

Under this alternative, timber harvest activities could be conducted in 42 percent of the Watershed, subject to State Forest Practice Rules. As describe in the preceding section, several measures would be implemented to minimize the influence of future timber harvest on fish habitat. An Ecological Reserve covering 58 percent of the Watershed, would be established where no commercial timber harvest activities would occur.

As described in Section 4.1 Geology and Soils, timber harvest under Alternative WM-1 poses a risk of triggering landslides to Damburat, Green Point, Otter, and Rack Creeks. Each of these creeks drains into Chester Morse Lake, and provide potential habitat for bull trout and rainbow trout in their lowermost sections. Habitat in each of these channels has had considerable disturbance from past debris flow events emanating from their respective headwaters. Any large and persistent increases in sediment delivery to these channels risks further channel aggradation, which can exacerbate habitat simplification and subsurface flows.

Other areas that could be affected by mass wasting include the upper portions of Rock Creek and the Taylor Creek forks. While wide buffers would exclude most of the toeslopes, timber harvest on upslope parts of these steep slopes could trigger shallow landslides, which could then deliver sediment to Taylor or Rock Creeks. Conditions in many of the high gradient confined channels of these basins are indicative of major sediment routing flows, whereas habitats within the alluvial fish-bearing reaches have been widened and simplified.

As described in the previous section, new road construction would be very limited. Although the effects of new road construction would be minimal, road failures that deliver sediment to channels could occur from existing problem roads to a similar degree as they have occurred in the recent past. Under the No Action alternative, re-construction and maintenance of roads associated with timber harvest specific to Forest Practice Permits would be required to meet updated Forest Practice Rules. State Forest Practice road construction and maintenance rules (WAC 222-24) have been designed to minimize delivery of sediment to stream channels. Road maintenance rules require adequate road drainage to prevent saturation of road fills and minimize the risk of road surface erosion delivering directly to stream channels during periods of high use. However, these updated standards need only be applied to the portions of

the road network used under a specific permit. There are existing roads that currently contribute fine sediment through surface erosion or have the potential to fail that are recognized as chronic sources of sediment in the basin, including roads associated with Boulder Creek and basins situated along the north side of Chester Morse Lake. Sediment from these roads are delivered to downstream fish-bearing reaches, including reaches used by bull trout in Boulder Creek. Under the No Action, maintenance of roads not part of the log hauling network would not be required under the state's Forest Practices Rules.

Under the No Action Alternative, no substantial increase in sediment delivery and attendant degradation of fish habitat caused by new forest practice entry would be anticipated. However, chronic sources of sediment and stream reaches impacted due to past forest practices would continue to influence the habitats for fish species of concern.

Proposed HCP Alternative for Watershed Management (WM-2)

Under the Proposed HCP Alternative, commercial timber harvest activity would be limited to just over 36 percent of the land base, whereas the Ecological Reserve area is increased to 64 percent of the Watershed as compared to the 58 percent set aside in the No Action Alternative (see Maps 13 and 15). This Reserve area builds upon the preliminary Reserve design established for the No Action Alternative. Additional areas for the protection of bull trout spawning and rearing habitat have been added to the Reserve system, as well as others to accommodate other resource concerns.

In addition to the fish habitat conservation features common to all action alternatives, the Applicant would commit to implement the set of Watershed Assessment Prescriptions described in the proposed HCP (see Technical Appendices 15 and 16). The Watershed Assessment Prescriptions require a slope-stability analysis prior to timber harvest or road construction on areas mapped as prone to landsliding. Site-specific operating prescriptions would be developed to avoid triggering landslides that would deliver directly to stream channels (see Section 4.1 Geology and Soils for further details on prescriptions).

Watershed Restoration

The Applicant would commit to a program of watershed restoration targeted at restoration of significant ecological processes. The most important and widespread elements of the restoration program are control and prevention of road-related sediment production, restoration of riparian functions, and restoration of instream habitat complexity. Other restoration opportunities, including culvert upgrades and replacement for fish passage and bank armoring, would be implemented on a more localized scale.

Road improvement

Under the Proposed HCP Alternative for Watershed Management (WM-2), the Applicant would commit to a program of road management and improvement designed to reduce sediment loading to streams from the road related landslides and surface erosion. The program would be based upon the results of a comprehensive Watershed Assessment and an analysis of road use and conditions. Numerous road segments have been identified as chronic sediment sources to fish habitat used by species of concern. Above the Chester Morse Lake, notable road related failures directly impacting bull trout spawning habitat include steep roads to the north of the Cedar River directly above the lake. The roaded valley walls of Boulder Creek are also chronic sediment sources via culvert and road failures. Extended riffles, bar development, and braiding have led to simplified habitat conditions downstream of these areas. Under the Proposed HCP Alternative, these roads would be targeted for improvement to decrease sediment delivery.

Road treatments will range from full decommissioning (closing and stabilizing a road to eliminate potential for storm damage and need for maintenance) to simple road upgrading.

Riparian restoration

Riparian areas will be managed to encourage development of diverse stream habitat. Some riparian areas of the Cedar River Municipal Watershed are dominated by early successional vegetation, the product of past management actions and watershed processes. The large conifers necessary to produce large, decay-resistant LWD are rare in some areas, especially in some young, hardwood stands. Management in these areas would focus on accelerating the development of diverse late successional forest stand conditions. However, development of riparian stands dominated by large conifers will take decades in many areas (Bisson et al., 1987; Sedell et al., 1988).

Proposed ecological thinning programs would promote restoration of large conifers in the riparian areas. Practices that would be considered include planting unstable and potentially unstable areas such as streamside landslide and flood terraces, thinning densely stocked young stands to encourage development of large conifers, releasing young conifers from overtopping hardwoods, and reforesting hardwood-dominated stands with conifer understory plantings.

Restoration of riparian functions is largely experimental at this time. While forest stand dynamics are well understood for upland conditions, less is known regarding streamside forests. Current research that provides direction for designing effective riparian restoration programs will be used as the basis for designing effective programs. Long term monitoring will be established in a rigorous experimental design to evaluate the effectiveness of any strategy implemented in the Cedar River Municipal Watershed.

Inchannel habitat structures

Deliberately adding LWD or boulders to streams which are deficient in this material is one aspect to the overall approach to restoring productive stream habitat. However, manipulation of instream habitat will not be effective if the factors which initially produced poor habitat are not addressed. The Applicant proposes to first identify and correct upslope factors that affect stream habitat. For instance, coarse sediment from landslides combined with a paucity of in-channel wood or large wood recruitment sources has led to simplified habitat conditions in some streams in the Watershed. The activities that perpetuated these poor habitat conditions would be corrected before attempting to address habitat deficiencies within stream channels.

Addition of LWD to streams may be used as an interim measure until riparian forest begins to deliver adequate amounts of LWD. In view of the considerable expense involved, addition of wood to channels should be limited to those areas where it is deficient and where there is a high probability of generating positive response to targeted fish species. To make this determination, the Applicant proposes to utilize the expertise of staff biologists and hydrologists.

Maintaining desired levels of channel habitat complexity in the short term may be best achieved by introduced structures, but a fully function riparian forest should be the source of large woody debris in the long-term. Inchannel restoration of stream habitat will be accompanied by riparian and upslope protection and restoration.

Overall, due to reduced timber harvest, greater acreage in Reserve areas, and site specific prescriptions on unstable slopes, there is a lower risk of sediment delivery to fish habitat as compared the No Action Alternative. Both the No Action Alternative and the Proposed HCP Alternative have the same stream buffer and inner gorge protection, and the difference in risk would be minimal. However, the watershed restoration program under the Proposed HCP Alternative would result in rehabilitation of habitat forming processes that were degraded by past timber harvest and road building activities, which would improve fish habitats in localized reaches.

Long-term Sustainable Thinning Alternative (WM-3)

Except for the way timber harvesting would be managed, all other elements of this alternative would be the same as the proposed action. The Ecological Reserve, covering 64 percent of the land base is the same for this alternative as in the Proposed HCP Alternative for Watershed Management (WM-2). All of the conservation strategies developed for streams, riparian areas, and species specific strategies under the Proposed HCP Alternative are also the same. Approximately 10 miles of new road construction would be needed as part of this alternative, primarily in the form of short spur roads required to establish landings for access to thin harvest units. The City would commit to implement

the set of Watershed Assessment Prescriptions described in the proposed HCP (Technical Appendices 15 and 16).

The main difference between this alternative and the Proposed HCP Alternative with respect to fish habitat is that commercial thinning rather than retention harvest would be conducted on non-reserve areas (matrix lands). Thinning would leave the dominant and co-dominant (larger) trees, while removing some of the smaller and less vigorous trees. Consequently, there is a slightly lower risk of mass wasting, although the Watershed Assessment Prescriptions in the Proposed HCP Alternative may result in thinning requirements anyway. Where applicable, all of the same forest management guidelines (constraints) and Watershed Assessment Prescriptions developed for the Proposed HCP Alternative hold for this alternative, as well.

The anticipated effects to fish habitat and fish species of concern under this alternative would be the same as that of the Proposed HCP Alternative.

Thinning Alternative with Phased Out Commercial Timber Harvest (WM-4)

This alternative is different from the previous alternative (WM-3) in three main ways. First, the Ecological Reserve for this alternative starts off approximately 3,795 acres larger than the Reserve area established for the Proposed HCP Alternative and Alternative WM-3. Second, although thinning is the only silvicultural method used to extract timber from non-reserve areas (matrix lands) under this alternative thinning would be scheduled primarily by stand age and size class within designated zones with different rates of harvest volume removal. Third, as these designated zones become thinned, they are added to the Reserve system over time until the commercial harvest of timber would be completely phased out in the Cedar River Municipal Watershed. All other elements of the Proposed HCP Alternative and Alternative WM-3 are the same for this one.

None of these actions would significantly alter the anticipated effects to fish habitat and species of concern relative to the Proposed HCP Alternative. However, because of the effective mitigation measures, harvest prescriptions and watershed restoration programs that would be established under the Proposed HCP Alternative, the eventual phasing out of logging in the Watershed would not create any significant benefits to the protection of fish habitat as compared to the Proposed HCP Alternative.

The anticipated effects to fish habitat and fish species of concern under this alternative would be the same as that of the Proposed HCP Alternative.

No Commercial Timber Harvest Alternative (WM-5)

Under this alternative all of the Watershed would be placed immediately into an Ecological Reserve. No commercial harvest of timber would take place. All

other elements of the proposed action, including the conservation strategies with proposed habitat restoration and enhancement projects, would also be implemented as part of this proposal.

The only difference between this alternative and the others is that the risk of sediment delivery to fish-bearing streams related to new timber harvest activities would be eliminated, as forest practice-related traffic would not occur and no new commercial timber harvesting would occur. However, because of the mitigation measures that would be incorporated into all of the other Alternatives with regards to future timber harvest entry, the difference in the risk to fish habitat between them and the No Commercial Timber Harvest Alternative is minimal and would likely not be detectable.

The anticipated effects to fish habitat and fish species of concern under this alternative would be the same as that of the Proposed HCP Alternative.

4.4.2 Anadromous Fish Mitigation Alternatives

Fish Habitat and Resources

Introduction

This section discusses the effects that might result from measures taken to mitigate for the Applicant's blockage to migrating salmonids at the Landsburg Diversion. The chapter is organized into four major sections. This section, Section 4.4.2.1, will briefly reintroduce the alternatives described in Chapter 2 and the Applicant's objectives regarding mitigation. In addition, this section will introduce the measures included in the different alternatives. The subsection entitled "Environmental Consequences of the Different Mitigation Measures" describes the measures in more detail and discusses the possible effects that could result from implementing the measures. A comparison of the five alternatives considered for detailed analysis is presented in the subsection entitled "Comparison of Alternatives." Finally, summary remarks are made at the end of the section.

Alternative measures for mitigating the Applicant's blockage to migrating salmonids at the Landsburg Diversion and other operations have been discussed extensively in both technical meetings and public forums. The five alternatives to be analyzed in detail are as follows:

- No Action Alternative (AFM–1)
- Proposed HCP Alternative for Anadromous Fish Mitigation (AFM–2)
- Downsized Sockeye Hatchery Alternative with Savings Going Towards Downstream Habitat Restoration (AFM-3)
- Deferred Hatchery Construction Alternative Contingent on Evaluation of More Information (AFM–4)

- All Downstream Habitat Restoration and Protection Alternative (AFM-5)

The Proposed HCP Alternative and other alternatives include four different types of measures that would be implemented in various combinations at different intensity levels. These measures are as follows:

1. Measures for chinook salmon, coho salmon, and steelhead trout
   - Interim measures designed to increase knowledge of the factors affecting these species in the basin and/or to provide emergency supplementation
   - Upstream and downstream passage facilities at Landsburg Diversion
   - An Ecological Reserve upstream of Landsburg Diversion that will result in protection and restoration of aquatic habitat

2. Artificial supplementation for sockeye salmon
   - An interim fry hatchery producing up to 16 million fry operating up to 12 years
   - A replacement hatchery capable of producing either 17 or 34 million sockeye fry, or no replacement hatchery

3. Expenditure of up to $24.1 million for downstream habitat
   - Implementation of valley floor restoration and rehabilitation projects identified by King County
   - Acquisition of lands along the lower Cedar River
   - Reclamation and restoration of the Cedar River floodplain and riparian zone
4. Research and monitoring

The comparisons of alternatives in Section 4.2.4.3 primarily concern the measures for mitigating the upstream migration blockage at Landsburg for sockeye salmon. Mitigation measures for coho, chinook, and steelhead are the same for Alternatives AFM-2, AFM-3, AFM-4, and AFM-5. In addition, research and monitoring will occur regardless of the alternative selected for implementation. However, the types of research and monitoring would depend upon the mitigation measures selected for sockeye salmon. The Applicant's instream flow proposal is also an important component to the health of anadromous fish stocks in the river, but is considered separately in Section 4.2.3.

Each of the alternatives is evaluated in the section below entitled "Comparison of Alternatives" against its likelihood of meeting the six primary objectives for the conservation of anadromous fish in the Cedar River developed by the Cedar River Policy and Technical committees and the City. These objectives are as follows:

1. Implement biologically sound, short- and long-term solutions that help provide for the recovery and persistence of well-adapted, genetically diverse, healthy, harvestable runs of sockeye, coho, and chinook salmon and steelhead trout in the Cedar River without negatively affecting other naturally reproducing stocks within the Lake Washington Basin.
2. Maintain a safe, high quality drinking water supply.
3. Implement restoration alternatives that have a high likelihood for success and that provide substantial value for target resources.
4. Provide fish passage over the Landsburg Diversion Dam, consistent with water quality protection, that is coordinated with run recovery, biological need, water supply operations, and facility maintenance requirements.
5. Coordinate with and support other compatible fish rehabilitation activities to help realize the full benefits offered by aquatic resource conservation efforts in the Lake Washington Basin.
6. Design restoration measures in a manner that satisfies the Applicant's mitigation objectives for the fish migration blockage created by the Landsburg Diversion, as defined by state and federal law and pursuant to City ordinance and initiatives. (Please note that alternatives utilizing downstream habitat restoration as a key component for sockeye mitigation are subject to approval by WDFW.)

Detailed descriptions of the activities and a discussion of the likely environmental consequences will be presented in the following section.

The CRAFC will advise and consult with the City to incorporate the best available science in the implementation of fisheries measures. These measures are intended to benefit the fishery resources of the Cedar River by protecting, improving, and increasing fish production and available habitat. The City, in cooperation with the other parties, will conduct studies of the fish populations and monitor the fisheries measures, then act on the results to manage anadromous fish mitigation in an adaptive fashion.

Environmental Consequences of the Different Mitigation Measures

Measures for Chinook Salmon, Coho Salmon, and Steelhead Trout

All of the alternatives except for the No Action Alternative include similar interim and long-term mitigation measures for chinook and coho salmon and

for steelhead trout. Funding for these measures will total $8.8 million over 50 years (Table 4.4-1).

Landsburg Diversion Dam

Interim Measures for Chinook, Coho, and Steelhead

The Applicant proposes the expenditure of $90,000 per year for scientific studies and/or a broodstock augmentation program, if appropriate for one or more species, under all reasonable alternatives other than the No Action alternative. Studies would be designed to provide information for the development of alternatives that could be implemented for the protection and recovery of the runs. If one or more of these populations are believed to be declining towards extinction, the Parties to the Landsburg Mitigation Agreement may decide that a portion of the investigation funds could be spent on an emergency supplementation program to help recovery of one or more of the stocks, prevent extinction or loss of genetic diversity, and provide supplementation monitoring.

Table 4.4-1. Cost allocation (in millions of dollars) for mitigation measures among alternatives

Mitigation Category	AFM-1	AFM-2	AFM-3	AFM-4	AFM-5
Measures for chinook, coho, and steelhead	0	8.8	8.8	8.8	8.8
Artificial supplementation for sockeye	14.6	22.5	18.9	4.9 to 22.5[1/]	0
Downstream habitat	0	1.6	5.2	1.6 to 19.3	24.1
Research and monitoring	0	3.7	3.7	3.7	3.7
Total Cost	14.6	36.6	36.6	36.6[1/]	36.6

1/ Higher hatchery costs resulting from a deferred decision would require cutting costs for other mitigation categories so that total costs are no more than 34.4 million.

Emergency supplementation of chinook, coho, or steelhead will only be used as interim mitigation if the parties to the Landsburg Mitigation Agreement all agree that:

- Such intervention is needed for the purpose of population support;
- Supplementation can be conducted without significant risks to the population being supplemented;
- Risks of supplementation can be effectively monitored and managed adaptively to protect the long-term genetic integrity and demographic viability of the target population; and
- Risks of supplementation of the target population will not result in significant risks to non-target salmonid populations.

Passage at Landsburg Diversion for Chinook, Coho, and Steelhead

The Applicant proposes the construction of two upstream fish ladders (at the diversion dam and the pipeline crossing), downstream passage facilities, and fish screens on the intake at the Landsburg Diversion to provide passage and protection for coho salmon, chinook salmon, and steelhead trout, allowing access upstream to the lower Cedar Falls, a natural migration barrier. These passage facilities are the principal mitigation measures the City proposes for these species. Costs for the fish ladders and screen facilities are projected to be $2,011,000 and $2,859,000, respectively. Construction of the ladders is expected to make 12.4 miles of the mainstem Cedar River and 4.6 miles of associated tributary streams (Rock Creek, Taylor Creek, Williams Creek, and Steele Creek) accessible for the spawning and rearing of these three species. It is expected that the design, permitting, and SEPA review of the passage project would require approximately 4 years for completion, and that construction could take up to two years.

The two ladders and associated sorting facilities will be designed for selective passage of coho, chinook, and steelhead and for exclusion of sockeye. As

presented previously, an important objective for the City's anadromous fish conservation program is maintenance of a high-quality drinking water supply for the City of Seattle. An analysis by Ebasco (1988) suggested that water quality impacts could be substantial if sockeye were allowed above Landsburg. In addition, a more quantitative assessment by CH2M HILL (1996) indicated that current levels of total phosphorus and carbon would increase an estimated 0.81 percent and 0.12 percent, respectively, from 4,500 coho and 1,000 chinook (46,500 pounds total) passed above Landsburg Dam, but would be insignificant and difficult to detect under field conditions. If 262,000 adult sockeye were allowed to spawn, approximately 1,310,000 pounds of carcasses would be available for decomposition above Landsburg. The consequences of this 34-fold increase in biomass from sockeye over the numbers examined in the CH2M HILL (1996) study would be a substantially higher risk of negatively affecting drinking water quality.

No sockeye will be passed above Landsburg Diversion because of the risk to, and importance of, drinking water quality. Despite the relatively low expected levels of risk, monitoring will be conducted to ensure that passage of coho, chinook, and steelhead will not affect water quality. If problems arise, passage of these species may have to be curtailed to some extent and an alternative mitigation measure pursued. Additional discussions of water quality issues that relate to the passage of anadromous fish above Landsburg Diversion are provided in Section 4.2.2.

The Applicant has agreed with fisheries resource agencies that the existing screening facilities at the raw water intake structure are inadequate and do not meet state and federal standards for the safe downstream passage of juvenile salmon. Consequently, construction of new screening facilities is proposed. Turbidity increases that could degrade drinking water quality below acceptable standards, possibly risking regulatory action regarding raw water quality, are expected during the period of construction. To maintain water quality, construction of the screening facility is planned to occur shortly after the completion of an ozone water treatment plant expected in 2004, with associated transfer of the new raw water quality compliance point to Lake Youngs. In addition, The City anticipates that the frequency and magnitude of short term turbidity events associated with construction activities will be minimized or avoided by implementation of protective measures during construction. Operations of the screening and passage facilities after construction are not expected to effect turbidity.

Assuming the approval and implementation of the proposed HCP in 1999 and a 6-year construction timeline for passage facilities at Landsburg, upstream passage for chinook, coho, and steelhead above Landsburg would begin in 2005, and downstream migration of the earliest juveniles produced upstream (chinook) would begin in 2006. However, the fish screens should be in operation by 2006, provided the ozonation plant is completed on schedule

(2004), so there should be no period in which migrating smolts of any of the three species would be exposed to the currently inadequate screens on the water intake. In the event that the City is not able to have fish screens or passage facilities in operation by those times, the City would provide interim mitigation funds, and the City, together with NMFS and WDFW, would oversee compensating mitigation (see Appendix 28, Section C for details).

Ecological Reserve in the Cedar River Municipal Watershed

The benefits of passage facilities at Landsburg Diversion are expected to be high because excellent fish habitat and water quality are present in the section of the Watershed between Landsburg and Cedar Falls. To a large extent, this portion of the river consists of second-growth forest that was initially cut early in the century and is gradually returning to a late successional stage. Lands within the basin upstream of Landsburg are wholly owned by the City. Protection and improvement of conditions on these lands and streams are expected to be substantial as part of many of the proposed watershed management strategies described in Chapter 2. Significant components of the watershed management strategy that effect anadromous fish include the following:

- An Ecological Reserve of between 64 and 100 percent of the City's ownership
- Road management and improvement
- Stream and riparian zone restoration
- Fish passage at road crossings for all fish-bearing streams
- Erosion and mass wasting protection
- Research and monitoring.

These components are expected to maintain or improve the existing habitat conditions (improved water temperatures, more natural rates of fine sediment loading and transport, and increased instream large woody debris) in the Cedar River above Landsburg.

Artificial Supplementation for Sockeye

Three of the four action alternatives may include sockeye supplementation by a combination of continuing the interim hatchery and building a permanent hatchery facility for producing sockeye fry. Several key objectives have been established for the sockeye fry-production program. First, the replacement sockeye hatchery should be designed to produce up to 34 million fry. Second, the program should be designed to produce fry that are equivalent in quality to those that are produced naturally. Third, the program should avoid or minimize detrimental impacts on the reproductive fitness and genetic diversity of naturally reproducing sockeye salmon populations in the Cedar River and Bear Creek subbasins. Fourth, the program should avoid or minimize detrimental ecological impacts on native salmonids throughout the Watershed.

Collection of broodstock from the Cedar River weir for the interim sockeye hatchery at Landsburg

The biological rationale for a hatchery is straightforward, but there are several possible negative effects. Recognition of these possible negative effects allows the development of monitoring and procedures to minimize or avoid them. This is an integral part of the alternatives that include a hatchery component.

The benefits from a sockeye fry hatchery result primarily from increases in egg-to-fry survival. The natural mortality of incubating eggs in the gravel can be considerable. Egg-to-fry sockeye survival rates are typically below 20 percent and averaged near 10.5 percent for six Alaska populations reported by Foerster (1968), but can be substantially higher or lower in a given year or river. In contrast, egg-to-fry survival within a hatchery can exceed 90 percent.

Because egg-to-fry survival is an important factor that contributes early in the life history to fish productivity, the difference in survival rates means a hatchery can increase the overall productivity of the stock. However, the negative effects described below, if left unmitigated, can limit both the potential of the hatchery stock and nearby naturally reproducing stocks.

There are a number of factors controlling sockeye productivity in the Cedar River that are largely beyond the City's control, including ocean conditions, conditions in the estuary, harvest rates, fish passage conditions at the Ballard locks, conditions in Lake Washington, habitat impacts, and the degree of channel confinement downstream of the Landsburg Diversion Dam. However, through the proposed HCP, the City would be making contributions to solving problems at the Ballard Locks and in Lake Washington, and protecting and

restoring habitat in the Cedar River downstream of the Landsburg Diversion Dam. More importantly, through its commitments in the proposed HCP, the City would mitigate for the impacts of its water supply facilities and operations on the Cedar River, thereby contributing to the conservation of sockeye salmon.

As described earlier in the Affected Environment, scour events have been identified as an important factor frequently reducing sockeye egg-to-fry survival. Consequently, one major benefit of an artificial propagation program is the ability to consistently supply Lake Washington with sockeye fry, regardless of in-river conditions that might negatively affect egg-to-fry survival. Because IHN virus is present in the Cedar River sockeye stock, it can be expected that a portion of the fry produced naturally will carry IHN and suffer its effects. Thus, an additional benefit of a sockeye hatchery, described in more detail later, is that it could produce disease-free fry.

The Washington Department of Fish and Wildlife has calculated that construction of a hatchery capable of producing 34 million sockeye fry of comparable quality to naturally reproducing fry will meet the sockeye mitigation required of the City for the presence of Landsburg Diversion. Consequently, preliminary plans for estimating costs have used this production level as a design criterion. Cost estimates have also been completed for a long-term hatchery capable of producing 17 million fry, included in alternative AFM-3. Alternative AFM-4 proposes to continue production of up to 16 million fry from the interim hatchery for the first 12 years of the HCP. The types of potential risks and effects possible from producing between 16 and 34 million fry are similar; however, the level of risk and magnitude of potential effects, both positive and negative, can be related to the level of production. Section 4.2.4 compares the risks and effects of the alternatives, while this section provides a general discussion of the possible effects.

Extensive use of hatcheries during this century has demonstrated there are risks that less-than-expected adult production and negative effects to nearby naturally reproducing stocks can occur. These risks/effects can be grouped under six general issues:

- Genetics and domestication
- Disease
- Water use and quality
- Effects of straying on naturally reproducing stocks
- Effects of harvest on naturally reproducing stocks
- Competition with naturally reproducing stocks for limited resources
- Other ecological effects on salmonids other than sockeye, including chinook and steelhead

WDFW's experience with anadromous and resident fish stocks has shown that these risks must be carefully considered. Negative effects of hatcheries, primarily on naturally reproducing coho, chinook, and steelhead stocks in many areas of the state, have contributed to the development of the Washington State's Wild Salmonid Policy. This policy represents a dramatic change in the state's management direction and emphasizes the protection and rehabilitation of naturally reproducing fish stocks (WDFW, 1997). The following paragraphs discuss these risks in detail and describe risk reduction techniques to be implemented under any of the alternatives that propose the use of a hatchery to increase sockeye fry production.

In reviewing this section, it is important to keep in mind that the current Cedar River sockeye stock was introduced to the system in the 1930s from Baker River stocks. The current run of sockeye is not indigenous to the Cedar River. Although considered by the state as a wild stock (naturally reproducing), the Cedar River stock is not considered at this time by NMFS to be determined as a species for consideration for protection under the Endangered Species Act. However, the stock present in Bear Creek, a tributary to the Sammamish River, is potentially of native origin (FR, Vol. 63, No. 46, pp. 11749-11771; Waples, 1998).

The Bear Creek population is considered by NMFS to be provisionally determined to be a species for consideration of ESA protection, although it is not believed to be presently in danger of extinction nor likely to become endangered in the foreseeable future if present conditions continue (FR, Vol. 63, No. 46, pp. 11749-11771). Enhancement of the sockeye population on the Cedar River could impact the Bear Creek population through straying of adult fish at spawning.

Genetics and Domestication

Maintenance of the genetic integrity of the Cedar River sockeye stock is important. Shifts in run timing, fish size, age of maturity, growth rates, and other heritable characteristics can be detrimental to stock productivity (Reisenbichler, 1996). These characteristics can change when factors limit successful reproduction to only a portion of the total population or available gene pool. Selective factors can be both natural and artificial. Artificial selective factors can include a fishery and hatchery management practices. For example, a fishery can selectively remove a greater proportion of larger individuals (e.g., a gillnet fishery) or a temporal segment of the run (Reisenbichler, 1996). Removal of larger individuals could lead to a smaller average size fish. Similarly, a fishery removing a higher proportion of early-run fish could gradually lead to a run that returns later in the year.

Domestication selection can affect the reproduction fitness of salmonids reared in hatcheries. A complimentary issue is the gradual domestication of a hatchery stock that is different from its adjacent naturally reproducing stock. Domestication results from adaptation to the hatchery environment compared

to the environmental stresses in a stream. Environmental stresses can include fluctuations in temperature and other physical factors, predation, and competition. Domestication leads to fish that grow and survive well in the hatchery, but may have relatively poor survival when released and are genetically inferior to their naturally reproducing counterparts (Reisenbichler, 1996). Mate selection, spawning site selection, and in-gravel survival all are phases of the reproductive process during which selection can be expected to differ between a sockeye hatchery environment and the natural environment (Waples, 1998).

Fish produced by the hatchery are intended to be genetically, physiologically, behaviorally, and ecologically similar to those produced naturally. As a result, naturally and artificially spawned fish in the Cedar River will be considered a single stock for management purposes. In a recent review, Waples (1998) suggests that the proposed program creates a moderate to high risk that some level of domestication will occur in the Cedar River sockeye population as a result of the proposed artificial propagation program. The review points out that, while the selective pressure for domestication per generation is likely to be relatively weak compared to hatchery programs that artificially rear fish for months or years, the risk of some level of domestication remains significant for three primary reasons: 1) differences in selection pressures between the hatchery and the wild, primarily with respect to spawning and mate choice behavior and the egg-to-fry life history stage; 2) the proposed duration of the program (indefinite); and 3) the relatively high proportions of the composite population that may be of hatchery origin in each generation.

The risks of domestication will be managed through the use of operational guidelines, monitoring, and an adaptive management program that will be developed and implemented by the City by agreement of the parties to the Landsburg Mitigation Agreement and in consultation with the CRAFC.

Waples (1998) cites six parameters that control the degree to which a hatchery program domesticates a wild population: "…1) the source of the broodstock and the degree to which it is already domesticated, 2) the degree to which the broodstock sample is representative of the target population, if the target population is itself the broodstock source, 3) the degree of difference between the wild and hatchery environments, 4) the duration of the hatchery program, 5) the level of gene flow between the hatchery and wild environments, and 6) the genetic basis for the traits subject to domestication selection. The first five parameters will be directly addressed by the proposed program. The program also will provide the opportunity to obtain additional information on the sixth parameter.

Although the Cedar River sockeye population was originally introduced from the Baker Lake system in the Skagit River basin, the population has been reproducing naturally in the Cedar since 1945 and is therefore believed to exhibit little or no evidence of domestication at the present time. Using run timing projections developed with the benefit of over 25 years of run timing

data, broodstock collection protocol will guide the collection of adults for the hatchery over a 3-month period in a manner that minimizes the risks that the hatchery broodstock will not be sufficiently representative of the target population. Selective pressures associated with a hatchery rearing environment will be minimized by avoiding rearing altogether or limiting rearing to very short periods of 1 to 2 weeks if such practice is deemed appropriate to ensure that hatchery fry are physiologically and ecologically similar to naturally produced fry. The level of gene flow from naturally produced fish into the hatchery produced component of the population is expected to be relatively high. Although the actual proportion of the naturally produced component of the population will vary from year-to-year due to factors such as flooding, other HCP commitments to improved instream flow management, habitat protection, and restoration will help promote robust levels of natural production and therefore help maintain and potentially increase the number of sockeye that are naturally produced each year. Additional habitat protection and restoration in the riparian areas and floodplain downstream of Landsburg will help ensure that a high proportion of the juvenile fish produced in the Cedar River will result from natural production.

The degree to which domestication selection in the proposed program might result in a decline in reproductive fitness is uncertain. Because all hatchery fish will be marked, the relative proportions of hatchery and naturally produced adult and juvenile salmon can be determined in every brood year. Trends in egg to fry survival and spawner to return ratios in the naturally reproducing component in the population will be monitored for indications of changes in reproductive fitness. If trends in these parameters indicate an unacceptable decline in reproductive fitness when compared to pre-project levels, the City, by agreement of the parties to the Landsburg Mitigation Agreement and in consultation with the CRAFC, will implement appropriate changes in operations and/or production levels.

Operation at the interim sockeye hatchery has demonstrated that the incubation period in the hatchery tends to be shorter than the in-river incubation period because of relatively warmer winter incubation temperatures in the hatchery. Changes in this life history feature can affect emergence timing, the timing of entry into the lake, and subsequent survival in the lake rearing environment. Facilities will be designed to include the ability to chill incubation water, allow volitional fry emergence and release, and to rear fry for up to two weeks in order to more closely simulate the condition of naturally produced fish (if determined to be appropriate after experimental testing).

The operation of traps in tributaries to the Columbia River to collect broodstock for supplementation efforts have sometimes failed to obtain a representative subset of the target population, have delayed migration to target and non-target stocks, or have resulted in the redistribution of the spawning population (Bugert, 1998). The weir collecting broodstock for the sockeye

hatchery will be designed to minimize the risk of these failures occurring, although some risk of such effects will exist. The weir will be designed for ease in deployment and recovery. Brood collection facilities will be designed to maximize opportunities to collect brood stock in a manner that is representative of the entire population. Migration delay to non-target fish at the weir is expected to be minimal and can be readily monitored over time. Operation of the weir will be intermittent, and will allow uninhibited passage of all upstream migrating fish during periods when the trap is not in operation. When the trap is in operation, non-target fish will be routed back to the river upstream of the trap.

Small differences in the natural selection pressures that could cause morphometric or phenotypic divergence among hatchery fry and naturally produced fry are possible. In particular, selection processes that may be associated with the choice of redd site and mate selection will not be impressed upon the hatchery-produced fish. Here again, the concept of a composite population will reduce the risk and help maintain the population's reproductive fitness. Each year, most of the hatchery-produced fish that return to the system will be spawning under natural conditions and will, thus, be subject to whatever natural selection pressures might be associated with mate and redd site selection. If habitat conditions in the lower river can be maintained and improved, these fish, in conjunction with other naturally produced fish, will contribute a major portion of the total number of sockeye fry entering Lake Washington.

In summary, all of the alternatives that include a hatchery component attempt to test the null hypothesis that naturally produced sockeye fry and those produced in the hatchery are similar. As discussed in Section 3.4.5, all hatchery fry are given an otolith (ear bone) mark that allows hatchery incubated sockeye fry to be distinguished from naturally reproducing fish. Monitoring programs that sample fish at different life stages will be implemented to obtain data on specific attributes such as survival rate, size, age of maturity, time of return, and spawning distribution that can be used to evaluate the hypothesis. Included in the monitoring program will be the use of new tools to measure differences in genetic attributes at the molecular level. Contingency plans will be developed and implemented if the null hypothesis is false.

Disease

Diseases can negatively impact both naturally reproducing and hatchery fish. Because of the relatively high fish densities present in hatcheries, however, disease outbreaks can rapidly strike a large percentage of a hatchery population. On the other hand, treatment and control of diseases is feasible in a hatchery setting, but nearly impossible in naturally reproducing populations and even very difficult in constructed spawning channels. Infectious hematopoietic necrosis (IHN) virus is of particular concern in sockeye salmon.

The IHN virus can cause high juvenile mortality rates and is common throughout the Pacific Northwest. It has been observed in the natural Cedar River population at infection rates approaching 100 percent in some years (Seattle Water Department, 1991). The IHN virus can be transmitted between parents and their progeny, between fish, and via the water supply.

Current disease control guidelines for the interim hatchery follow the Alaska Sockeye Culture Protocol, which has been effectively employed in Alaska for over 15 years (McDaniel, et al.). Detailed hatchery operating protocols for the permanent facility will be developed during Year 1 of the proposed HCP if the hatchery is implemented. Some of the guidelines specific to the control of IHN and other diseases include the following:

- Disinfecting eggs
- Incubation of eggs in small lots with independent water routing to prevent disease transmission between lots
- Monitoring eggs for disease
- Destruction and disposal of IHN-infected eggs.

Despite detailed guidelines, disease control may not always be 100 percent. However, the guidelines should minimize the risk of a substantive failure in any brood year. Guidelines currently in place at the interim sockeye fry hatchery have provided an excellent record for IHN prevention. During 6 years of producing fry at the interim hatchery, the IHNV has been detected only once in a single small group of fry and was fully contained. The production of IHN-free sockeye fry in the hatchery, plus the concept of a composite population, has the potential to reduce the incidence of IHN infection throughout the Cedar River Basin.

Water Use and Quality

The proposed hatchery will require the non-consumptive use of water for its operation during a portion of the year. The water source for the proposed hatchery will be a set of natural springs that flow into the Cedar River near the Landsburg Dam. The total maximum flow from the hatchery is expected to be approximately 4 to 5 cfs (incubators plus any operating fry raceways). This water is expected to reenter the river at a point less than 1/3-mile below its present entry point. The minimum allowable stream flow in the Cedar River during the period in which the hatchery will be operating at full capacity is 250 cfs. Stream flows are expected to be well above minimum levels for much of this period. Consequently, less than 2 percent of the river flow would be diverted over a relatively short section of river.

Since the hatchery will be primarily a spawning and incubation facility, there will not be large amounts of organics introduced into the water in the form of food and fish feces. The maximum discharge of slightly over 2-cfs from the facility incubators at full production may carry a slightly elevated

concentration of metabolites from developing embryos. These substances are generated by naturally incubating fish in the river, and increases in their concentrations downstream of the hatchery will be extremely minor and undetectable.

Some chemicals (primarily formalin, hydrogen peroxide, and iodophor) will be used to treat or prevent disease outbreaks in the hatchery. Iodophor residues will be contained and properly disposed to prevent any negative effects. Formalin treatments of incubating eggs are administered at very low concentrations and effluent will be below the limit specified in the applicable NPDES permit. These, and any other chemicals utilized in the hatchery will have standards and guidelines developed for their use and disposal. Consequently, few to no negative effects are expected from their use, and substantial benefits are expected for the control of disease in the hatchery.

Effects of Straying on Naturally Reproducing Stocks

Salmon are known throughout the world for their ability to home to their natal stream for spawning. The high proportion of homing fish in a population is an important factor contributing to the development of stock-specific characteristics (Quinn and Dittman, 1990). However, the complement to homing, straying, is also important for the colonization of underutilized streams (Quinn and Dittman, 1990). Straying rates of about 5 percent are considered typical for Pacific salmon (Hasler and Sholtz, 1983), but rates as low as 1 percent have been reported for several sockeye stocks in British Columbia (Quinn et al., 1987).

As presented earlier, the Cedar River stock is derived from Baker Lake on the Skagit River. Naturally reproducing sockeye stocks are present in Cottage and Bear Creeks that drain to the Sammamish River (Hendry et al., 1996). Sockeye also spawn along beaches in Lake Washington, in Issaquah Creek, and in other creeks in the Lake Washington basin. It is currently unknown what level of straying occurs between these stocks, but some likely occurs. These naturally reproducing populations are considered to be depressed by the WDFW (WDFW, 1992) and escapement has been as low as 1,795 fish within the combined Cottage and Bear Creek drainage (Hendry et al., 1996). As noted above, however, NMFS does not consider the Bear Creek population to be presently in danger of extinction nor likely to become endangered in the foreseeable future if present conditions continue (FR, Vol. 63, No. 46, pp. 11749-11771) .

Substantial increases in the number of strays from the Cedar River, regardless of whether they are hatchery or naturally produced, to tributaries containing naturally reproducing stocks have the potential to degrade the genetic integrity of the naturally reproducing stocks. Although the number of strays that would represent a substantial proportion of the naturally reproducing stocks has not been defined, the current genetic structure of populations of sockeye within the Lake Washington basin has been investigated by Hendry et al. (1996). The

available evidence from Hendry et al. (1996) suggests that no substantial introgression has occurred between Cedar River and the naturally reproducing stocks in Bear Creek.

The available evidence from Hendry et al. (1996) suggests that no substantial introgression has occurred to date between Cedar River and the naturally reproducing stocks in Bear and Cottage Creeks. To minimize the risk of future introgression between the Cedar River and Bear Creek populations that might occur with augmented sockeye production in the Cedar River, the City will fund a monitoring program to measure the rate at which artificially propagated Cedar River sockeye stray into Bear Creek. All fry released from the interim and proposed new hatchery will carry distinguishing marks on their otoliths. By agreement of the parties to the Landsburg Mitigation Agreement (Appendix 28) and in consultation with the CRAFC, the City will develop thresholds for straying rate and will monitor the incidence of spawning Cedar River sockeye in the Bear Creek system. Should measured straying rates exceed established thresholds, the City, by agreement of the parties to the Landsburg Mitigation Agreement (Appendix 28) and in consultation with the CRAFC, will develop and implement appropriate corrective measures ranging from alterations in operational practices to reductions in production levels.

Effects of Harvest on Naturally Reproducing Stocks

One of the major objectives of the City's mitigation plan is to contribute to the development of a viable tribal and sport fishery for in Lake Washington. Current sockeye production levels provide for a fishery 1 out of 4 years or less, because run sizes are insufficient to meet escapement goals. A consistent fishery that operates every year is desirable, has a positive effect on the local economy, and contributes to a lifestyle valued in the Pacific Northwest. These components are discussed in the Recreation and Socioeconomic Sections of this EA/EIS.

Although sockeye is only one of the four salmon species utilizing the Lake Washington basin, it has the greatest possibility for producing a sizable fishery because of its life history and obligatory lake-rearing phase, in which there is essentially no competition among fry for food in their natal stream. In contrast, coho and steelhead stocks that live in the basin rear in streams for a year or more. Consequently, the availability of rearing habitat limits the production of these stocks to substantially lower levels relative to sockeye, which is considered to be a mass-spawner. Ocean-type chinook are less dependent on instream rearing environments than coho and steelhead. However, a significant portion of most ocean-type juvenile chinook populations rear for up to 3 months in streams and are therefore also significantly more dependent upon stream environments than juvenile sockeye. The chinook population in the Cedar River may be further limited by the substantial anthropogenic alterations in the hydrologic configuration of the

basin that have placed a very large natural lake directly in the path of outmigrating under-yearling juvenile fish (Chapter 3.4).

Management of a Lake Washington fishery and its anadromous fish stocks can be complicated. One ramification of the higher productivity of a hatchery stock is the concomitant increase in harvest that the stock can provide. Harvest rates on a hatchery stock can be as high as 95 percent (Hilborn, 1992), while naturally reproducing fish stocks can seldom sustain rates much higher than 50 to 60 percent (WDFW, 1997). Consequently, in a mixed-stock fishery containing both hatchery and naturally reproducing fish, harvest at a rate appropriate for the hatchery fish over-exploits the naturally reproducing stock. In contrast, if harvest occurs at a rate appropriate for the naturally reproducing stock, hatchery fish are under-exploited. Under the Proposed HCP Alternative, all Cedar River sockeye would be considered a single stock with a productivity level that includes a composite egg-to-fry survival rate from both hatchery and naturally reproducing fish. Consequently, mixed-stock fisheries would only occur when these fish are present in harvest areas containing other stocks originating from outside the Cedar River basin.

The potential problems associated with a mixed-species fishery for sockeye are not considered a concern for coho salmon and steelhead trout because they are not present in Lake Washington during the period in which sockeye salmon harvests are conducted. Although the majority of returning chinook salmon typically enter Lake Washington after the period during which sockeye harvests are conducted, a significant portion of the population is present in the lake during the sockeye fishery. The potential impact of future sockeye fisheries is somewhat uncertain. State and tribal harvest co-managers are expected to use time and area closures, gear restrictions, and mandatory live fish release restrictions to minimize potential impacts of incidental chinook capture.

Cedar River fish harvests are co-managed by the WDFW and Muckleshoot Indian Tribe. Although, the mitigation in the City's proposed HCP is expected to improve the likelihood of future harvests, such harvests are solely at the discretion of the co-managers. Current management under the Wild Salmonid Policy (WDFW, 1997) indicates that rates of harvest by non-tribal fishers will be targeted for the rate appropriate to the naturally reproducing stock in areas of mixed-stock harvest. The Muckleshoot Tribe is not a signatory to the Wild Salmon Policy; therefore, this policy's impacts on harvest rates may be limited to non-treaty fisheries. Fisheries for Lake Washington sockeye occur as marine fisheries within Puget Sound and the Straight of Juan de Fuca and a terminal sport fishery within Lake Washington (WDFW, 1992). The marine fisheries are primarily mixed-stock. Harvests by the Muckleshoot Indian Tribe usually occur within the Lake Washington Ship Canal and could include fish bound for tributaries throughout Lake Washington.

In contrast, harvest management techniques such as area and timing restrictions can allow for substantial separation of the stocks within Lake

Washington. Past restrictions have included limiting sport harvest to areas south of the State Route 520 bridge. Experience suggests that this management regime is quite effective in preventing incidental harvest of north-end sockeye, which include those originating from Bear Creek. For example, in 1996, nearly 140,000 fish were harvested in Lake Washington. After the harvest, escapement to the Cedar River fell well short of maximum seeding levels, while the north-end populations experienced record escapements. Overall, the City expects that negative effects of harvest to naturally reproducing stocks will be minimized as a result of the implementation of an appropriate harvest management strategy by WDFW and the Muckleshoot Indian Tribe, including monitoring during and after the sport harvest.

Competition with Naturally Reproducing Fish for Limited Resources

An important assumption implicit in the hatchery proposal is that sockeye fry from the hatchery will not limit naturally reproduced fry production from the Cedar River or the northern Lake Washington tributaries through competition for resources (e.g., space or food) in the lake. The validity of this assumption is not certain. On-going and proposed investigations are designed to test this assumption and are an important component to the adaptive management strategy pursued in the proposed HCP. One component of the studies is to gradually increase the number of hatchery-produced fry that are released to the system to learn more about the lake's carrying capacity for juvenile sockeye and determine if it is possible to optimally adjust hatchery production to meet the annual carrying capacity of the lake. Data from the studies may suggest a number of outcomes and alternatives for meeting this assumption:

- Lake Washington is underutilized by sockeye. Intraspecific competition is minimal. The assumption of adequate carrying capacity is valid.
- Competition from hatchery fry added to the system reduces sockeye smolt size, but not survival. Depending on the magnitude of the change, hatchery production may need to be altered.
- Competition is an important limiting factor during particular periods of the year, and hatchery fry releases need to be timed appropriately.
- Competition is severe, and Lake Washington cannot support the release of 34 million fry. Hatchery production should be lower than the 34 million capacity.
- Competition is important during some years, but not others. Monitoring and predictive models are needed to determine optimal production and release strategies each year.

Other results and alternatives are possible, and interactions with other fish species (interspecific competition or predation) such as longfin smelt and resident trout can play an important role. Many fish species have evolved mechanisms to reduce competition by separating themselves in time or space

for all, or a portion of, their life spans. Similarly, different stocks such as Bear Creek and Cedar River sockeye, may not actively compete for a resource because they rear in different areas of the lake.

Sockeye smolts leaving Lake Washington are some of the largest in the world (Burgner, 1991). Consequently, one might suspect the lake could support many more fish than it currently does. Ironically, naturally reproducing Cedar River sockeye have had relatively low productivity compared to other nearby stocks (Ames, 1983). And recent results of the Lake Washington ecological studies have suggested that, at least in the early spring, there may be food limitation for sockeye fry, at least in some years. The current situation is perplexing and highlights the importance of continuing the Lake Washington ecological studies until some of these fundamental questions are answered.

Ecological Effects on Other Species

Besides the potential discussed above for effects of competitive interactions and mixed-stock harvest, increases in production of sockeye from the Cedar River could have several ecological impacts on other salmonids, including chinook salmon and steelhead trout. These include the potential for transmission of diseases such as IHN from sockeye to other species and interference with spawners of these species by spawning sockeye (Waples, 1998).

However, it should be noted that increases in the production of sockeye salmon through habitat enhancement or other measures than a hatchery could increase the risk of diseases transfer as well. Furthermore, as discussed above, operation of the hatchery includes strict protocols to control or eliminate IHN and other diseases, so that the risks of disease transmission for hatchery fry should be less than for naturally produce fry.

Spawning sockeye could effect other species if, in excavating their own redds, female sockeye disturbed the redds of other species. Again, any actions that increase the overall escapement levels of sockeye, not just hatchery production, could have this outcome. However, effects of spawning sockeye on steelhead trout will not occur at all, because steelhead spawn well after the sockeye spawning season is over. Effects on chinook should be minor for several reasons. Chinook are very aggressive to other species, they most often spawn in considerably deeper water than sockeye, and they most often place their eggs deeper in the gravel than sockeye.

Potential Effects of Broodstock Collection Practices

The sockeye broodstock collection program has two primary objectives: i) to capture an adequate number of adult sockeye salmon in a manner that provides a representative subset of the entire Cedar River sockeye population and ii) to avoid and minimize any impacts the program may have on naturally reproducing salmonids in the Cedar River. While the City is not aware of any definitive information demonstrating that ongoing broodstock collection

activities associated with the present interim sockeye hatchery have had significant detrimental impacts on salmonid reproduction in the Cedar River, past experience with the prototype sockeye hatchery program has demonstrated the need for a thoughtful and well-founded approach to broodstock collection.

In 1997, after a period of exceptionally high flows during the later part of the sockeye spawning season followed by reduced stream flows associated with a decline in natural flows and efforts to manage regulated flows to allow for removal of the sockeye broodstock collection facilities, the City received reports that adult sockeye and sockeye redds had been stranded. Upon investigation, the City learned that stranding of small numbers of adult sockeye had been confirmed at two locations. Both locations were created as a result of recent mechanical alterations of the stream channel and represent unnatural and unique conditions, not typical of the rest of the stream channel. Anthropogenic alterations of the channel morphology at these locations appear to have been a significant contributor to the stranding of adult sockeye and several of the redds they had created during a period of high flow late in the spawning season.

In the fall of 1998, some observers suggested that the operating regime for the broodstock collection facilities caused chinook salmon to spawn in higher densities than normal in the areas just downstream of the broodstock collection facility. Although the effects of this possible alteration in spawning distribution on reproductive success were not measured, the Cedar River Sockeye Technical Committed (CRSTC) is currently working to develop improved protocols to further reduce the chances that broodstock collection activities will have a negative impact spawning and incubating salmonids.

Later in 1998, the broodstock collection facility was partially buried by bedload tranpsort during a peak flow event. Subsequent facility removal operations resulted in disruptions to substrate in the vicinity of the weir on December 9. Although the City is not aware of any measurement of the impacts of this opearation on incubating salmonids, some observers claim that chinook and sockeye redds were significantly impacted by this operation. In response, the CRSTC is developing improved operating procedures to further reduce the potential impacts of facility removal practices on naturally reproducing salmonids.

The City believes that the potential risks associated with installation, operation, and removal of interim and long-term broodstock collection facilities can be minimized and avoided through the development of rigorous broodstock collection protocol and implementation of improved broodstock collection practices beginning in Year 1 of the HCP.

The design and implementation of improved sockeye broodstock collection practices will be addressed during the planned development of sockeye mitigation program guidelines in Year 1 of the HCP. Under AFM-2, AFM-3,

or AFM-4, ongoing evaluation, analyses, and design activities will determine the precise method of broodstock collection for the final sockeye fry production program. Interim and long-term broodstock collection facilities will be designed and operated in a manner that avoids and minimizes potential negative impacts on naturally reproducing fish in the Cedar River. Specific aspects of the long-term broodstock collection program will be further addressed during project specific environmental review prior to initiating construction of a final facility.

Potential Effects of Adaptive Management on Hatchery Production

Because the City intends to carefully monitor the effects of the sockeye hatchery on naturally producing sockeye and other species (see discussion below in section entitled "Research and Monitoring") and to operate the sockeye hatchery within an adaptive management paradigm, it is possible that hatchery production will be set by the fisheries co-managers at a level less than the 34 million fry facility capacity, at least in some years. Thus, there is some uncertainty about the final average production for the long-term hatchery. In addition, it is also possible that the Parties to the Landsburg Mitigation Agreement will decide, based on results of research and monitoring, to either not construct or cease operation of the hatchery facility.

Habitat Restoration and Protection Downstream of Landsburg

Habitat Restoration and Protection Project Descriptions

Habitat restoration and protection projects downstream of the Landsburg Diversion Dam have been suggested as possible ways to completely, or at least partially, fulfill the Applicant's mitigation goals for sockeye salmon. As discussed in Chapter 2 of this EA/EIS, any alternative that uses downstream habitat restoration projects as a component of a mitigation program for sockeye is subject to the approval of WDFW, pursuant to state law. As discussed below, there is a great deal of uncertainty in estimating fry production values from habitat restoration projects. Therefore production numbers presented below are discussed in terms of a range of values. Even under the best of circumstances these production values may not be achieved every year because of many factors, and the vast majority of potential habitat projects would be on private land and sites that have yet to be investigated in depth.

Some of the factors affecting the certainty of fry production from downstream habitat restoration projects (primarily groundwater-fed side channels) include:

1. Local landowner cooperation;
2. effect of IHN on survival and the increased potential of an episodic IHN event;
3. whether potential production decreases over time (Possibly as a result of fine sediment infiltration of spawning gravels or other long-term

deterioration of groundwater-fed spawning channels beyond what could be corrected through routine maintenance);

4. securing and maintaining a clean, reliable source of groundwater;
5. level of predation on emerging sockeye fry by other fish species;
6. unexpected failures from flood damage or other unforeseen circumstances;
7. actual overall fry production realized from these projects as a result of displacement of sockeye which might otherwise utilize the mainstem of the Cedar River for spawning; and
8. ability to fully seed habitat restoration projects from the available escapement of adult fish.

The proposed projects include the acquisition, enhancement, or restoration of fish habitat, floodplain, or riparian areas in the lower Cedar River. As described in the Affected Environment section of this EA/EIS, the lower Cedar River has been severely impacted by urban development, channel modifications, and reduction and harvest of riparian zones (King County, 1998). Mainstem and side-channel habitat quantity and quality have been reduced substantially compared to pristine conditions. In addition, these changes have increased the frequency of scour events that could negatively affect salmonid redds. King County (1998) has developed a Cedar River Basin and Non-Point Pollution Action Plan that includes recommendations for restoration and enhancement projects. The Applicant believes there is substantial merit for many of these proposed projects and the purchase and protection of other lands adjacent to the river.

The alternatives considered here include a range of funding for projects that would be selected by Parties to Landsburg Mitigation Agreement. Specific projects to be implemented or properties to be acquired have not been identified at this time, with advice from the CRAFC.

The Cedar River Basin and Non-Point Pollution Action Plan (King County, 1998) includes three types of projects: valley floor, mainstem, and tributary. The mainstem projects are generally designed to add bioengineering components to existing levees and revetments that are expected to improve riparian conditions. No added sockeye spawning habitat is expected from the mainstem projects. The tributary projects are designed to improve passage, channel, and riparian conditions in major tributaries to the lower Cedar River, particularly (lower) Rock Creek and the Walsh Lake Diversion Ditch. Some tributary projects would increase the available spawning area for anadromous fish. The valley floor projects are designed to enhance, restore, or create new salmonid spawning and rearing habitat from groundwater-fed side channels, wall-based tributaries, and oxbow ponds. The valley floor projects include 37 possible projects that have the potential for increasing the production of sockeye and other species through the construction of new spawning habitat

and enhancing existing habitat. These projects are the focus of the discussion on habitat enhancement measures.

These valley floor restoration or enhancement projects take advantage of the hyporheic zone of a stream channel. The hyporheic zone is the subsurface area of a stream that connects the surface waters to the landform's groundwater (Naiman et al., 1992). Topographic features characteristic of streams such as the Cedar River result in alternating areas of recharge and discharge (Naiman et al., 1992). In areas of discharge, upwelling through suitably sized gravel can provide flows suitable for the incubation of salmon eggs. Restoration and enhancement projects take advantage of the available groundwater by digging channels, modifying old stream meanders or side channels, or adding clean graded gravel (Althauser, 1985). An important feature of groundwater-fed spawning channels is the protection of redds from scouring flows (Althauser, 1985). On the other hand, these channels are also protected from flushing flows that can remove deleterious fine sediments that infiltrate gravels, as well as IHN, and reduce egg-to-fry survival rates.

Unfortunately, no studies are available to provide guidance on the level of production that could be expected from implementing groundwater-fed spawning channel projects for sockeye salmon. The lack of empirical data on sockeye use of groundwater-fed channels portends some uncertainty as to the long-term success of enhanced or restored groundwater-fed channels in the Cedar River. However, to provide some quantitative estimate on potential project benefits, King County used egg-to-fry survival and spawning density information from sockeye salmon spawning at the Weaver Creek Spawning Channel in British Columbia.

The Weaver Creek Spawning Channel is substantially more artificial than groundwater-fed channels or ponds, because of its regulated flows from a silt-free water source (settling pond) and graded, optimally-sized spawning gravels that are mechanically cleaned on a regular basis. Recognizing the data from the Weaver Creek Spawning Channel would substantially overestimate production from groundwater-fed channels, King County reduced the Weaver Creek egg-to-fry survival rates by 50 percent at the suggestion of Jim Ames, a WDFW expert on sockeye (G. Lucchetti, King County, personal communication, August 1998). These reduced egg-to-fry survival values were then combined with estimates of sockeye fecundity, egg deposition levels, and spawning densities from the Cedar River. This methodology employed by King County has been reviewed by sockeye experts in British Columbia, and they considered it to be a reasonable approach (G. Lucchetti, King county, personal communication, August 1998).

The calculations provided an estimated fry production level that ranged between 491 fry/m^2 at low spawning densities to 1,063 fry/m^2 at high spawning densities (King County, 1998). Under moderate spawning densities, King County estimated 849 fry/m^2 could be produced. King County believes these to be conservative estimates and that even higher production might

result. However, just as in the case of allowing coho, chinook, and steelhead renewed access to the additional habitat above the Landsburg Diversion, escapement levels would have to increase over current values to fully seed newly built groundwater-fed spawning channels, the build-up of stocks could take many years, and such higher returns might not be realized if other factors limit the sockeye population.

King County has also proposed six tributary enhancement projects that could provide additional sockeye spawning areas. The cost of these projects ranges from approximately $61,000 to $6.9 million. Scouring of redds is expected to be higher in tributaries, compared to groundwater-fed channels or ponds. Consequently, the County assumed egg-to-fry survival rates to be much lower for all of the tributary enhancement projects except the Walsh Diversion Ditch and Rock Creek. Fry production at a low, moderate, and high spawner density was estimated as 76, 238, and 514 fry/m^2, respectively.

Although groundwater-fed spawning channels for sockeye salmon are relatively new, data are available for channels used by chum salmon in British Columbia since the late 1970s (Bonnell, 1991) and for the Satsop River basin in Washington State since the mid 1980s (Cowan, 1991). The mean fry production estimated for chum salmon (as sockeye, also mass spawners) that spawned in groundwater-fed channels constructed in British Columbia was 297 fry per square meter of spawning channel (Bonnell, 1991). Studies in the Satsop River basin demonstrated that chum fry production from improved and natural groundwater-fed channels averaged 136 fry/m^2 (range 29 to 327 fry/m^2; Cowan, 1991).

According to King County (1998), the chum data from Bonnell (1991) and Cowan (1991) were inappropriate for use in estimating sockeye production because of differences between species and watersheds and the lack of project details, limiting the applicability and usefulness of the data to the Cedar River. Important biological differences between sockeye and chum salmon that are likely to influence production levels include egg size, redd size, spawning time, and optimal spawning gravel size. An important watershed difference is the ambient level of fines in the sediment load. In particular, the Satsop River has substantially higher levels of sands and silts relative to the Cedar River (G. Lucchetti, personal communication, August 1998). Overall, one of the most important factors that led to not using chum salmon production values was that in calculating production levels Bonnell (1991) and Cowan (1991) reported and used the total available habitat area rather than only the area of suitable spawning habitat. This difference in methodology resulted in lower chum fry production levels than if the area of suitable spawning habitat had been used.

Monitoring results from four of the groundwater-fed chum spawning channels provides some information on their continuing viability over an initial 8-year period. Variability in chum salmon production within these channels was high, and three of the four projects showed substantial declining trends in fry survival over the 8 years following construction (Bonnell, 1991). Two of the

four projects had fry production levels at the end of the monitoring period that were lower than the average production of chum fry from typical river channels in British Columbia (150 fry/m^2) (Bonnell, 1991). The information suggests that all channels may not perform as expected over the long term, and continued high production may require periodic maintenance every 4 to 8 years, which could be costly or infeasible. Despite the declining survival rates in some groundwater-fed channels, over 40 have been constructed in British Columbia and the overall program was considered successful (Bonnell, 1991).

King County has constructed the Elliot Groundwater Channel valley floor project located on the left bank of the Cedar River at RM 4. The Elliot Groundwater Channel is a 700-foot-long channel built in the summer of 1995 on park land provided by the City of Renton. Actual construction costs for this project were approximately $280,000. In early November of 1995, sockeye began to migrate into the channel. A peak of 50 spawners was observed using the channel that year. Peak spawner counts were 456 in 1996 and 336 in 1997. Assuming a two-week spawner life, the estimated total number of spawners in 1996 would be 1,500. Assuming that half of these fish were female and that 75 percent of the 10-foot channel width was adequate for spawning, then the estimated female spawner density for the project would approach 1.2 females per square meter.

The Applicant supports the restoration and enhancement of salmonid habitat in the Cedar River downstream of the Landsburg Diversion. As shown in Table 4.4-1, the four mitigation alternatives would spend between $1.6 million (AFM-2) and $24.1 million (AFM-5) for implementing habitat restoration projects, including groundwater-fed spawning channels, and the purchase and protection of lands adjacent to the river. Preliminary estimates to construct, monitor, and maintain individual groundwater-fed spawning habitat projects range from approximately $108,000 to nearly $2.0 million (King County, 1998).

It is not possible to estimate with reasonable accuracy the level of fry production for each of the individual anadromous fish alternatives and their associated funding levels because of the uncertainty of which particular projects would be built and in which order. However, if *all* of the valley floor projects and tributary projects proposed by King County that are expected to produce sockeye fry were implemented at an estimated cost of over $25.8 million and *all* production assumptions were realized, the estimated range of fry production would be 20.0 to 44.8 million fry. This range of fry production is based on three different levels of spawner densities. About 35.1 million sockeye fry would be produced at the moderate spawner density suggested by Jim Ames (0.83 females/m^2), about20.0 million fry would be produced at a low spawner density (0.40 females/m^2), and about 44.8 million fry would be produced at a high spawner density (1.3 females /m^2) (G. Lucchetti, King County, personal communication, August 1998).

However, as indicated earlier and discussed in more detail below, the uncertainty of many factors suggests that the realized fry production would be less that the above estimates. Even disregarding the lack of biological data directly applicable to groundwater-fed side channels for sockeye, it is unlikely that all landowners would cooperate, that groundwater would be adequate at all site, that production would not decline over time for any projects (because of disease, sedimentation, pollution, or other factors), that no projects would be damaged by floods or other events, and that escapement would be adequate to fully seed this habitat in all or most years.

Factors Affecting Potential Fry Production Values

The actual level of sockeye fry production from groundwater-fed channels, ponds, and other enhancement projects is uncertain for a number of reasons. Which particular projects will be selected from the suite of 39 projects available, in what order will they be built, and when will they be built, are not clear at this time. Criteria for project selection and prioritization are likely to include a variety of factors, including cost-effectiveness and the likelihood of success.

A factor that will affect successful implementation of the valley floor projects is the degree to which individual private landowners will cooperate. Most projects will require owner authorization to implement. Delays in project implementation might also result in lost opportunities if ownership changes or if owners decide to implement other, conflicting uses of their land. Other landowner concerns might include: 1) whether or not the proposed projects would increase public access to their property; 2) whether or not the creation of a groundwater-fed channel would increase a landowner's regulatory liability, such as requiring buffers around the channel; and 3) whether or not the projects would create odor and scavenger problems associated with salmon carcasses.

It can be expected that only an unknown subset of the proposed projects could actually be implemented. On the other hand, although the County conducted a comprehensive study of the river for potential projects, some additional new projects will likely be found. Despite these concerns, most of the landowners contacted by King County during their planning process for the Cedar River Basin and Non-Point Pollution Action Plan have expressed support in general for these types of projects (King County, 1998). However, it is important to note that the individual private landowners associated with the valley floor projects that might be implemented by the Applicant have not been contacted at this time. As a result, landowner cooperation is a significant uncertainty. Consequently, even with favorable outcomes for production assumptions, estimated fry production will likely be reduced from the low, moderate, and high levels mentioned above.

In addition to programmatic uncertainties, biological assumptions used in the production estimates have yet to be verified. Initial sockeye use of the recently

constructed Elliot Groundwater Channel has been at spawning densities approaching the high level assumed in the estimates (King County, 1998), but other uncertainties are present in implementing any given project. All of the projects are in a conceptual design stage, and numerous details could substantially change the feasibility of a project. For example, easements must be obtained from private property owners; permits would be required from county, state, and federal agencies; and additional testing could demonstrate a site has lower or higher suitability than currently estimated. The projects are likely to have beneficial effects on sockeye and other aquatic resources, but these uncertainties make it difficult to assess the extent to which these projects would allow the City to meet its mitigation goal.

Sockeye fry produced in groundwater-fed spawning channels probably would be infected with the IHN at rates similar to, or higher than those currently present in the naturally producing sockeye population. Somewhat higher infection rates may be possible if spawning densities are relatively high compared to the mainstem river and if build-up of the virus occurs in the enhanced channels. Although the virus is often observed in natural populations, including the Cedar River, episodic breakouts of the disease associated with high levels of mortality have been rarely documented under natural conditions. Unlike a hatchery environment, control of diseases will not be possible for groundwater-fed spawning channels. Unexpected, relatively higher levels of disease in some years could reduce fry production below estimated values for any given set of side channels.

Another factor affecting long-term fry production from the habitat restoration projects is the potential for some deterioration over time. As previously discussed for chum salmon spawning in channels in the British Columbia, fry survival declined over time in three of four projects. Deterioration over time could be influenced by environmental consequences, such as the infiltration of fine sediment and organic material into spawning gravels. Protection of redds from scour also protects gravels from cleansing flushing flows. Consequently, the flushing of fines and organic debris will primarily occur from digging during redd construction.

The potential for long-term deterioration may require maintenance beyond what is currently proposed for maintaining production from these projects over the 50-year life of the proposed HCP. As a result, long-term deterioration is another uncertainty affecting fry production from these projects. However, even if egg-to-fry survival in the channels declines from initial values, it may still be higher than typical in-river survival rates. If channel conditions deteriorate, benefits to sockeye and other salmonid species may continue, but the magnitude of benefits may be lower than expected.

Groundwater-fed spawning channels require a clean, reliable source of groundwater for success. At this time, a detailed analysis of available groundwater resources has not been conducted for all of the proposed valley floor projects. In addition, it is unknown what effect future groundwater

withdrawals in the basin could have on these projects over time. As a result, the presence or absence of suitable groundwater is another factor that may contribute to the uncertainty of fry production estimates from these projects.

Another factor affecting long-term sockeye fry production from groundwater fed channels and ponds on the valley floor is potential predation by juvenile coho salmon and cutthroat trout. Experience in other areas suggests that emerging sockeye fry will likely experience a significant level of predation, particularly by coho pre-smolts. Groundwater channels constructed for chum salmon have been found to support significant densities of pre-smolt coho (Sheng et al., 1990). In a groundwater channel constructed for sockeye spawning, at Adams River in British Columbia, coho pre-smolts consumed an estimated 25 percent of the emerging sockeye fry population (Mel Sheng, Department of Fisheries and Oceans, Nanaimo, B.C., personal communication with Brent Lister of D.B. Lister & Associates).

Though salmonid predation may negatively affect sockeye recruitment to Lake Washington, enhanced growth and marine survival of species such as coho salmon will likely provide some offsetting fish production benefits.

It will require between 50,000 and 120,000 additional returning sockeye salmon to seed the valley floor projects at the densities assumed in the production estimates (King County, 1998). As the valley floor projects get constructed, some adult sockeye which normally would have spawned in the mainstem of the Cedar River will spawn in the new groundwater-fed spawning channels. Consequently, the level of mainstem fry production will be lower. However, because egg-to-fry survival in the valley floor projects is expected to be higher than egg-to-fry survival from redds placed in the mainstem river, there ultimately could be a net increase in fry production that would contribute to the mitigation goal of 34 million fry. If production in the side channels is consistently higher, genetic selection could occur so that adults would begin to prefer such spawning sites over the longer term, and, over the long term, mainstem seeding could recover, contingent on overall adequate escapement. A build-up of the run, thus, may take many years, depending upon realized returns and the harvest strategy selected by the WDFW and Muckleshoot Tribe. For the side channels to contribute significantly to meeting the City's mitigation goal on an annual basis would require that returning runs of sockeye be large enough to fully seed the projects.

The risk of straying by fish produced from groundwater-fed spawning channels is similar to that for hatchery produced fish. If the number of strays from the Cedar River to the north Lake Washington tributaries were proportional to the number of adult sockeye entering the lake, the effects would be similar, regardless of the source of those adults. If large numbers of strays become a substantial part of the spawning population, they could dilute the gene pool of the north-end stock. Fish produced in groundwater-fed spawning channels, however, would not contain any distinguishing mark. Consequently, direct straying rates could not be estimated and corrective actions taken to reduce

straying if it became a problem. However, NMFS has indicated that concerns about straying into Bear Creek could be greater for hatchery produced fish (Waples, 1998). These fish can be recognized by otolith markings, and straying of these fish will be monitored by the City so that appropriate action can be taken if straying exceeds an agree-upon threshold rate.

The WDFW and Muckleshoot Indian Tribe might choose different harvest management policies, depending upon the relative contributions of hatchery, mainstem, and groundwater-fed spawning channel production. A higher egg-to-fry survival rate means a higher harvest rate can be acceptable without overfishing the stock. Consequently, if hatchery production represents a relatively large component of the stock, a higher harvest rate may be possible (ideally this higher harvest rate should be applied only to the component of the stock with the higher survival rate). In contrast, if groundwater-fed spawning channel production predominates, harvest rates may be relatively lower. This factor and others will be important when WDFW and the Muckleshoot Indian Tribe determine harvest management policy.

The groundwater-fed channels and ponds would also result in benefits to coho salmon and sea-run cutthroat trout because of improved spawning and rearing conditions, including the production of sockeye fry as prey items. King County (1998) estimates that 94,000 (range 53,000 to 192,000) coho smolts and 29,000 (range 22,000 to 50,000) cutthroat trout smolts could be produced if all valley floor projects were implemented. In contrast, benefits to chinook would likely be relatively small. Fall chinook typically spawn in mainstem channels and have limited use of the river during the fry life stage, because they outmigrate shortly after emergence. Although King County and the City believe that some benefits would be present for steelhead trout and chinook salmon fry, these benefits are expected to be relatively low, and no production values were calculated by the County.

Under all the action alternatives, the Parties to the Landsburg Mitigation Agreement, with advice from the CRAFC, may choose to expend some or all of the available funds for the acquisition and rehabilitation of lands adjacent to the lower Cedar River. These activities will benefit the overall ecological health of the river. Removal of lands from those available for further development may reduce the risk of further degradation to the lower river and eventually result in improved conditions. Riparian zones can repopulate with conifers, and channels can develop a more natural morphology with higher levels of large woody debris. Resident and anadromous fish populations would directly benefit from riparian and floodplain protection and enhancement; however, the benefits may take many decades to be realized and are difficult to quantify. Of the anadromous species, sockeye is the least likely to benefit substantially from land acquisition and riparian zone enhancement and rehabilitation because it does not use instream habitat for rearing. In contrast, coho salmon, steelhead trout, chinook salmon, and resident fish would likely receive most of the benefits.

Research and Monitoring

The Applicant proposes to use an adaptive management approach to implementing the proposed HCP. Overall, research and monitoring accounts for about 10 percent of the City's budget for mitigating for the presence of the Landsburg Diversion and the water supply line. The Applicant includes monitoring in its anadromous fish mitigation plan to increase the likelihood of its success through modification of measures that fail to perform adequately. The following monitoring programs will be partially or fully supported by the Applicant as part of the proposed HCP:

- Fish ladder counts at the Landsburg Diversion
- Intake screening evaluation and monitoring at the Landsburg Diversion
- Monitoring of the effects of fish carcasses on water quality above the Landsburg water intake
- Monitoring of the physiological condition of fry released from the proposed hatchery
- Artificially produced fry (thermal) otolith marking and mark evaluation
- Trapping and counting of naturally produced fry and artificially produced fry
- Monitoring of the health and diseases of artificially produced fish
- Evaluation of short-term rearing (up to 2 weeks) of artificially produced fry
- Lake Washington plankton studies (to better under stand potential food limitations)
- Adult salmon survival and distribution studies
- Phenotypic and molecular genetic studies of Lake Washington sockeye stocks
- Straying studies
- Interim steelhead, chinook, and coho supplementation monitoring or restoration studies
- Cedar River steelhead redd and incubation monitoring (discussed elsewhere in association with instream flows)

The total expenditures for these monitoring projects are limited to approximately $3.7 million over the 50-year term of the HCP, not including the monitoring of steelhead redds associated with adaptive instream flow management. Additional monitoring that could supplement the City's efforts may also occur by county, state, and federal agencies, the Muckleshoot Indian Tribe, and educational institutions as part of independent projects they pursue. Funding of monitoring for all action alternatives would be the same in amount, but the exact nature of the monitoring and research would depend on the final choice of mitigation measures in consultation with the CRAFC.

The CRAFC will advise and consult with the City to incorporate the best available science in the implementation of fisheries measures. These measures are intended to benefit the fishery resources of the Cedar River by protecting, improving, and increasing fish production and available habitat. The City, in cooperation with the other parties, will conduct studies of the fish populations and monitor the fisheries measures, then act on the results to manage anadromous fish mitigation in an adaptive fashion.

Comparison of Alternatives

All of the action alternatives include the following measures:

- Construction of an adult fish ladder at the Landsburg Diversion Dam, fish screens for juveniles at the Landsburg water intake, and an adult fish ladder and sorting facility at the Landsburg pipeline crossing, and allowing passage of chinook salmon, coho salmon, and steelhead trout into the municipal watershed
- Protection of salmonid habitat above the Landsburg Diversion by establishment of an Ecological Reserve that includes 12.4 miles of the mainstem Cedar River and 4.6 miles of associated tributaries
- Monetary support for improvements in fish passage and water use efficiency at the Chittenden Locks (associated with instream flows)
- Research and monitoring
- Implementation of at least $1.6 million of habitat acquisition, protection, restoration, or enhancement projects downstream of Landsburg Dam.

The comparisons below will highlight the differences for sockeye supplementation and the total level of habitat enhancement proposed in each alternative.

The total amount of funds to be spent on research and monitoring is the same for all action alternatives. However, the types of research and monitoring will vary among the alternatives, depending upon the measures to be implemented. For example if AFM-5 is implemented, monitoring would focus more on the productivity and use of groundwater-fed spawning-channel and pond projects. On the other hand, if AFM-2 is implemented, monitoring to compare the survival and characteristics of hatchery fry to naturally produced fry will have a higher priority. Detailed research and monitoring plans have not been developed, other than those already implemented under the Lake Washington Ecological Studies. Consequently, it is not possible to compare specific research and monitoring projects under the different alternatives.

With the exception of the No Action Alternative (AFM-1), all of the alternatives have a high likelihood for meeting five of the six conservation objectives for anadromous fish (Table 4.4-2). All of the alternatives include measures that can provide benefits in both the long and the short term, provide

substantial value to target resources, are coordinated with other plans and measures developed by King County and the Corps of Engineers, and allow passage for species that would not affect drinking water quality. However, differences do occur in the likelihood of meeting Objective 6, mitigation obligations of the Applicant for sockeye salmon under state law. As described below, under favorable outcomes, all of the action alternatives couldproduce the number of fry required in SB5156. SB 5156 defines what actions must be taken to receive full mitigation credit for the blockage at Landsburg. The only option that clearly conforms to the intent of the legislation and to the direction provided by the Cedar River Sockeye Technical Committee is the hatchery option (AFM-2). Therefore the City has virtual certainty that by implementing this option, it will receive full mitigation credit as described in SB 5156. All other action options have greater uncertainty of meeting the requirements of SB 5156. The No Action Alternative (AFM-1) will not meet any mitigation objectives except Objective 2. If an approved HCP is not implemented, drinking water quality for the Cedar River source should continue to be very high.

Table 4.4-2. Likelihood for meeting conservation objectives for anadromous fish

Objective	AFM-1	AFM-2	AFM-3	AFM-4	AFM-5
1. Biologically sound short- and long-term solution	None	High	High	High	High
2. Maintain a safe, high quality drinking water supply.	High	High	High	High	High
3. Provide substantial value for target resources.	None	High	High	High	High
4. Provides passage over the Landsburg Dam consistent with water quality protection.	None	High	High	High	High
5. Supports other compatible fish protection and restoration activities in the basin.	None	High	High	High	High
6. Meets the Applicant's legal mitigation obligations.	None	High	Low	Moderate	Low

The No Action Alternative (AFM-1)

Under the No Action Alternative, none of the proposed new activities would be implemented.. Negotiations for meeting mitigation goals would continue between the City, the state, and the federal agencies. Litigation might be pursued by some parties or individuals to force the Applicant to meet any legal requirements those parties contend the City may have. Passage facilities at Landsburg Dam for coho salmon, chinook salmon, and steelhead trout would not be constructed, or at least such construction is uncertain, and the habitat between Landsburg and Lower Cedar Falls would continue to be underused.

Funding for the existing interim hatchery, though always uncertain, would probably be continued at a cost of $256,000 per year plus an estimated $1.8 million necessary for critical upgrades. The Applicant would not expend funds for habitat restoration, protection, and enhancement in the lower river. No support would be provided to the ACOE to implement improvements at the Chittenden Locks designed to increase downstream passage survival. However, King County may still pursue some habitat projects on its own, and some improvements may still occur at the Chittenden Locks without the financial support of the Applicant.

Opportunities to harvest sockeye salmon in Lake Washington would continue to be sporadic, if they occurred at all. This alternative could lead to the continued decline of one or more of the anadromous species within the Cedar River and possibly the extinction of some stocks within the drainage.

Proposed HCP Alternative for Anadromous Fish Mitigation (AFM-2)

In addition to the measures to be implemented for all alternatives, under the Proposed HCP Alternative, the Applicant would commit to building a sockeye fry hatchery capable of producing up to 34 million fry of comparable quality to naturally produced fry. In some or even all years, and with the concurrence of the Parties to the Landsburg Mitigation Agreement, fry production possibly may be less than the 34 million fry the hatchery would be capable of producing. Using research and monitoring and an adaptive management approach, annual fry production levels would be set to optimize sockeye returns to the river and minimize or adverse impacts to naturally reproducing salmonids. The approximate cost for the hatchery over the 50-year life span of the proposed HCP would be approximately $22.5 million (Table 4.4-1). Included in this cost would be continued funding for the interim hatchery until the long-term facility can be completed in HCP year5. The annual production goal for the interim hatchery during this period would continue to be up to 16 million fry.

Under this alternative, $1.6 million would be also spent implementing habitat enhancement projects in the lower Cedar River that would produce additional sockeye fry, coho smolts, and resident trout. Relative to the other three action alternatives, AFM-2 has the highest likelihood for meeting the Applicant's mitigation objectives for sockeye salmon, because the hatchery would have the capacity to produce and meet the 34 million fry mitigation goal even under the extremely unlikely event that the habitat enhancement projects were a complete failure (Table 4.4-3).

Compared to the other anadromous fish mitigation alternatives, AFM-2 has the potential for the highest harvest rate, because the hatchery production component would be the highest (although ideally the higher harvest rate would be applied only to the stock component with the higher survival rate). The higher egg-to-fry survival (an important component of stock productivity) possible under hatchery conditions means fewer spawners are needed to

produce the same number of fish in the next generation. Consequently, a higher proportion of fish could be harvested. Furthermore, AFM-2 would possibly produce the largest number of fry between combined hatchery and natural production. If no carrying capacity limitations are present for sockeye rearing in Lake Washington or the ocean, AFM-2 has the potential to make a larger proportion of the returning adult run available for harvest because it requires the smallest number of sockeye adults to seed the habitat enhancement projects and provide brood stock for the hatchery.

The benefits that may be derived from a sockeye fry hatchery result primarily from increases in egg-to-fry survival. The natural mortality of incubating eggs in the gravel can be considerable. Egg-to-fry sockeye survival rates are typically below 20 percent and averaged near 10.5 percent for six Alaska populations reported by Foerster (1968), but can be substantially higher or lower in a given year or river. Much of the Cedar River downstream of the Landsburg Diversion is constrained by dikes and revetments. Because of this constrained condition, incubating sockeye are particularly vulnerable to mortality due to increased bedload scour during high flow events. During high flow events, the confined channel results in increased water velocity, increased energy, and subsequent increases in bedload movement. Egg-to-fry survival in the Cedar River subsequent to the 2-year flood event is typically much lower than 10 percent (Seiler and Kishimoto, 1997). In contrast, egg-to-fry survival within a hatchery can exceed 90 percent. Because egg-to-fry survival is an important factor that contributes to fish productivity early in the life history of the species, the difference in survival rates means a hatchery can increase the overall productivity of the stock. However, as out-of-kind mitigation, the proposed sockeye hatchery program does entail certain risks not encountered in other forms of mitigation.

A number of sources have detailed the problems associated with artificial propagation in the past and have suggested that these problems be addressed when applying this approach in the future (Hard et al., 1992; Hilborn, 1992; National Research Council, 1996; Reisenbichler, 1996; WDFW, 1997; Waples, 1998). Many of these potential problems (genetics, straying, harvest, etc.) were discussed in an earlier section of this EA/EIS. In many years, the number of fry released from the hatchery under AFM-2 will represent a significant portion of the total sockeye fry produced in the Lake Washington Watershed. Clearly, the hatchery propagation program should not be viewed in isolation from the many other rehabilitative features of the proposed HCP. Nor should the risks associated with a relatively high technology approach be quickly dismissed.

Prototype testing with the interim hatchery since 1991 indicates that it is feasible to consistently produce healthy, high-quality sockeye fry in a hatchery setting using recently developed protocols for managing the fish health risks associated with the IHNV (McDaniel et al., 1994). Preliminary review of early performance data suggests that hatchery-produced fry may perform in a

manner similar to naturally produced fry. Data from the 1997 returns will provide the first substantial body of information on the relative performance and behavior of the hatchery fry. This recently collected data set is still being analyzed and will require corroboration with data collected in subsequent years to adequately address a number of the uncertainties associated with the sockeye fry production program. The Applicant recognizes that, while the sockeye fry production program offers potential benefits for the population, it also entails a level of uncertainty and risk that will require careful monitoring and adaptive management to make the program successful and to minimize any adverse impacts.

As part of the sockeye mitigation program, the Applicant intends to implement measures to manage risk and uncertainty: first, through the development of rigorous pre-project planning; and, second, through implementation of an effective monitoring and adaptive management program (see Kapuscinski and Miller, 1993; Kapuscinski, 1997).

Prior to final design, construction, and operation of the hatchery facility, program guidelines will be developed to maximize the chances for long-term success and minimize potential negative impacts on naturally reproducing salmonids in the Cedar River and elsewhere in the basin. The Applicant will provide up to $32,000 in HCP year 1 for the development of specific guidelines to support the design and management of the long-term sockeye fry production program to help ensure the long-term success of the program and minimize genetic and ecological risk.

The hatchery facility and operating budgets have been designed to meet the following guidelines:

- Broodstock will be taken only from sockeye returning to the Cedar River.
- Broodstock will be collected randomly from a representative sample of the entire spawning population continuously from mid-September through mid-December.
- The number of fish collected for broodstock may be as great as 27,000 fish per year, but will never be greater than 50 percent of the total number of fish returning to spawn in the Cedar River.
- Matings will be randomized and conducted at a ratio of one male to one female, unless other procedures can be developed that better simulate natural mate selection (Waples, 1998).
- Fish culture and fish health management practices will strictly adhere to established sockeye culture protocol (McDaniel et al., 1994) to minimize the risks associated with infectious hematopoietic necrosis (IHN) and ensure the production of healthy fry.

- All hatchery fry will be marked by manipulating incubation temperature to place an identifying series of bands on their otoliths (Volk et al., 1990).
- Emergent fry will be allowed to volitionally outmigrate from incubators.
- Fry will be released into the Cedar River and allowed to outmigrate to Lake Washington in a manner that approximates the timing of emergence and outmigration of naturally produced fry.
- Although it may be necessary to hold early emerging fry for a short period of up to 2 weeks (as part of an experimental fry rearing program in HCP years 1-4) to ensure that the developmental condition and timing of hatchery fry migration into Lake Washington corresponds with that of naturally produced fry, there will be no extended rearing of hatchery fry.
- Chilling of incubator may be used to delay fry emergence.
- Fry production will be increased gradually while monitoring forage conditions in Lake Washington and the performance of naturally reproducing and hatchery produced fry.
- Fry production for any given year may be set at less than the maximum facility capacity in response to information gained from the monitoring program or to avoid risks.

Prior to beginning final design of the long-term fry production facility, the Applicant will sponsor a process that will reexamine the potential genetic and ecological risks associated with the sockeye mitigation program. The results of this exercise will be used to refine facility design criteria and operating protocol in conjunction with the monitoring results from the interim hatchery program.

Beginning in HCP year 1, the Applicant will initiate a $3.5 million research and monitoring effort (Section 4.5) to help ensure the success of the sockeye mitigation program and to reduce the risk of deleterious effects on naturally reproducing sockeye salmon and other species. Research and monitoring activities will be overseen by the Parties to the Landsburg Mitigation Agreement, in consultation with the CRAFC. Specifically, the monitoring program is focused on the following questions:

- Are hatchery produced sockeye fry developmentally, morphologically, and behaviorally similar to naturally produced sockeye fry in the Cedar River?
- Are morphological and behavioral characteristics (such as adult body size, run timing, and spawning distribution) of hatchery produced fish different from naturally produced fish in the Cedar River?
- Do hatchery fry survive at the same rate as naturally produced fry?

- Can the molecular genetic attributes of hatchery produced fish be distinguished from those of naturally produced fish?
- Is the reproductive fitness of the Cedar River sockeye population changing over time as a result of the mitigation program?
- Is the mitigation program increasing the rate at which Cedar River sockeye stray into the north Lake Washington tributaries, and, if so, is it having a detrimental effect on genetic diversity and adaptive character of the population as a whole?
- Is the carrying capacity of the lake sufficient to support the supplemental fry without negatively affecting naturally produced sockeye fry from the Cedar River and elsewhere in the basin?
- Does the artificial production program pose a significant health risk to naturally reproducing salmonids in the Lake Washington Watershed?

The monitoring program will also be refined and reexamined prior to the construction of the long-term sockeye mitigation facility. The Cedar River Fish Committee would have the flexibility to establish measurable threshold values for decisions regarding impacts. Results from the monitoring program will be used by the Parties to the Landsburg Mitigation Agreement to manage the implementation of the sockeye mitigation program in an adaptive fashion to make the program successful and to minimize adverse impact sot naturally producing sockeye and other species.

The interim and long-term mitigation and monitoring programs will be overseen by the Parties to the Landsburg Mitigation Agreement, in consultation with the CRAFC. The Parties to the Landsburg Mitigation Agreement will use the results of the research and monitoring program to evaluate the performance of the program and recommend program alterations. The Parties will approve annual operating and monitoring plans, review annual operating and monitoring reports and govern annual operating plans and procedures. If, based upon the results of the Research and Monitoring Program, the sockeye hatchery (or other planned mitigation) is deemed by the Parties to the Landsburg Mitigation Agreement, which include the Applicant and the Services, to be no longer appropriate during the term of the proposed HCP, or, if for reasons beyond its control, the Applicant is unable to complete the sockeye hatchery, then the Applicant will commit remaining funds, at a level not to exceed the total of its original commitments, to alternative mitigation as agreed upon by the Parties. If alternative mitigation cannot be agreed upon, then the City will use the funds for fish habitat acquisition, restoration, or enhancement in the Lake Washington Basin

Currently, the carrying capacity of Lake Washington is unknown. Consequently, it is not possible to compare the alternatives for this factor. Depending upon the functional relationship between fry-to-smolt survival and fry density and the mechanisms that form that relationship, the action alternatives may be similarly affected by Lake Washington carrying capacity,

or alternatives with higher fry production levels may be disproportionately affected. Including a hatchery component within the implemented alternative would provide additional flexibility for reaching higher productivity in the system regardless of the capacity. Theoretically, it is possible that fry releases at appropriate times and locations can lead to higher survival than under strictly natural conditions. Better coordination of fry entries to Lake Washington with environmental conditions is only possible from a hatchery and with an appropriate monitoring plan. In addition, the proposed hatchery also provides a "safety net" in years of high flood scour.

Domestication and genetic risks to sockeye in the Lake Washington Basin are expected to be low under this alternative for two reasons: (1) because standards and guidelines will be developed that are expected to minimize this risk, and (2) because monitoring and adaptive management will be conducted in a manner that allows altering hatchery operations, even to the extent of terminating operations, if the risk management objectives are not met. The City intends to develop unambiguous threshold values for key risk factors that can be monitored to provide the information needed for such decisions. Ecological risks to other salmonids are expected to be minor under this and all other alternatives, and some species may benefit by the increased rate of importation of nutrients from the marine environment into the freshwater environment, which his known to create stream systems that support more individuals and species (Bilby et al., 1996).

Downsized Sockeye Hatchery Alternative with Savings Going Towards Downstream Habitat Restoration (AFM-3)

In addition to the measures to be implemented for all alternatives, under AFM-3 the Applicant would commit to building a sockeye fry hatchery capable of producing up to 17 million fry of comparable quality to naturally produced fry. Economies of scale related to hatchery construction result in the fact that a hatchery capable of producing half of the fry required to meet mitigation goals costs substantially more than half the cost of the proposed full-size hatchery. The approximate cost for the hatchery over the 50-year life span of the HCP would be approximately $18.9 million (Table 4.4-1). Included in this cost would be continued funding for the interim hatchery until the permanent facility was completed in Year 4 of the proposed HCP. The annual production goal for the interim hatchery would continue to be 16 million fry during this period.

Under this alternative, $5.2 million would be available to be spent on habitat acquisition and enhancement in the lower river. This amount is over three times the level to be spent on habitat enhancement under AFM-2 and about 20 percent of the estimated cost for the entire suite of projects capable of producing sockeye fry. It is likely that a sufficient number of suitable projects with landowner cooperation can be found within the suite of 37 projects outlined by King County (1998). Under this alternative, the level of combined

hatchery and groundwater-fed spawning channel fry production would be substantial, but unlikely to meet the 34 million fry mitigation goal unless nearly all production assumptions were favorably met (i.e., high spawning densities and fry survival), which is highly unlikely. Consequently, Alternative AFM-3 was given a low likelihood for meeting Objective 6.

AFM-3 spreads the risk and benefits between hatchery production and habitat enhancement. It makes substantially larger contributions to the construction of valley floor habitat enhancement projects compared to AFM-2, but also provides the certainty and flexibility of IHN-free fry production possible from a hatchery. While there is risk, and a likelihood, under AFM-3 that the Applicant's mitigation goal would not be met if groundwater-fed spawning channels and ponds were under-used (low spawning densities) or if production assumptions were over-estimated, substantial benefit to the ecological health of the system should still be realized.

The potential benefits and some of the risks of the half-sized hatchery are reduced under this alternative, compared to AFM-2. Domestication and genetic risks are only slightly lower under this alternative than under AFM-2 and are not expected to be significant as discussed above for AFM-2. Similarly, the risk of uncontrollable disease outbreak in the hatchery would be slightly lower because of the lowered production targets, but that risk is expected to be low for all action alternatives that include a hatchery because of the rigorous protocols that will be implemented for hatchery operation.

Under the assumption of no Lake Washington smolt capacity limitation, risks to naturally reproducing north-end stocks would be reduced because fewer Cedar River fish would be produced. As with all of the action alternatives, there is some risk of exceeding the Lake Washington carrying capacity for sockeye salmon under Alternative AFM-3. With a lower level of fry production (again, assuming no lake or ocean capacity limitation), the total number of fish available for harvest would also be lower under this alternative, compared to the Proposed HCP Alternative.

Deferred Hatchery Construction Alternative Contingent on Evaluation of More Information (AFM-4)

A major difference between AFM-4 and the other alternatives is deferring the decision on building a permanent sockeye fry hatchery until Year 10 of implementation. Instead, the Applicant would commit approximately $4.9 million to upgrade and operate the interim sockeye hatchery during the first 12 years of implementation, and approximately $1.6 million would be spent on habitat enhancement, restoration, or acquisition and protection. The remaining funds (approximately $22.5 million) would be reserved until a final decision could be made for their use. The potential for fry production from habitat enhancement during the first 12 years of implementation would be similar to AFM-2, but about one third the potential of AFM-3 (based strictly upon the level of funding, not the potential production of funded projects, which is

unknown). During this period, monitoring of naturally reproducing and hatchery-produced fry would continue as described under the Proposed HCP Alternative. Results of this monitoring and the Lake Washington ecological studies would be used to determine the scale of hatchery supplementation required through the remainder of implementation. Some funds could and should be used to evaluate actual production from enhancement projects, but this would further reduce the remaining funds available when a decision is to be made.

When the studies are completed in Year 10, a decision will be made on building a long-term hatchery. Possible outcomes include the following:

1. Build a full-sized hatchery (without staff housing) capable of producing 34 million sockeye fry
2. Build a smaller hatchery with savings going to habitat enhancement, restoration, or acquisition.
3. Do not build a long-term hatchery, continue the interim hatchery with appropriate upgrades, and implement additional habitat enhancement, protection, and restoration projects with the remaining funds.
4. Do not build a permanent hatchery, shut down the interim hatchery, and implement approximately $19.3 million in additional habitat enhancement, protection, and restoration projects.

If the decision is made to build a full-sized hatchery by Year 12, the potential benefits of producing up to 17 million sockeye fry would be delayed for 8 years (the difference between interim and full-sized production goals). Under this scenario, the long-term positive effects on sockeye salmon are similar to the Proposed HCP Alternative, but the risk of negative effects could be reduced as a result of new knowledge gained during the intervening years. Implementation of either the permanent hatchery or additional habitat enhancement, restoration, or acquisition would probably proceed with a more precise understanding of effects and benefits to the naturally reproducing salmonid stocks and ecological health of the Cedar River. It is also possible that, during the intervening years, new technology might become available that could further reduce the risks of disease in the hatchery.

If the decision is made not to build the hatchery, a substantial number of habitat protection, restoration, and enhancement projects would be implemented, but any positive effects of these projects would also be delayed. Under this scenario, money eventually would be available to implement most of the valley floor projects proposed by King County. As mentioned earlier, at millions of additional sockeye fry could be produced from valley floor projects and tributary projects if all projects were implemented and King County (1998) production assumptions were met. Although it is unlikely that all projects could be built, when a decision is made in Year 10, many of the assumptions made for estimating production will have been subjected to field

verification, and new estimates will be a factor in the decision-making process. Therefore, this alternative has been given a moderate likelihood for eventually meeting Objective 6 (Table 4.4-2). Please note that as discussed in Chapter 2 of this EA/EIS, any alternative that utilizes downstream habitat restoration as a component of mitigation for sockeye salmon is subject to the approval of WDFW.

If no hatchery is constructed, sockeye productivity will likely be considerably lower than for AFM-2 and AFM-3, and somewhat less than for AFM-5, opportunities for some habitat projects may be lost with a delay in implementation. King County (1989) estimates that sockeye egg-to-fry survival in groundwater-fed spawning channels and ponds would range from 24 to 36 percent, depending upon spawning density level. This is higher than typical natural egg-to-fry survival of 10 to 20 percent (Foerster, 1968), but much lower than the minimum 85 percent survival expected from the proposed hatchery (Montgomery Watson, 1997; HCP Technical Appendix 25). Consequently, harvest rates for AFM-4 may also be lower than that possible under AFM-2 or AFM-3. The Parties to the Landsburg Mitigation Agreement may decide to use all or some of the remaining sockeye mitigation funds for land acquisition and habitat restoration projects not included in the suite proposed by King County to protect the Lower Cedar River or to rehabilitate mainstem or tributary fish habitat. These projects would have the potential for substantial benefit for the aquatic and riparian ecosystem within the lower river, but the direct benefits to sockeye salmon are currently even more uncertain than for projects that have been proposed by the County.

Delaying the decision to build the hatchery could also result in future unintended additional delays. Complex and lengthy negotiations have been required to reach agreement on the proposed components of the proposed HCP and their timing. If the results of the Lake Washington ecological studies and other monitoring for the interim hatchery do not clearly favor the suitability of hatchery production or habitat enhancement, substantial renegotiations may be needed to make a decision. Consequently, this alternative has the potential to continue an ongoing cycle of negotiation without implementing long-term measures.

Substantial financial risk to the Applicant and other aspects of the mitigation program would result from implementing alternative AFM-4. The interim hatchery was designed for short-term use and does not contain the same margin of safety for reducing the risk of brood-year failure due to disease, mechanical or electrical problems, or other physical problems (earthquakes or floods). Alternative AFM-4 requires a substantive investment of $4.9 million to provide an adequate safety margin while hatchery and enhanced habitat fry production is evaluated. If, after 10 years, the decision is made to build a full-sized hatchery, a shortfall of up to approximately $1.5 million may occur. This shortfall will have to be made up by cutting costs in other components of the

fish mitigation to remain within the Applicant's cost cap, or could be provided by outside sources.

All Downstream Habitat Restoration and Protection Alternative (AFM-5)

Under this alternative, the sockeye fry hatchery would not be constructed, and approximately $24.1 million would be expended on habitat enhancement, restoration, and acquisition downstream of Landsburg (Table 4.4-1). Under this alternative, most of the valley floor and tributary projects proposed by King County that include sockeye spawning habitat have the potential to be funded. As mentioned earlier, millions of additional sockeye fry could be produced from these projects according to King County's production assumptions, but it is unlikely that all projects could actually be implemented. Under both the low and moderate spawning densities, the Applicant would probably fail to meet the mitigation goal of 34 million sockeye fry. Consequently, AFM-5 has been given a low likelihood for meeting Objective 6.

As described above under the no-hatchery scenario for AFM-4, sockeye productivity under AFM-5 will be lower than in either AFM-2 or AFM-3 because of differences in expected egg-to-fry survival. King County (1998) estimates that sockeye egg-to-fry survival in groundwater-fed spawning channels and ponds would range from 24 to 36 percent, depending upon spawning density level. This is higher than typical natural egg-to-fry survival (Foerster, 1968), but much lower than the minimum 85 percent survival expected from the proposed hatchery (Montgomery Watson, 1998; HCP Technical Appendix 25). Consequently, the potential harvest rate would be lower than under AFM-2 or AFM-3, because no hatchery component would be present in the population.

As mentioned above under AFM-4, the Parties to the Landsburg Mitigation Agreement may elect to spend some or all of the available funds on land acquisition or habitat restoration projects other than those proposed by King County. However, the direct benefits to sockeye salmon within 50 years, beyond those estimated from enhancement projects proposed by King County, are difficult to assess. Even if large amounts of riparian lands are purchased and preserved or restored under this alternative, benefits may require many years to develop and probably will not reach their full potential within 50 years. Areas that currently lack riparian forest will likely require more than 100 years to return to full function. For all practical purposes, some areas may never return to pristine conditions, because dykes and revetments have changed the channel morphology and floodplain, eliminating important events (floods) that contributed to the historic riparian characteristics. Only large-scale rehabilitation projects far beyond the scope of the Applicant's mitigation obligations could change these permanent channel characteristics.

4.4.3 Effects of Instream Flow Alternatives

The operation of the Applicant's water storage and diversion facilities and hydroelectric generating plant directly affects the quantity and quality of fish habitat in the Cedar River and Chester Morse Lake. Stream flow regulation can affect a number of factors that influence anadromous salmonid production potential downstream of the Lower Cedar Falls. The volume of water, or instream flow (generally measured in cubic feet per second), flowing through the stream channel can affect the amount and distribution of spawning and rearing habitat in the river at any given time; affect survival of incubating eggs or larval fish; affect the risk of stranding fish during reductions in flow; and can affect conditions for upstream and downstream fish migration. In addition, fluctuations in reservoir levels associated with water storage and withdrawal can affect fish populations resident to Chester Morse Lake.

There are two alternatives under consideration with regards to instream flows. The first alternative is the No Action Alternative (IF-1) for Instream Flows which would continue the non-binding guidelines for managing flows recommended by the WDOE Instream Resource Protection Program (IRPP) established in 1979. No additional instream flow management provisions would be implemented. The second alternative is the Proposed HCP Alternative for Instream Flows (IF-2) under which the Applicant would commit to a binding set of instream flow requirements in order to establish greater long term certainty for fish habitat conditions and water supply planning as outlined in the Instream Flow Agreement (Technical Appendix 27). The Applicant would also supplement the required flows to meet biological objectives under specific conditions that reflect actual and forecasted water availability. Additional instream flow management provisions would be implemented to protect fish resources, including the establishment of a commission to provide general oversight, coordination, and, where specifically authorized, direction regarding the implementation of the Instream Flow Agreement.

Section 4.4.3.1 below describes the basis for alternative comparison and summarizes the primary studies used in evaluating the environmental consequences of the two alternative flow regimes, Section 4.4.3.2 describes additional considerations that need to be recognized when comparing the two alternative flow regimes. Section 4.4.3.3 describes the effects of No Action Alternative while Section 4.4.3.4 describes the effects of the proposed HCP flows. Finally, Section 4.4.3.5 provides a summary comparison of the two flow regime alternatives with regard to fish habitat.

Basis for Alternative Comparison

Concerns for establishing an appropriate flow regime have led to a number of studies related to instream flows in the Cedar River during the last 30 years. In 1986, the Applicant began funding a collaborative study effort under the direction of the Cedar River Instream Flow Committee (CRIFC) in an effort to

develop an instream flow regime that would provide protection for all life history stages of the anadromous salmonid populations in the Cedar River. The CRIFC, consisting of representatives from SPU, the Washington Department of Fish and Wildlife, the Washington Department of Ecology, the U. S. Army Corps of Engineers, the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and the Muckleshoot Indian Tribe, oversaw all aspects of the study and subsequent publication of the study results in 1991. This collaborative study program included a comprehensive Instream Flow Incremental Methodology (IFIM) study and a number of companion investigations.

Recognizing that the IFIM would not provide all the necessary information for establishing the appropriate instream flow regime, the CRIFC requested a number of additional analyses be conducted to complement the IFIM.

Beginning in 1993, the CRIFC carried the information from the studies into further discussions, analyses, and negotiations in an effort to develop a comprehensive instream flow regime to protect aquatic resources throughout the historic range of anadromous fish in the Cedar River. These further efforts culminated in the development of the instream flow management regime described in the March 17, 1997 Agreement in Principle for the Cedar River Habitat Conservation Plan (SPU, 1997), signed by five cooperating state and federal agencies and presented here as part of the Applicant's proposed HCP.

The effects of the two alternative flow regimes on salmon and steelhead are based primarily on evaluation and comparison of the quality and quantity of fish habitat as described by the investigations conducted under the CRIFC study program. A brief summary of the investigations are provided in the following sections. Further detail of the instream flow and related studies are provided in Chapter 3.3.2 of the Applicant's proposed HCP.

IFIM Study

One method of alternative evaluation includes the degree to which each alternative achieves the maximum habitat availability as determined by the Instream Flow Incremental Method (IFIM). The IFIM is based on the premise that stream dwelling fishes prefer a certain range of depths, velocities, substrates, and cover types, depending on the species and life stage, and, that the availability of these preferred habitat conditions varies predictably with stream flow. With input from stream flow, substrate, and cover type measurements, the IFIM uses a set of computer programs developed by the FWS to quantify habitat availability over a range of flows. Relative to other instream flow methods, the IFIM is quite rigorous in its demand for field data and quantitative analysis.

The IFIM is a physically based model in which the primary variables are hydraulic and structural, e.g. water depth, water velocity, substrate size, and cover quality. An index of biological value is ascribed to each of these

variables according to the habitat preferences unique to the species and life stage of interest. The IFIM model combines the habitat preferences of the species of interest with river specific stream flow, substrate, and cover quality data to produce a habitat/discharge curve known as Weighted Useable Area (WUA). For example, a chinook salmon has a preference for a certain range of water depths and velocities over a preferred size of substrate for redd building and spawning. For the Cedar River, optimum depth for chinook spawning ranges from 0.75 feet to 3.4 feet and optimum velocity ranges from 1.75 feet per second to 3.0 feet per second. Preferred substrate size is in the range of 2 inches to 4 inches. The river discharge that provides the greatest area of these combined habitat preferences would be the optimum flow for spawning and would be represented by the peak of the chinook spawning WUA curve (Figure 4.4.1).

Generally, WUA increases as river discharge increases up to a certain level and then WUA decreases as river discharge reaches a level that produces depths and velocities that are beyond the fish's habitat preference. The fact that WUA decreases to the right of the peak (as discharge increases) is an important aspect of the WUA function and is integral to discussions throughout this effects analysis. In some cases, particularly with the salmonid rearing lifestage, WUA remains relatively flat throughout the range of normal river discharges, thus demonstrating that rearing habitat is less sensitive to discharge. Conversely, spawning habitat quantity may be lost at a significant rate as flows increase beyond discharge needed to create maximum WUA.

It is important to recognize that the result of the IFIM is not a set value but a range of values to be used as a tool for determining the appropriate stream flow or set of stream flows. Other measures of habitat quality and effectiveness analyzed by the CRIFC are described below.

Effective Spawning Analysis

The purpose of the effective spawning analysis is to protect against suffocation or dehydration of incubating eggs that may result from controlled stream flow reductions during or following the spawning period. The effective spawning analysis uses the hydraulic output from the IFIM to predict the discharge at which spawning areas in the stream could become dewatered. The product is a series of matrices and figures that specify the post-spawning flow required to protect incubating sockeye and steelhead eggs from dehydration (Cascades Environmental Services, 1991).

Cumulative Spawning Analysis

The purpose of the cumulative spawning analysis as envisioned by the CRIFC was to determine if sockeye spawning potential in the Cedar River below Landsburg could be maximized through regulated incremental increases in discharge during the spawning period. This "stepped flow" approach would

theoretically provide maximum spawning potential by progressively adding habitat from the middle of the channel toward the edge of the channel through the duration of the sockeye spawning period. The cumulative spawning model was developed in a collaborative process with the CRIFC. The primary data source for the cumulative spawning model is spawning habitat output from the IFIM.

Figure 4.4-2. Relationship between flows measured at Landsburg as compared to flows measured at Renton

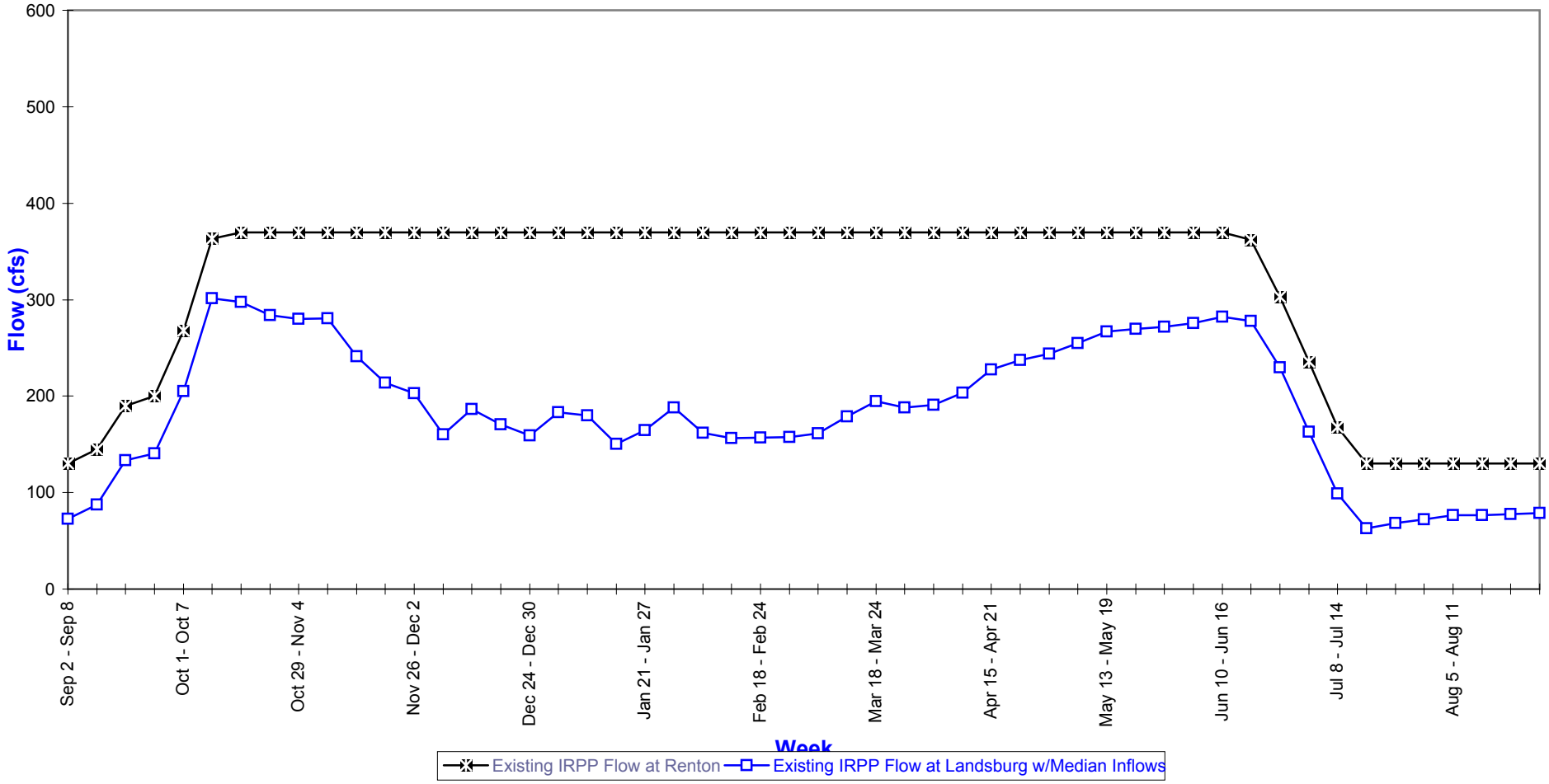
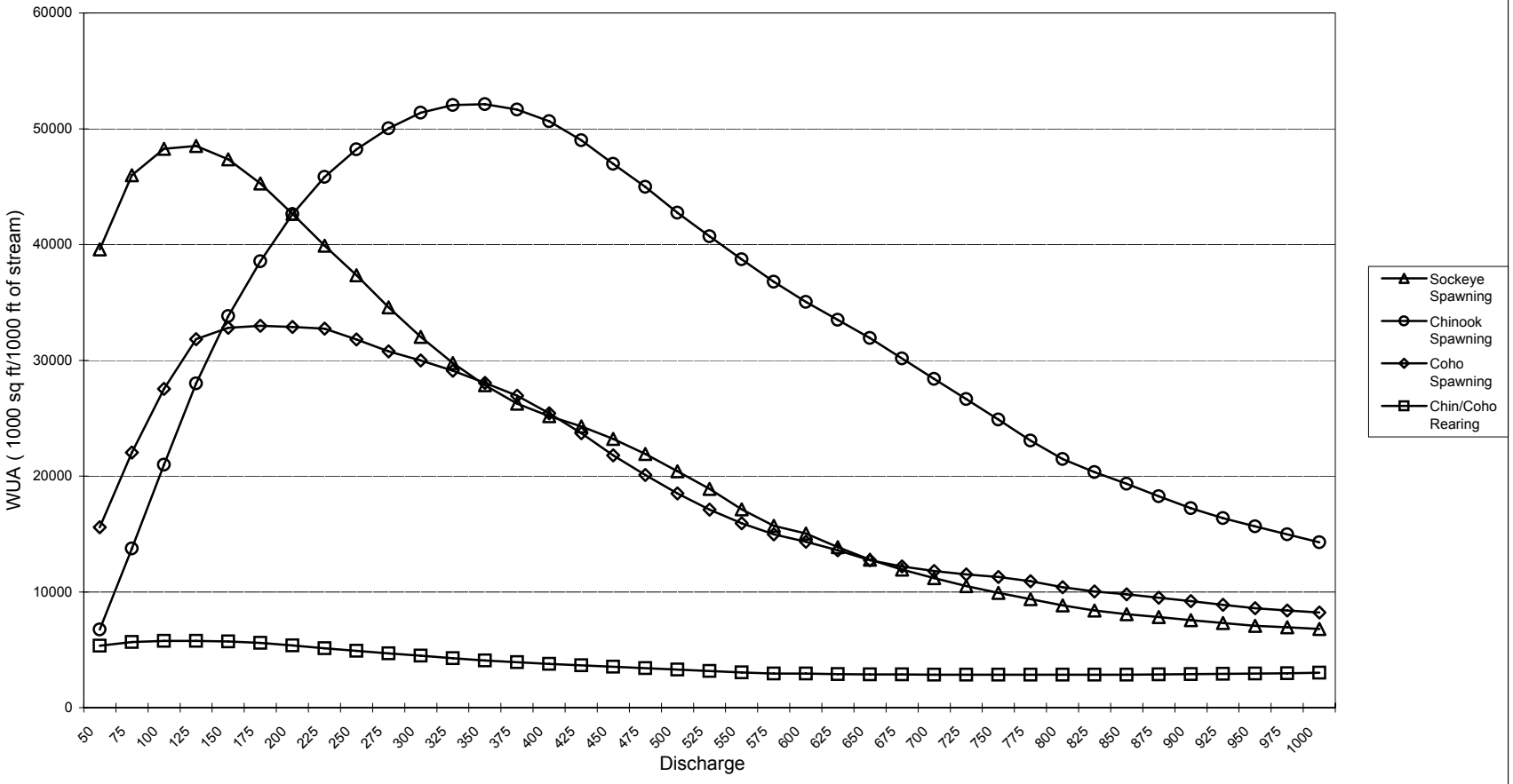


Figure 4.4-1. Relationship between stream flow and the quantity of salmon spawning and rearing habitat as expressed by Weighted Useable Area determined by the Instream Flow Incremental Method for a single study area in the Cedar River.



Redd Scour Studies

Flood flows in the Cedar River have been determined to have an adverse impact on sockeye egg survival. Because of this potential impact, the CRIFC was concerned that a negotiated lower flow during the sockeye spawning period could increase egg mortality by concentrating spawners in the mid-channel zone where bed scour is presumably more likely to occur. The CRIFC directed that a study be conducted to assess relationship between discharge, sockeye spawning habitat, and bed scour potential.

A Radio Telemetry method was developed by Cascades Environmental Services in consultation with the CRIFC in which small radio transmitters were buried in sockeye redds and then monitored for displacement during subsequent flood events. Correlated to the concern of sockeye redd scour was the CRIFC's desire to provide safe areas for spawning, presumably along the margins of the river, where bed scour would not occur or would be less severe. An Edge Spawning Habitat Analysis method was also developed in consultation with the CRIFC. The basic purpose of the Edge Spawning Habitat Analysis was to examine the range of flows necessary to provide suitable sockeye spawning habitat in specified edge areas along the margins of the river.

Ramping Rate Analysis

Fry and juvenile salmonids and other fishes are vulnerable to sudden flow reductions in the Cedar River. Fish can be killed by stranding on open gravel bars or by isolation in potholes or side channels that subsequently dry up. To prevent such occurrences, the WDFW has established ramping rate guidelines that limit the rate of flow reduction. The ramping rate guidelines are most effective when they are coupled with site specific information such as river channel morphology, hydraulics, species presence, and operational constraints and opportunities of the water project. The primary source of information for the Cedar River on the relationship between reductions in discharge and stream bed exposure was output from the IFIM.

Fish Passage

Although the absolute minimum flow that would allow passage was not determined, studies indicated that upstream passage of adult chinook would not be impeded at flows of 94 cfs or more (Cascades Environmental Services, 1991). The CRIFC decided that studies of less than 94 cfs would not be necessary as long as negotiated instream flows (at the passage transect) were equal to or greater than 94 cfs.

Reservoir Levels and it Effects on Lake Fish Populations

Because of storage and release of water behind Masonry Dam for water supply and instream flow requirements, both IF-1 and IF-2 effect water levels in Chester Morse Lake at certain times of year. Low reservoir levels may impact the spawning migrations of bull trout and pygmy whitefish. High reservoir levels may impact bull trout redds established in the Cedar and Rex Rivers that are subject to inundation.

To assess the incremental effect of instream flow regimes on Chester Morse Lake reservoir levels, a simplified numerical water balance model of the Cedar River system is used that incorporates reservoir operation under the two alternative flow regimes. The model assumes that historical stream inflows to the reservoir from October 1, 1928 to March 24, 1993 represents future inflow conditions. This model was used for the purpose of providing a comparison of modeled weekly Chester Morse Lake reservoir levels resulting from the two different instream flow scenarios. Model analyses involved comparisons of weekly reservoir levels between the two regimes during the 13-week bull trout spawning period from September 16 to December 16 and the 3-week pygmy whitefish spawning period from November 26 to December 16.

The Applicant acknowledges the difficulty associated with modeling actual real-time operational constraints and the uncertainty of the collaborative decision-making processes that will occur between the parties to the Instream Flow Agreement under IF-2. Both modeled scenarios used simplified assumptions about the Cedar River system and operational constraints. The results from the models are not intended to precisely predict actual future or past reservoir levels in Chester Morse Lake, but rather are used to predict if there will be significant differences in reservoir levels between the two alternative flow regimes (for more details see Section 4.5.6 of the HCP).

Additional Considerations in Alternative Flow Regime Comparisons

A number of comparisons are presented describing effects of the two instream flow regime alternatives. These comparisons require further explanation with regard to the terminology used and the manner in which they were derived.

Minimum Instream Flow Requirements

Throughout the Applicant's proposed HCP and this EA/EIS document, minimum instream flow requirements are frequently discussed. The minimum instream flow requirements are in fact a major component in the conservation strategies for salmon and steelhead in the Cedar River. The term minimum instream flow requirements is not used here, as it is used in some cases, to indicate the lowest stream flow levels required to marginally protect fish habitat. Rather, the term is used here to indicate the levels below which the Applicant will not allow stream flows to drop in the Cedar River. The

Applicant holds that the minimum instream flow requirements under the IF-2 have been collaboratively developed with the benefit of an extensive biological information base and represent beneficial flows that will help ensure the continuous provision of high quality fish habitat throughout the Cedar River between Lower Cedar Falls and Lake Washington.

Normal and Critical Flow Regimes

Throughout the remainder of this Section 4.4.3, normal and critical flow regimes are commonly referenced. Instream flow regimes under both the No-Action and Proposed HCP Alternatives contain provisions for a normal flow schedule and a critical flow schedule. The term normal and critical are used here by convention established by the existing Department of Ecology IRPP regime which distinguishes between "normal" conditions and the hardship or "critical" conditions that can result during a drought situation. Normal minimum flows are defined as the minimum instream flow rates that the Applicant will provide except under very adverse and infrequent hydrologic conditions, during which time critical instream flow rates apply. Under both alternatives, critical flow rates would apply only under adverse conditions and would be expected at a frequency of approximately once in 10 years on the average.

Level of commitment

In comparing the numerical aspects of the two flow regimes, they have been presented as if they were equal in their level of commitment and enforceability. However, the IF-2 regime, unlike the IRPP regime under the IF-1 Alternative, will obligate the Applicant to operate according to a set of binding prescriptions. Therefore, when compared to the historical flow record, analysis of the IF-1 flow regime may overstate actual stream flows during periods of dry hydrologic conditions.

The two regimes are similar in that each provides a normal flow schedule and a critical flow schedule. However, the IF-1 regime provides no opportunity to establish higher stream flow commitments during periods of favorable hydrologic conditions. In contrast, the proposed HCP regime provides opportunities for increased stream flow commitments during periods of key importance to anadromous fish. The precise timing and distribution of these flows will vary from year to year depending on hydrologic conditions, biological need, and direction from the Parties to the Instream Flow Agreement. The effects of these increased stream flow commitments are a key consideration in comparisons of the two alternative instream flow regimes.

Different Measurement Points

When comparing the two alternative flow regimes, it is important to note that the two regimes have different measurement points. The stream flow

measurement point for the IF-1 flow regime would continue to use the USGS stream gage #12119000 in Renton, 1.6 miles upstream from Lake Washington. Under the IF-2, the Applicant would move the flow measurement point from Renton to river mile 20.4 near Landsburg.

In order to compare the stream flow commitments in the proposed HCP, as measured at river mile 20.4 near Landsburg, with the IF-1 flow regime as measured at river mile 1.6 in Renton, it is necessary to account for flow accretion into the river between Landsburg and Renton. Flow accretion is the gain in river discharge between two points due to surface or subsurface inflows from tributaries, seeps, or upwellings. Also, in order to correctly quantify the amount of habitat relative to the optional Renton or Landsburg control points, it was necessary to determine the cumulative discharge at IFIM study locations and Renton relative to any given discharge as measured below the Landsburg Diversion Dam.

An extensive investigation of inflows between the two points was conducted as part of the Cedar River Instream Flow and Salmonid Habitat Utilization Study (Cascades Environmental Services, 1991). The investigations resulted in the production of a model providing mean weekly inflows for the full range of hydrologic conditions experienced between 1929 and 1988 (Technical Appendix 8). The accretion flow model developed during the instream flow study program has been used here to make the appropriate adjustments to facilitate comparisons of the two regimes.

For comparison of alternatives, 50th percentile (median) accretion flows to the lower river were used to compare habitat availability between the two alternatives under the normal minimum flow regime. The 6th percentile inflows were used in comparison of the critical minimum flow regime. Figure 4.4-2 illustrates the relationship between instream flows as measured at Landsburg and Renton, respectively. Note that the difference between flows at the respective gages varies throughout the year. These differences have been accounted for in evaluating the two alternative flow regimes.

Species and life history stages prioritized

A basic understanding of the life history of the salmon and steelhead species is important for recognizing and understanding the likely impacts associated with different flow regimes. From the strict standpoint of WUA, the primary species and life history stages of interest are spawning and rearing chinook, coho, and steelhead and spawning sockeye (sockeye fry migrate immediately to Lake Washington after emergence and therefore do not rear in the river). Differences in the timing of life history stages mean that flows most advantageous for a particular life history stage of one species may not be effective for another. Figure 4.4-3 displays the timing of the target species and life stages used by the CRIFC in developing various flow regimes. Because each species and life stage has different habitat preferences it is not possible to

Figure 4.4-2. Relationship between flows measured at Landsburg as compared to flows measured at Renton

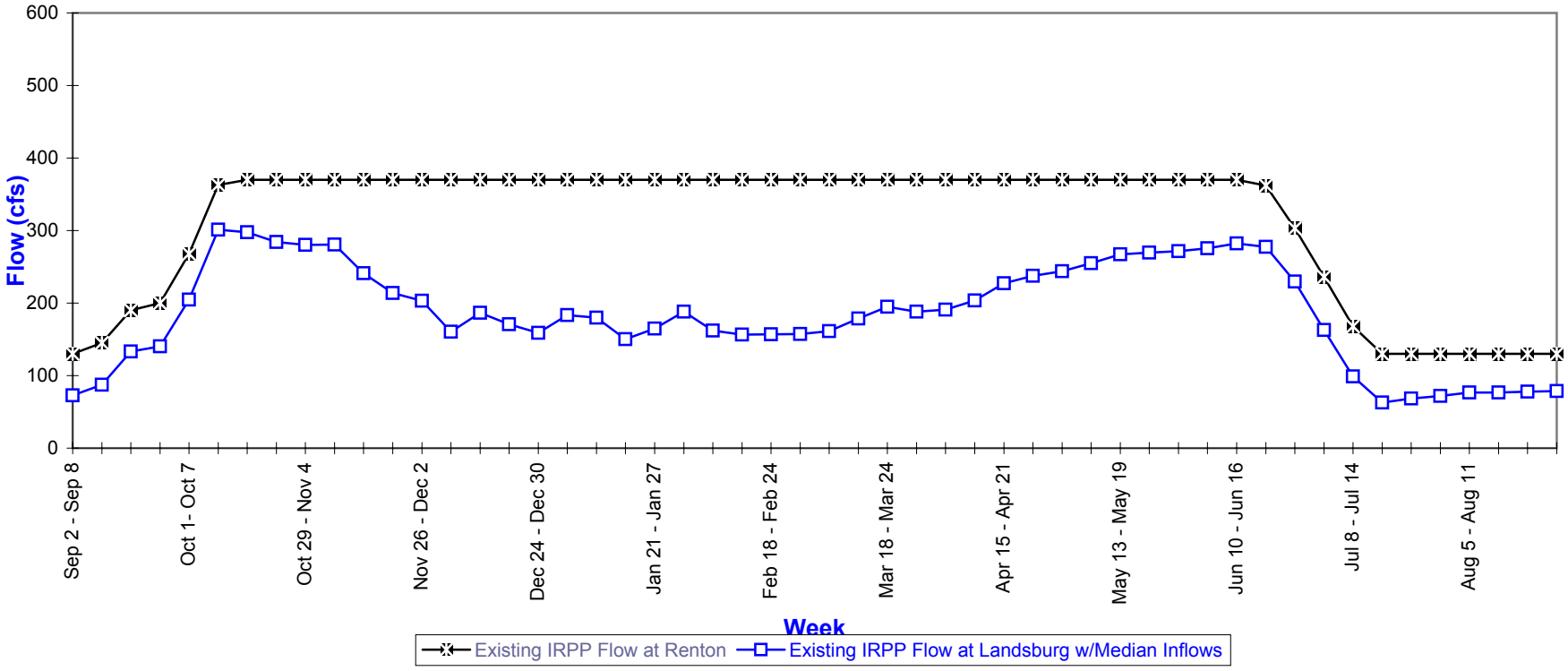


Figure 4.4-3. Approximate Life history timing of sockeye, chinook, and coho salmon and steelhead trout in the Cedar River

Table 4.4-3. Key instream flow considerations used by the CRIFC during development of proposed HCP flow regime for anadromous fish in the lower Cedar River.

Time Period	Primary Species and Life History Life Stage Considerations	Additional Important Considerations
Mid-Sept. to Mid-Nov.	• Quantity of chinook spawning habitat	• Cumulative habitat and edge habitat for spawning sockeye • Protect incubating salmon • Quantity of juvenile rearing habitat
Mid-Nov. to End Dec.	• Edge habitat for spawning sockeye	• Protect incubating salmon • Quantity of coho spawning habitat
End Dec. to Early Feb.	• Salmon incubation protection	• Quantity of coho spawning habitat
Early Feb to mid-April	• Outmigrating sockeye fry	• Protect incubating salmonids • Quantity of steelhead spawning habitat • Avoid excessively high sustained flows that force steelhead to spawn in areas where redds will be vulnerable to dewatering
mid-April to early June	• Avoid excessively high sustained flows that force steelhead to spawn in areas where redds will be vulnerable to dewatering	• Outmigrating sockeye fry • Quantity of steelhead spawning habitat • Quantity of juvenile rearing habitat • Protect incubating salmonids
Early June to early Aug.	• Protect incubating steelhead	• Quantity of juvenile rearing habitat
Early Aug to Mid-Sept.	• Quantity of juvenile rearing habitat	

achieve maximum WUA for all species and life stages at a single river discharge when timing of species and lifestage in the river overlap. For example, WUA for spawning sockeye is achieved at 105 cfs whereas peak WUA for spawning chinook is achieved at 275 cfs (measured at Landsburg). When the WUA/discharge function of two different species or lifestages do not

overlap but timing does, species prioritization decisions must be made. One answer is to optimize habitat for all species and lifestages. Basically, this is an "averaging" technique and is not generally accepted by the WDFW and WDOE. The other solution is to prioritize species and life stages and attempt to maximize WUA accordingly.

The CRIFC took the prioritization approach to establish instream flows for Proposed HCP Alternative, IF-2. The rationale for species and life history stage prioritization used for development of the proposed flow regime are elaborated in Section 4.4.2 in the Draft HCP. Through the remainder of this chapter, species and life history stages that were considered the primary focus for establishment of instream flows during any particular period are referred to as *key species and life history stages*. The proposed HCP instream flow regime attempts to address key species and life history requirements while minimizing conflicts between species. Species specific life history stages that required the greatest discharge at any time of the year were first used as a foundation for development of instream flow regimes. The CRIFC realized some features of habitat quality important for key species and life history stages cannot be effectively protected by simply maximizing WUA. Additional provisions were added to address other key factors that are important in maximizing habitat quality and fish production. Table 4.4-3 displays the primary species and life history stage considerations the CRIFC focused on for establishing flow regimes. These same considerations were used in analyzing the effectiveness of the two alternative instream flow regimes.

The results of the comprehensive IFIM study and other collaborative studies have been used as the foundation for the effects analysis for each alternative. The first consideration in analyzing the alternative flow regimes was to evaluate the degree to which each alternative achieves the maximum habitat availability for species and life history stages throughout the year as determined by the IFIM. IFIM is an important and powerful tool that is helpful in describing the relationship between stream flow and fish habitat and is the accepted methodology in Washington State used to establish instream flow requirements for fish. However, it is recognized the methodology does not address all aspects of the biological requirements of fish (Castleberry et al., 1996). Therefore, each alternative was analyzed to the degree which flows help provide for other key factors of habitat quality as identified by the CRIFC and described by the companion investigations conducted during the collaborative study program.

Relationship between flows and maximum available habitat for key species and life history stages

Figures 4.4-4 and 4.4-5 are presented as the basis for discussing the relationship of normal minimum flows to maximum available habitat expressed as maximum WUA for key species and life history stages as they are

measured at Renton and Landsburg gages, respectively. Figure 4.4-6 and 4.4-7 illustrate the relationship of critical minimum flows to maximum WUA. To adjust the respective flow regimes to alternative compliance points, we have assumed median levels (50th percentile) of inflow between Landsburg and Renton under normal flow years, whereas the 6th percentile levels of inflow were assumed for dry conditions under critical flow years. The illustrations depicting normal flow regimes reveal that the required flows under both the IF-1 and IF-2s are often well above the level needed to maximize WUA for key species and life history stages. The effects of prioritizing flows to accommodate for other habitat considerations (i.e. incubation protection, cumulative spawning habitat) at the expense of habitat quantity (WUA) for life history stages of other species are addressed.

No Action Alternative (IF-1)

The No Action Alternative represents what is likely to occur as part of the management of instream flows if the Applicant does not pursue an Incidental Take Permit (ITP) and implement an approved HCP. In general, IF-1 is defined as no change from current management direction or level of management intensity. Under this alternative it is assumed that the Applicant would continue to operate under the City's Water Supply Plan adopted in 1992. This program recommends using the flow regime suggested in 1979 for the Cedar River by the IRPP as general, non-binding guidelines for managing flows. The IRPP regime contains provisions for a normal flow schedule and a critical flow schedule which is implemented during periods of severe drought (Table 4.4-4).

Instream Flows Downstream of Landsburg Diversion

Throughout much of the year under normal flows, the IF-1 flow regime provides more flow than is required to create maximum WUA at any one time as defined by the IFIM study for steelhead and salmon species and life history stages (Figure 4.4-4 and 4.4-5). However, during mid-July through mid-September, instream flows are below the discharge needed to provide maximum available habitat for juvenile steelhead and coho rearing. Likewise, during mid-September through the first week of October and again in November, flows are below those required to create maximum WUA for chinook spawning. During portions of the year, normal flow requirements result in decreases in spawning and rearing habitat for some species, but provide additional overriding benefits to other key species and life history stages. Under adverse hydrologic conditions during which the critical minimum flow regime is in place, the IF-1 flow regime is below discharge needed to create maximum WUA for key species and life history stages for most of the year (Figure 4.4-7). Required critical flows exceed levels necessary to maximize WUA only for sockeye and coho salmon spawning during the December, January, and February. In addition, the critical flow requirements provide no higher incubation flows for salmon and steelhead, nor do they provide cumulative spawning habitat for sockeye as described below.

Figure 4.4-4. A comparison of normal minimum flows at Renton. The figure displays the existing IRPP flows, or No Action Alternative flows, as compared to the HCP Alternative flows. The flows required to create maximum weighted useable area (WUA) as defined by the IFIM study for key life history stages are displayed.

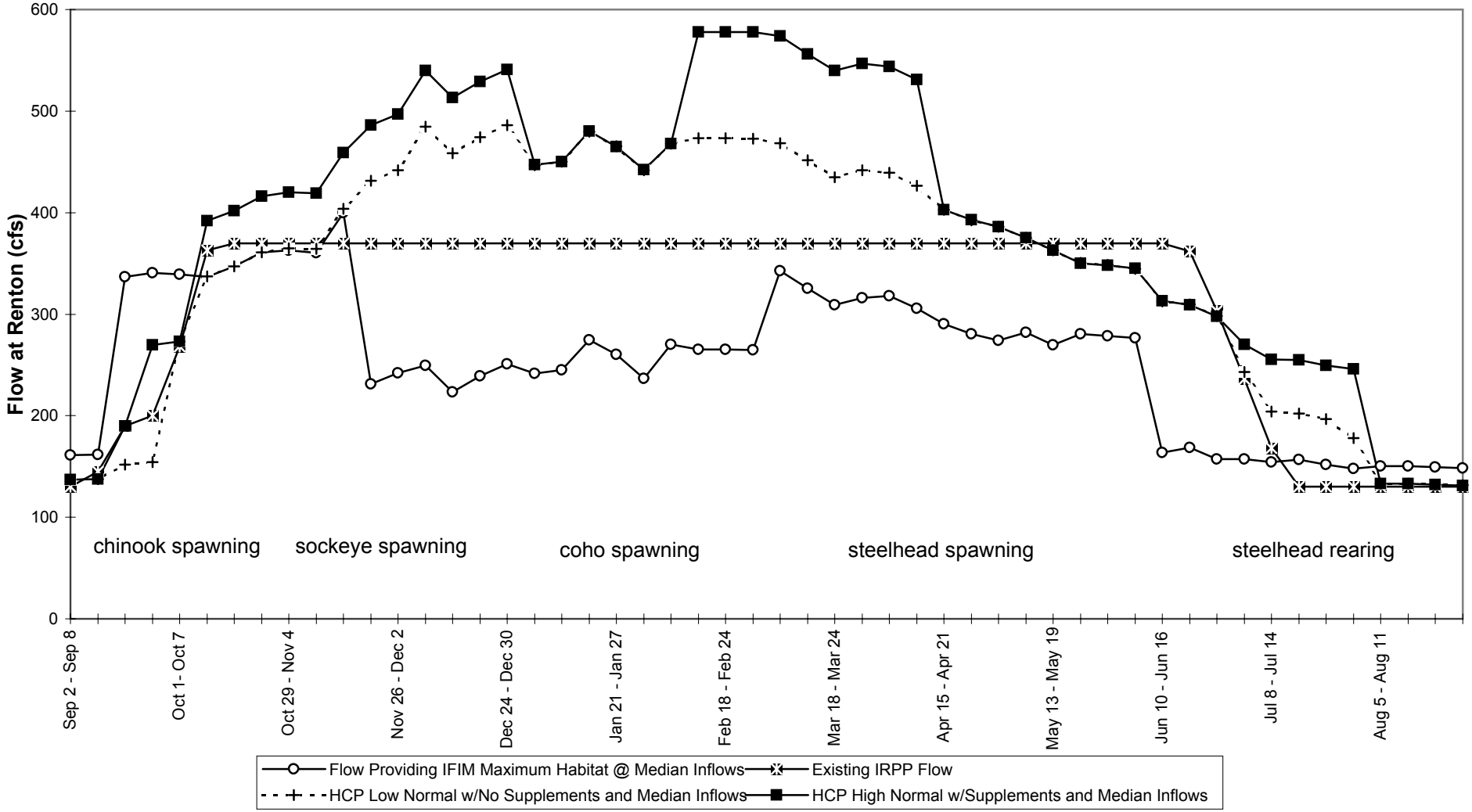


Figure 4.4-5. A comparison of normal minimum flows at Landsburg. The figure displays the existing IRPP flows, or No Action Alternative flows, as compared to the HCP Alternative flows. The flows required to create maximum weighted useable area (WUA) as defined by the IFIM study for key life history stages are displayed.

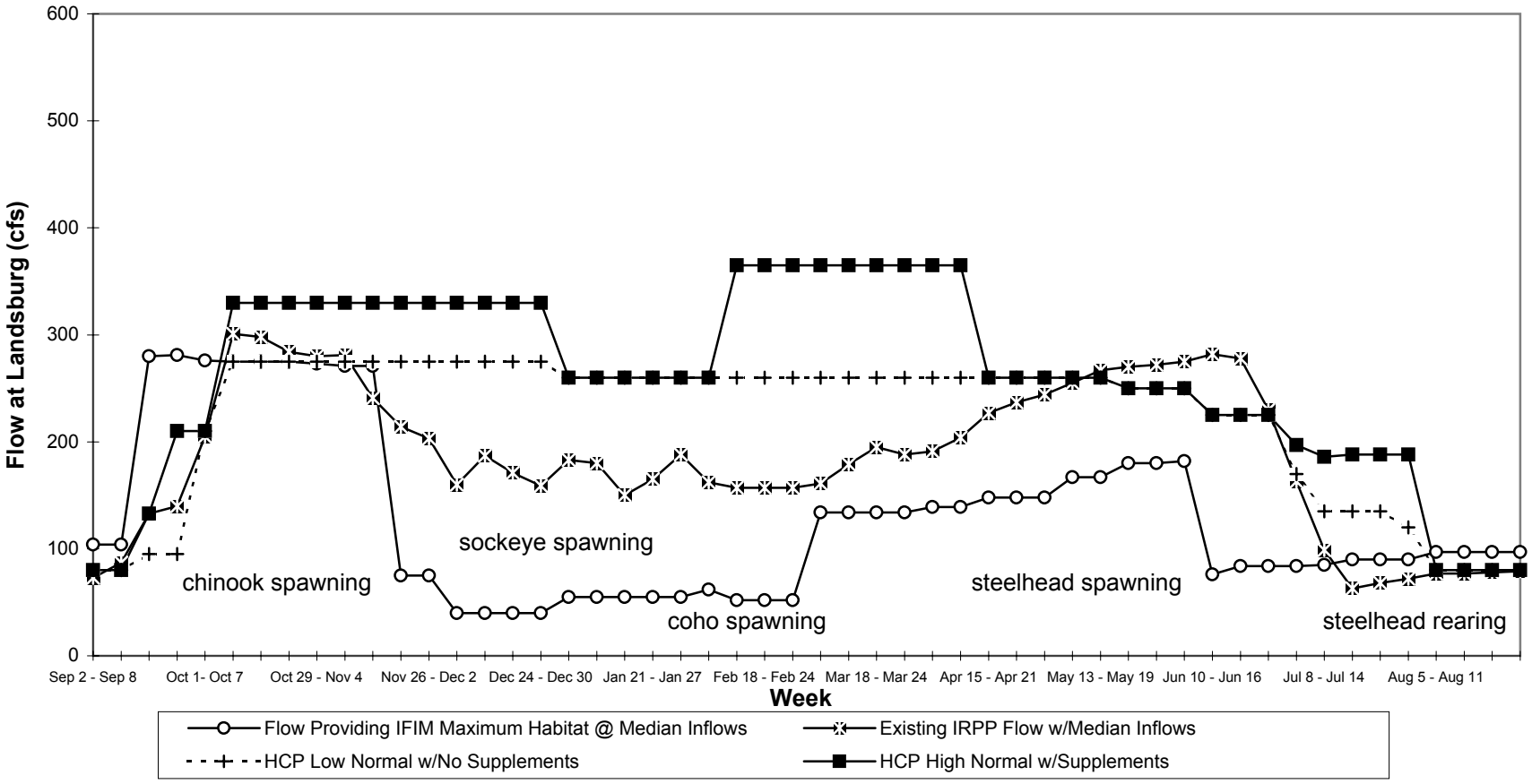


Figure 4.4-7. A comparison of critical flows at Landsburg. The figure displays the existing IRPP flows, or No Action Alternative flows, as compared to the HCP Alternative flows. The flows required to create maximum weighted useable area (WUA) as defined by the IFIM study for key life history stages are displayed.

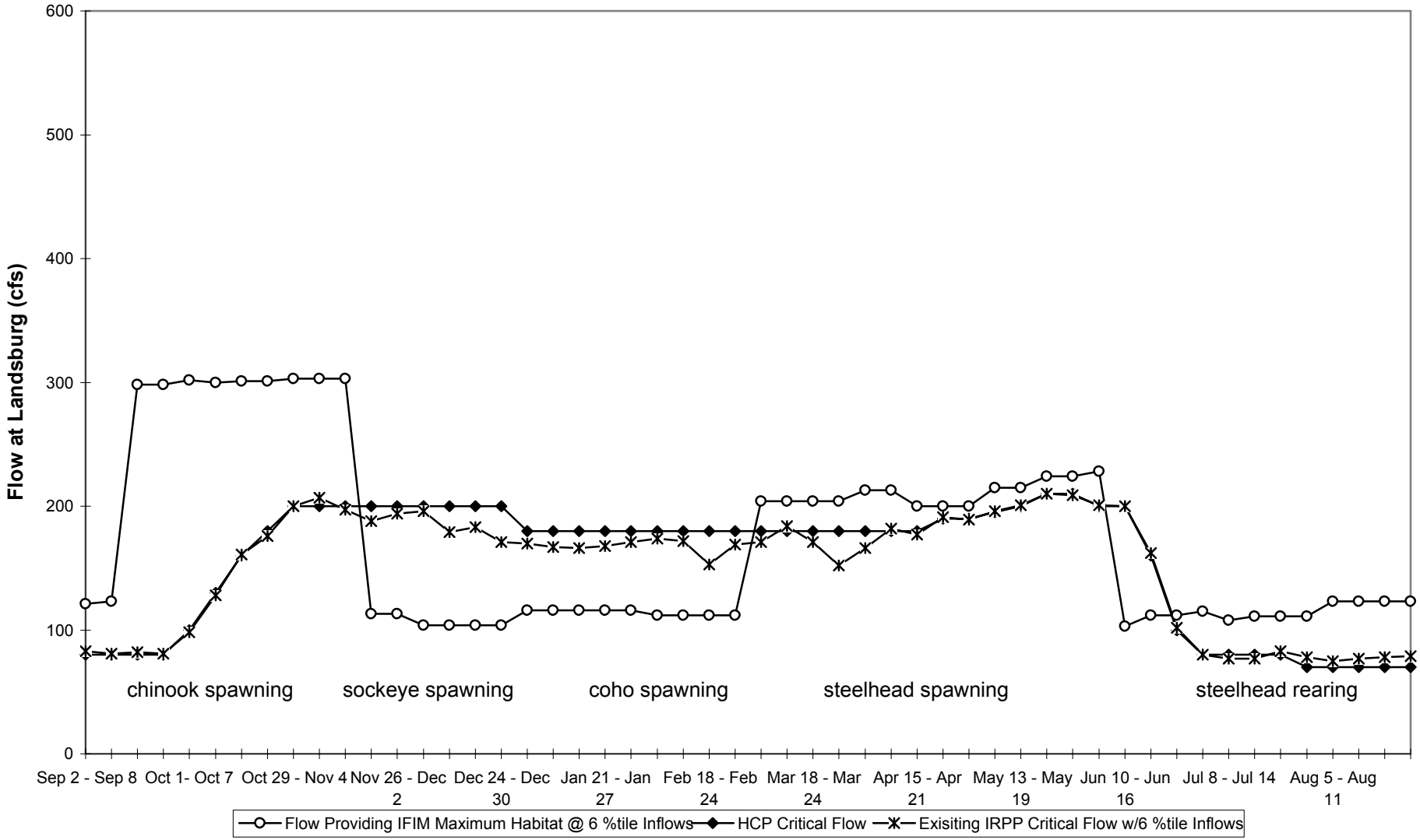


Figure 4.4-6. A comparison of critical flows at Renton. The figure displays the existing IRPP flows, or No Action Alternative flows, as compared to the HCP Alternative flows. The flows required to create maximum weighted useable area (WUA) as defined by the IFIM study for key life history stages are displayed.

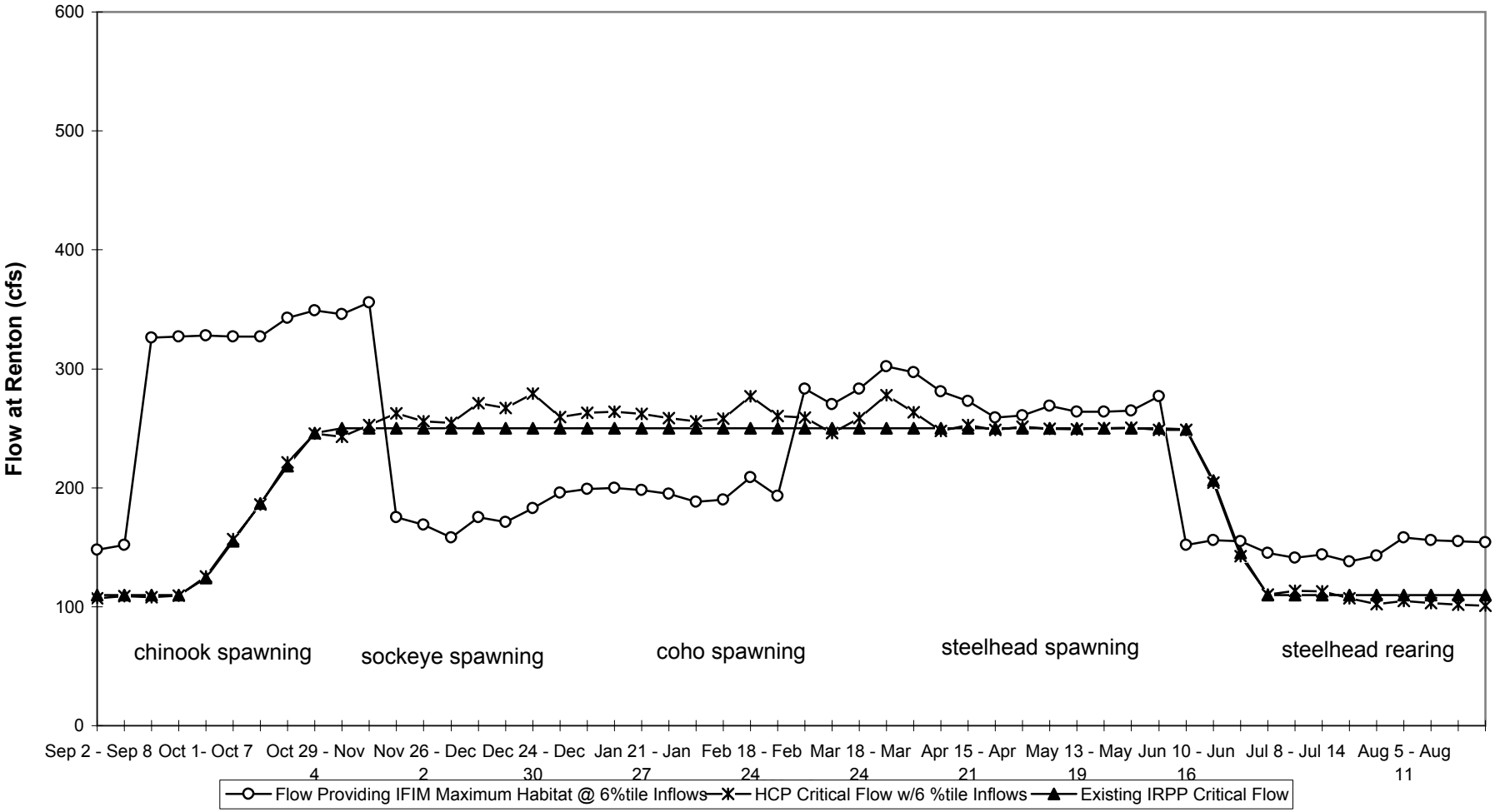
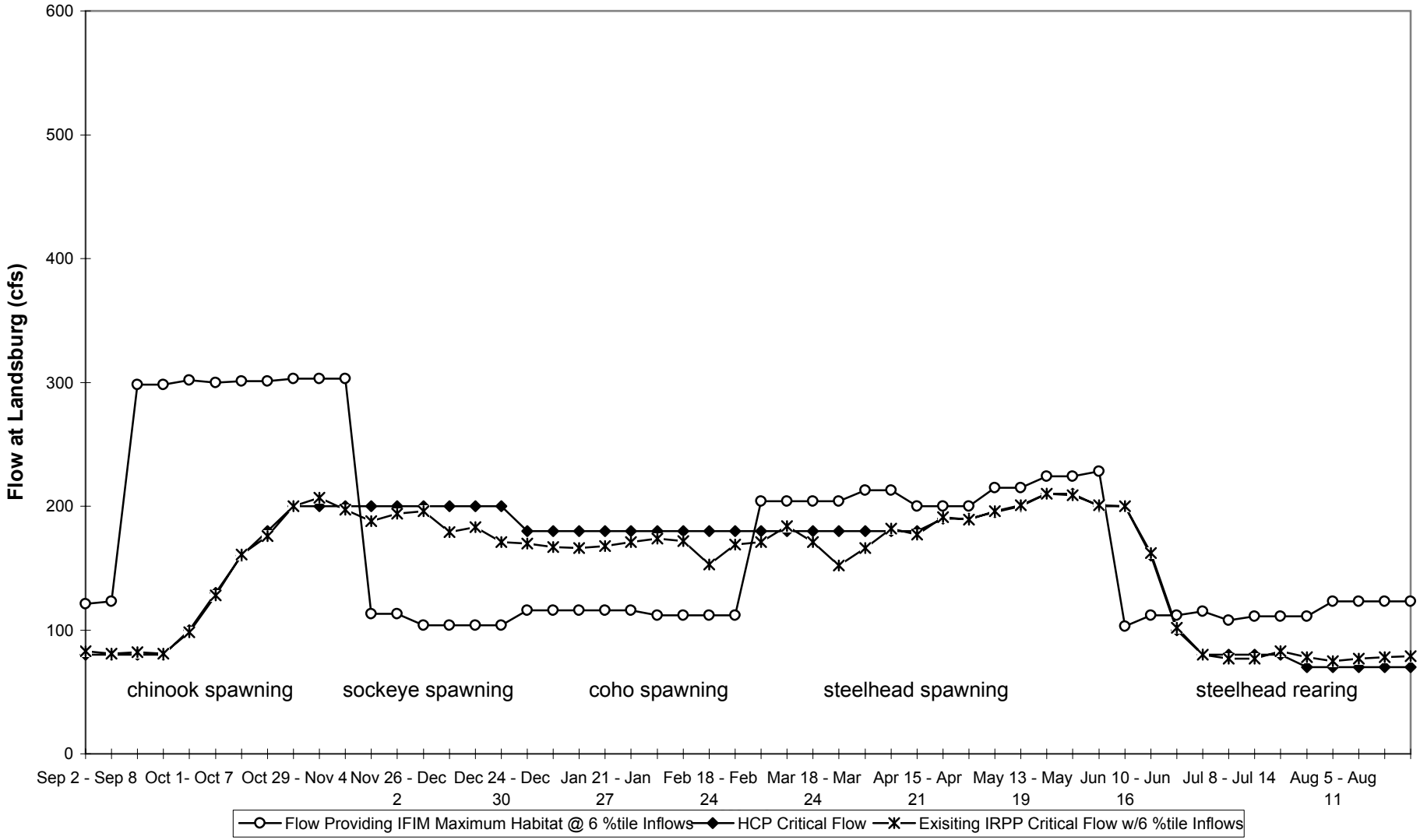


Figure 4.4-7. A comparison of critical flows at Landsburg. The figure displays the existing IRPP flows, or No Action Alternative flows, as compared to the HCP Alternative flows. The flows required to create maximum weighted useable area (WUA) as defined by the IFIM study for key life history stages are displayed.



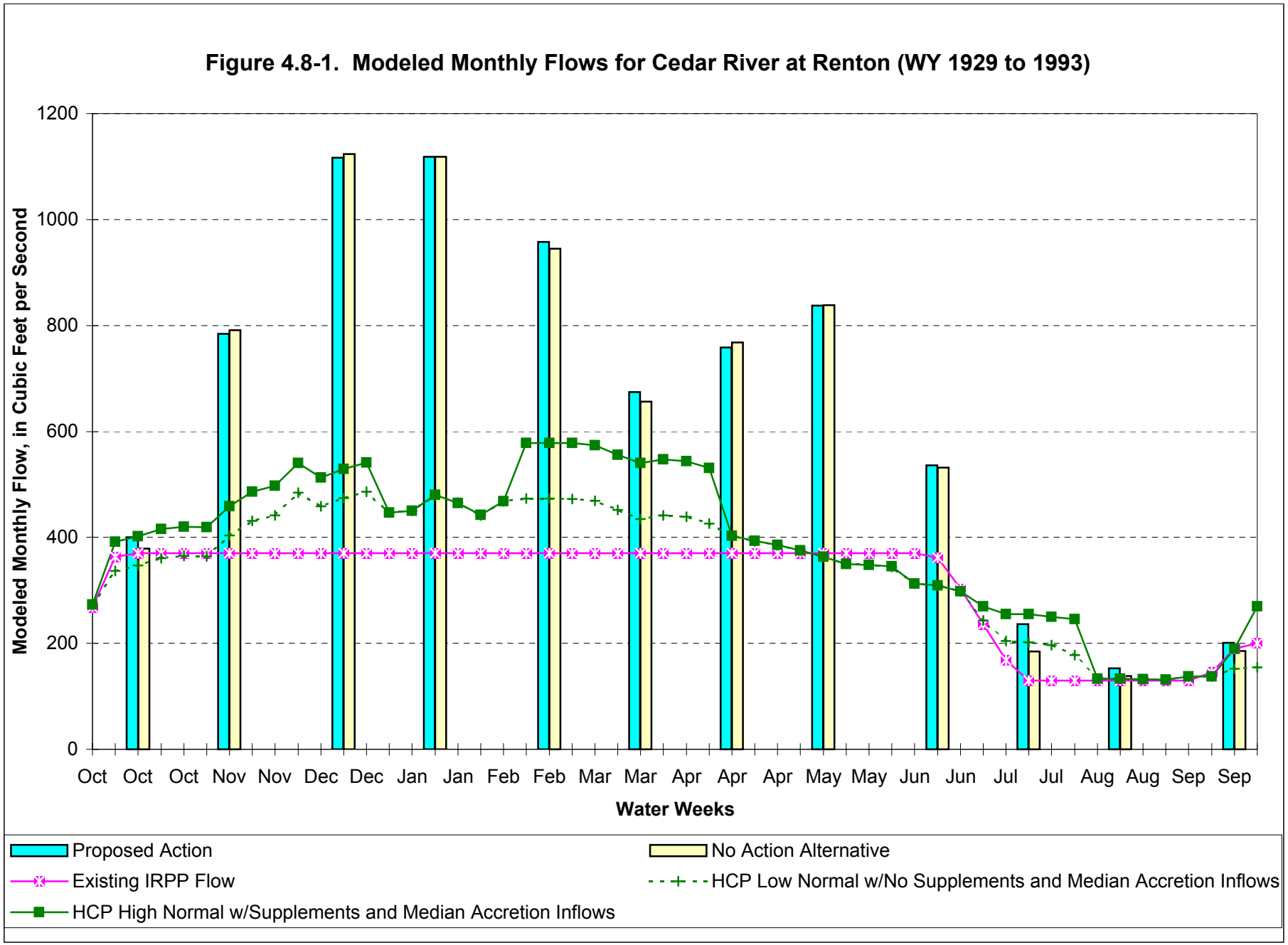


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Table 4.4-4. Comparison of HCP and No Action (IRPP) Instream Flow Schedules

	HCP Instream Flow Schedule								*No Action Instream Flow Schedule IRPP*			
	Requirements at Landsburg				Expected Minimum at Renton				Expected Minimum at Landsburg		Renton Target Flow	
Calendar Week	High Normal (cfs)	Low Normal (cfs)	Critical (cfs)	Requirement With Supplemental Flow (cfs)	High Normal (+50%tile accretion) (cfs)	Low Normal (+50%tile accretion) (cfs)	Critical (+6%tile accretion) (cfs)	Total Expected With Supplemental Flow (cfs)	Normal (-50%tile accretion) (cfs)	Critical (-6%tile accretion) (cfs)	Normal (cfs)	Critical (cfs)
Sep 2 - Sep 8	80	80	70	80[1/]	137	137	97	107[1/]	73	83	130	110
Sep 9 - Sep 15	80	80	70	80[1/]	138	138	99	109[1/]	87	81	145	110
Sep 16 - Sep 22	95	95	80	133[2/]	152	152	108	190[2/]	133	82	190	110
Sep 23 - Sep 30	95	95	80	210[2/]	155	155	109	270[2/]	140	81	200	110
Oct 1 - Oct 7	210	210	100		273	273	126		205	98	268	124
Oct 8 - Oct 14	330	275	130		392	337	157		301	128	363	155
Oct 15 - Oct 21	330	275	160		402	347	186		298	161	370	187
Oct 22 - Oct 28	330	275	180		416	361	222		284	176	370	218
Oct 29 - Nov 4	330	275	200		420	365	246		280	200	370	246
Nov 5 - Nov 11	330	275	200		419	364	243		281	207	370	250
Nov 12 - Nov 18	330	275	200		459	404	253		241	197	370	250
Nov 19 - Nov 25	330	275	200		486	431	262		214	188	370	250
Nov 26 - Dec 2	330	275	200		497	442	256		203	194	370	250
Dec 3 - Dec 9	330	275	200		540	485	254		160	196	370	250
Dec 10 - Dec 16	330	275	200		513	458	271		187	179	370	250
Dec 17 - Dec 23	330	275	200		529	474	267		171	183	370	250
Dec 24 - Dec 30	330	275	200		541	486	279		159	171	370	250
Dec 31 - Jan 6	260	260	180		447	447	260		183	170	370	250
Jan 7 - Jan 13	260	260	180		450	450	263		180	167	370	250
Jan 14 - Jan 20	260	260	180		480	480	264		150	166	370	250
Jan 21 - Jan 27	260	260	180		465	465	262		165	168	370	250
Jan 28 - Feb 3	260	260	180		442	442	259		188	171	370	250
Feb 4 - Feb 10	260	260	180		468	468	256		162	174	370	250
Feb 11 - Feb 17	260	260	180	365[3/]	473	473	258	578[3/]	157	172	370	250
Feb 18 - Feb 24	260	260	180	365[3/]	473	473	277	578[3/]	157	153	370	250
Feb 25 - Mar 3	260	260	180	365[3/]	473	473	261	578[3/]	157	169	370	250
Mar 4 - Mar 10	260	260	180	365[3/]	469	469	259	574[3/]	161	171	370	250
Mar 11 - Mar 17	260	260	180	365[3/]	451	451	246	556[3/]	179	184	370	250
Mar 18 - Mar 24	260	260	180	365[3/]	435	435	259	540[3/]	195	171	370	250
Mar 25 - Mar 31	260	260	180	365[3/]	442	442	278	547[3/]	188	152	370	250
Apr 1 - Apr 7	260	260	180	365[3/]	439	439	264	544[3/]	191	166	370	250
Apr 8 - Apr 14	260	260	180	365[3/]	426	426	248	531[3/]	204	182	370	250
Apr 15 - Apr 21	260	260	180		403	403	253		227	177	370	250
Apr 22 - Apr 28	260	260	190		393	393	249		237	191	370	250
Apr 29 - May 5	260	260	190		386	386	251		244	189	370	250
May 6 - May 12	260	260	195		375	375	249		255	196	370	250
May 13 - May 19	260	260	200		363	363	249		267	201	370	250
May 20 - May 26	250	250	210		350	350	250		270	210	370	250
May 27 - Jun 2	250	250	210		348	348	251		272	209	370	250
Jun 3 - Jun 9	250	250	200		345	345	249		275	201	370	250
Jun 10 - Jun 16	225	225	200		313	313	249		282	200	370	249
Jun 17 - Jun 23	225	225	160	[4/]	309	309	204	[4/]	278	162	362	206
Jun 24 - Jun 30	225	225	100	[4/]	298	298	143	[4/]	230	102	303	145

Jul 1 - Jul 7	170	170	80	[4/]	243	243	110	[4/]	163	80	236	110
Jul 8 - Jul 14	105	105	80	[4/]	174	174	113	[4/]	99	77	168	110
Jul 15 - Jul 21	80	80	80	[4/]	147	147	113	[4/]	63	77	130	110
Jul 22 - Jul 28	80	80	80	[4/]	142	142	107	[4/]	68	83	130	110
Jul 29 - Aug 4	80	80	70	[4/]	138	138	102	[4/]	72	78	130	110
Aug 5 - Aug 11	80	80	70		133	133	105		77	75	130	110
Aug 12 - Aug 18	80	80	70		133	133	103		77	77	130	110
Aug 19 - Aug 25	80	80	70		132	132	102		78	78	130	110
Aug 26 - Sep 1	80	80	70		131	131	101		79	79	130	110

[1/] Total flow during critical years if flashboards in place

[2/] Total flow during normal years if flashboards in place

[3/] Total flow provided 70% of time in normal years

[4/] Additional 2,500 ac ft in all normal years 6/17 - 8/4, ***and*** additional 3,500 ac ft in 70% of normal years 6/17 - 8/4

Salmon spawning flows in the fall and winter

Both Cedar River chinook and sockeye begin to spawn in early September and peak in mid- to late-October (Figure 4.4-3). Chinook spawning activity continues through late November, whereas sockeye continue into early January (Cascades Environmental Services, 1995). Cedar River coho salmon begin to spawn in mid-October, reaching their peak in January and continue through mid- to late February.

By September 15 with an average of 6 percent of the chinook run in the river, the IF-1 normal flows are below levels needed to create maximum WUA, and provide approximately 77 percent of the possible maximum WUA for chinook spawning. Flows continue to increase through October 10 and slightly exceed the level required to provide maximum chinook spawning habitat. This flow increase corresponds to the peak of the chinook spawning. Minimum flows remain at this level for the duration of the chinook spawning and provide over 99 percent of the maximum WUA during normal flow years. Under the critical flow regime, flows are less than the level required to provide maximum chinook spawning habitat throughout the entire spawning period and provide 45 to 93 percent of the maximum WUA. Critical flow requirements provide 83 to 92 percent of the maximum WUA during the peak chinook spawning in mid- to late-October.

With an average of 10 percent of the run in the river, sockeye spawning habitat is nearly maximized (approximately 99 percent of maximum WUA) by IF-1 flows in mid-September. Flows continue to increase until October 10 and exceed the level that provides maximum WUA for sockeye spawning in attempt to increase cumulative spawning habitat and recruit edge habitat. These increases result in a reduction of as much as 35 percent of the available spawning habitat by mid-October. By October 10, flow commitments at Renton level off for the remainder of the sockeye spawning season (Figure 4.4-4). Although significant amounts of sockeye spawning habitat are lost at these higher flows, the losses in static habitat are partially offset by increases in potential cumulative sockeye spawning habitat. However, due to the increasing inflows to the lower river from mid-October through the remainder of the sockeye spawning period, releases from Landsburg can actually be decreased and still meet the flow target at Renton (Figure 4.4-5). Because of the flow commitments based on the Renton gage, increases in cumulative spawning habitat can be negligible from after October 10 through the remainder of the spawning period. Nearly 50 percent of the sockeye run occurs after mid-October.

The critical flow regime provides 100 percent of the maximum WUA in the early part of the sockeye spawning period during the last week of September, but declines to as low as 87 percent of maximum WUA during the last two weeks of October when sockeye spawning activity begins to peak. This loss in habitat is associated with flows in exceedance of the levels that provide

maximum WUA. Gains in cumulative spawning habitat associated with these increases are negligible under the IF-1 critical flow regime.

Critical and normal flows are greater than the amount required to provide maximum WUA for coho spawning and subsequently result in a loss in habitat. Normal flows provide 81 to 88 percent of maximum WUA, critical flows provide 95 to nearly 100 percent of maximum WUA. Because coho salmon spawn principally in smaller tributaries to the Cedar River, the loss of coho spawning habitat associated with normal flow years would not significantly reduce habitat used by coho spawners. Although sustained elevated winter flows can result in a significant reduction in mainstem spawning habitat for coho salmon throughout much of the Cedar River, these higher flows accommodate a cumulative gain in sockeye spawning along channel margins and provide protection for incubating salmon eggs in the winter and spring as described below.

Salmon incubation flows in the winter and spring

The spawn timing of coho, sockeye and chinook salmon make their redds especially vulnerable to the fluctuating stream flows associated with late fall and early winter. Minimum flows remain elevated throughout the incubation period to reduce the risk of stranding. However with a downstream compliance point 20 miles downstream at Renton, releases from the Landsburg Dam can be greatly reduced during periods of normal to high inflows while still achieving flow targets as illustrated in Figure 4.4-2. And, in fact, there are times when releases from Landsburg can approach zero, while still meeting IF-1 target flows at Renton. With this regime, redds established near the margins of the stream in the upper portions of the river near Landsburg are subject to a significant risk of dewatering and eventual egg desiccation. During periods of high flows in the fall associated with elevated precipitation events, chinook and sockeye may spawn in areas that are at risk of being dewatered if flows subsequently drop to low levels. Although eggs can be quite resilient to dewatering if the gravels remain moist, dewatered alevins can experience high levels of mortality (Becker et al., 1983).

In addition to dewatering concerns associated with the IF-1 regime, the timing and location of salmon spawning make their redds vulnerable to scour during floods associated with large winter storm events typical of the western Cascade Mountains. It is believed that redd scour during flood events is a dominant factor controlling the survival of species such as sockeye that spawn in the mainstem Cedar River (Thorne and Ames, 1987), and may also effect chinook salmon. Coho salmon spawn principally in smaller tributaries to the Cedar River, so mainstem redd scour was not regarded as a significant influence in coho production by the CRIFC.

Some level of redd scour and related moralities during incubation are a normal part of salmon life history. Because of the constrained nature of the Cedar River, flood impacts on sockeye incubation survival in the river can be

substantial, varying with the magnitude of peak flows during incubation (Thorne and Ames, 1987; Seiler and Kishimoto, 1997). The degree of flood imposed mortality varies and depends on spawner distribution and channel configuration, among other factors. During flood events, Stober (1978) suggests that eggs and alevins in redds established towards the channel margins have a higher likelihood of survival as compared to those in mid-channel redds. Although the results of redd scour studies directed by the CRIFC demonstrated that safe and risk zones are not clearly delineated in terms of channel margin and mid-channel zones (Cascades Environmental Services 1991), there appears to be a slight reduction of redd scour risk in areas near the edge of the stream.

Under IF-1, flow commitments at Renton result in a gradual increase until mid-October, at which time flow required flows at Renton level off for the remainder of the sockeye spawning season (Figure 4.4-4). At least for the early part of the sockeye run, some opportunity for margin spawning habitat is accommodated. As described under the subheading *Salmon spawning flows in the fall and winter* releases from Landsburg can actually be decreased and still meet the flow target at Renton after mid October. This results in a situation where the available spawning habitat in much of the river is situated in mid-channel areas that believe to be more prone to scour, especially in river portions nearer to Landsburg.

Sockeye outmigration flows in the spring

Sockeye fry begin to emerge from the gravel in late January and continue through May, with a peak in late March and early April. Upon emergence, fry immediately begin migrating downstream. Most fry arrive at Lake Washington within 48 hours of emergence. Preliminary studies conducted by WDFW (Seiler, 1995; Seiler and Kishimoto, 1996, 1997) suggest that flow can be an important factor affecting survival during the outmigration to Lake Washington. Their studies document higher survival of hatchery fry released from near Landsburg Dam during periods of elevated flows. Although mortality at a given flow level can vary significantly from year to year, the mortality of outmigrating fry appears to be lower during periods of elevated flows (Seiler and Kishimoto, 1997). It has been hypothesized that higher flows reduce the period of time fry are susceptible to predation by sculpins in the lower river. The exact quantitative relationship between stream flow and the survival of outmigrating wild sockeye fry is not presently known.

Elevated flows for incubation protection during the winter and spring also provide benefit for outmigrating sockeye. During periods of normal to high inflows under IF-1, there is no assurance that flows will remain elevated in much of the river, as the downstream compliance point allows for significant flow reductions in the upper portions of the river as previously described. In addition there are no provisions for elevated minimum flows during favorable

hydrologic conditions. This situation may increase sockeye fry vulnerability to predation and other mortality factors associated with reduced flows.

Chinook rearing and outmigration flows in the spring

Chinook fry begin emerging from the gravel in February and may continue into April. Depending on their life history variation, fry may begin their migration out of their natal stream immediately upon emergence or remain in the river and rear for up to 3 months and outmigrate as late as mid-June. Under IF-1, minimum flows during the entire period of chinook emergence, rearing, and outmigration are well above the levels that create maximum WUA for juvenile chinook rearing.

Factors other than discharge, including photoperiod, water temperature, turbidity, habitat availability, predation, river system geography, food abundance, fish density, fish size, and swimming ability may also be important determinants in fish migration behavior and survival. The relative importance and interaction of discharge in relation to these other factors that may govern juvenile chinook outmigration survival is unknown in the Cedar River.

In addition, the relative importance of conditions for chinook outmigration versus conditions for chinook instream rearing is unclear. Flow levels in the spring and early summer are well above the levels that provide maximum WUA for chinook juvenile rearing. Increased velocity and depth associated with these higher flows may provide benefits for outmigrating juvenile chinook. However, the increased velocity and depth also result in an overall reduction in available habitat for rearing juvenile chinook. Reductions in rearing habitat and elevated stream velocities could encourage newly emerged fry to move into the lake environment shortly after emergence when they are very small and have relatively limited swimming ability. "Ocean type" chinook fry, such as found in the Cedar River, do not typically rear in large natural lakes and the effect of such movement (versus extended stream rearing) on fry survival is currently unknown.

Unlike other freshwater life history stages, such as spawning and rearing, there are no indices for evaluating the amount of flow required for successful and timely juvenile chinook migration. During the period of juvenile chinook outmigration, flows under the No Action alternative are well above the levels that provide maximum WUA. Higher flows result in a reduction in juvenile chinook rearing habitat, but may benefit outmigrating juvenile chinook. Flow management decisions during much of this period also consider the requirements for steelhead spawning and salmonid egg incubation. Because runoff in the lower 57 percent of the basin is not controlled by SPU, heavy precipitation downstream of Chester Morse Lake during this period can periodically cause high flow events. Such events may induce and/or facilitate chinook outmigration and may or may not benefit juvenile chinook survival.

Steelhead spawning and incubation flows in the spring and summer

Steelhead spawning generally begins in March, peaks during mid-April to mid-May, and continues into mid-June. The flows during normal flow years provided by IF-1 exceed the flows that produce maximum WUA for steelhead spawning during the entire steelhead spawning period. Available steelhead spawning habitat ranges from 96 to 99 percent of maximum WUA. Under the IF-1 critical flow regime, flow guidelines remain below optimum levels, yet they still provide 98 to 99 percent of the maximum WUA.

It is important to note that steelhead spawn at a period when river flows can fluctuate naturally and commonly exceed the IF-1 minimum requirements. Periods of higher flows associated with storm events in the spring may also force steelhead to spawn in areas that may later be dewatered as flows drop. Recent investigations conducted by SPU in collaboration with WDFW, indicate that under the IF-1 instream flow regime, significant numbers of incubating steelhead can be placed at risk of being dewatered between late June and the first week of August when fry emergence is finally complete (Burton and Little, 1997). The level of risk is variable from year to year and is partially dependent upon stream flows during spawning. Higher flows at spawning result in higher risks of subsequent redd dewatering; consequently, eggs and alevins may be vulnerable to dewatering, particularly during years of especially high spring flows that provide habitat not normally available for spawning. The IF-1 regime does not provide mechanisms to address this potential risk to incubating steelhead.

Steelhead and coho rearing flows year round

Rearing juvenile steelhead and coho are present year round in the Cedar River. The flows that create maximum WUA for juvenile steelhead rearing are similar to but slightly greater than analogous flows for juvenile coho and chinook. Therefore, the CRIFC selected juvenile steelhead as the primary target for rearing flow considerations. Fry emerge during June and July and juvenile steelhead generally rear in the Cedar River for up to two years. Under the IF-1 flow regime, minimum flows drop below the level required to maintain maximum available rearing habitat from mid-July through mid-September. During this period, the flows provide between 98 and 99 percent of maximum WUA. From mid-September through mid-July, flows remain well above the levels required to provide maximum WUA and provide between 79 and 88 percent of optimum WUA. Available rearing habitat is considered most crucial during periods of elevated metabolic activities during the spring through fall. It is at this time fish are most active in terms of foraging and associated growth. During the winter, as the metabolic rate of rearing fish declines with decreasing water temperatures, steelhead trout juveniles are known to seek sheltered areas within the channel substrate (Chapman and Everest, 1972). It is assumed that velocity shadows among channel substrates is not of limited supply in the Cedar River.

Upstream passage of fish

Shallow depths across a riffle or gravel bar can limit a fish's ability to swim upstream. This barrier is termed a low flow blockage. If the shallow depth condition occurs just prior to the spawning period, upstream spawning migration can be blocked. Under these conditions there are usually one or two "critical" riffles that are most sensitive to reductions in discharge and first become limiting as flows drop. If sufficient flows are maintained over these critical sections of the river then passage is assumed possible in all sections of the affected river reach. The critical passage section on the Cedar River was found at the shallowest and widest riffle in the river, approximately 0.5 miles upstream of Rock Creek.

Although the absolute minimum flow that would allow passage was not determined, studies indicated that upstream passage of adult chinook would not be impeded at flows of 94 cfs or more (Cascades Environmental Services, 1991). Under IF-1, normal and critical minimum flows at the critical riffle near Rock Creek will generally exceed 94 cfs and conditions should be favorable for upstream passage during key migration and spawning periods.

Instream Flows Upstream of Landsburg Diversion

Landsburg to Lower Cedar Falls

The IF-1 flow regime contains no provisions for the Cedar River upstream of the Landsburg Diversion to lower Cedar Falls. Because of the need to deliver water via this stream reach from diversion into the municipal water supply intake at Landsburg, flows immediately upstream of Landsburg will generally be significantly higher than flows downstream of Landsburg, except when diversion facilities are taken out of service. However, significant inflow to the Cedar River both upstream and downstream of Landsburg may at times be of sufficient capacity to meet the Applicants water supply demand and IF-1 instream flow requirements at Renton. Under such a situation, the Applicant can use stream flow originating from the upper municipal watershed above the Masonry Pool to refill Chester Morse Lake for later use and effectively terminate water delivery into the lower river via the Masonry Dam and Hydroelectric Facilities.

Implementation of the IF-1 flow regime would be in concurrence with implementing the No Action Alternative associated with the anadromous fish mitigation (AFM-1) as described in Section 4.4.2. Under this alternative scenario, passage facilities at Landsburg Diversion Dam would not be constructed and the 17 miles of habitat between Landsburg and Lower Cedar Falls would continue to be underutilized by anadromous fish. Therefore the absence of an established flow regime for the Cedar Falls to Landsburg reach would have no effect on anadromous fish production in the Cedar River upstream of Landsburg, but could limit available habitat for resident rainbow trout.

Lower Cedar Falls to the Masonry Dam

Approximately 0.5 miles of potential anadromous fish habitat is present in the river between the tailrace of the Cedar Falls hydroelectric project and the natural migration barrier formed by Lower Cedar Falls at RM 34.2. This 0.5 mile bypass reach is located upstream of the influence of water delivered from Masonry Pool to the Cedar River via Cedar Falls Hydroelectric Project. The IF-1 flow regime contains no provisions for the Cedar River between lower Cedar Falls and the Masonry Dam. During much of the year water is delivered from Masonry Pool to the Cedar River at Cedar Falls via the Cedar Falls Hydroelectric Facility. Flow between Lower Cedar Falls and the Masonry Dam originates largely from spill over the dam or seepage of water stored in Masonry Pool, which fluctuates throughout the year, depending upon reservoir water levels. During dry periods when the level of Masonry Pool is low, flows in this reach can drop to very low levels which may limit available habitat for resident rainbow trout.

Effects of Instream Flows on Reservoir Fish Populations

The Applicant uses water stored behind Masonry Dam for both water supply and instream flow management. Achieving water supply demands and instream flow requirements results in fluctuating water levels in the Chester Morse Lake. Current reservoir operation limits range from 1,563 feet above sea level at full pool to a minimum drawdown of 1,532 feet. Under emergency conditions, the reservoir can be lowered to 1,502 feet using existing pumping systems. The potential impacts associated with the operation of Chester Morse Lake during low reservoir levels include the possible creation of physical obstructions to the upstream migration of fall spawning fish during. During periods of high reservoir levels, potential impacts include the inundation of redds and incubating eggs that were deposited by bull trout in the Rex and Cedar Rivers during periods of lower lake levels.

Migration barriers

Entrance and access to tributary habitats by fall spawning bull trout and pygmy whitefish may be restricted or precluded under conditions of low reservoir levels due to the existing channel/reservoir topography where the Cedar and Rex River deltas meet the main body of Chester Morse Lake. Detailed bathymetry conducted at the downstream edge of the Cedar and Rex River deltas determined that the slope in the steep areas of the Rex and Cedar River deltas would be 17 percent and 14 percent, respectively. Such steep gradients could pose a hindrance or even complete barrier to upstream migration if the actual channel gradient and resultant stream conditions exceed the swimming and jumping capabilities of the fish. These steep delta areas are first exposed in the Rex River and Cedar River as reservoir levels drop below about 1,540 feet. The degree of impact is smallest near or immediately below the 1,540 foot elevation, as only a short distance of steep gradient stream channel

would be exposed. However, as the reservoir level drops below 1,535 feet, the steep channel gradients are believed to be sustained for a sufficient stream length where migration may not be possible (R2 Consultants, 1995). Although no detailed channel assessments have been completed during reservoir drawdown to accurately evaluate whether actual channel conditions result in reaches impassable to bull trout, the Applicant recognizes the potential risk associated to bull trout migration during infrequent drawdown conditions.

Chester Morse Lake water levels have occasionally dropped below 1,540 feet during the spawning periods since 1983. An extended period of 60 consecutive days of lake levels below 1,540 feet occurred in 1987. The lowest level reached during the 1987 spawning period was 1,533 feet, when theoretically there was a 7-foot exposure of the steep delta slopes. Lake levels have not been below 1,540 feet since 1991.

Modeling analysis conducted by the Applicant demonstrated that out of the 13-week bull trout spawning seasons modeled over 64 years, the IF-1 flow regime results in reservoir levels below 1,540-foot elevation at total of 5.1 percent of the weeks modeled (43 weeks out of a 843 weeks modeled over 64 years). Reservoir modeling indicates the lake level drops below the 1,540 foot mark 12 of 64 years, or approximately 1 out of 5 years for an average of 3.6 weeks and may persist at these levels for an average of 3.3 consecutive weeks.

Lake levels below the 1,535 feet elevation, the point where upstream passage is believed to be most affected, are less common 1.4 percent of the modeled weeks. Modeled lake levels during the bull trout spawning season dropped below the 1,535 foot mark 5 of 64 years, or approximately 1 in 12 years and remained below the 1,535 foot mark for an average of 2.4 consecutive weeks.

The model results demonstrate that when the reservoir drops below the level sufficient to expose the Cedar and Rex River delta toe, they rarely are sustained for more than one-half of the 13-week spawning period. Additionally, as water levels drop, the Cedar and Rex Rivers likely cut newer, less steep channels in the delta sediment that would aid fish passage, but the time necessary for such a process to occur is not known. Furthermore, because the short, steep reaches occur at the mouths of the rivers, bull trout encounter the delta toes at the onset of their upstream migration, and are relatively fit for successful ascent through potentially marginal passage conditions.

The risk to bull trout spawning migrations under IF-1 is difficult to ascertain with a high degree of confidence. Although the timing of bull trout entering the Rex River and Cedar River may be affected by the low reservoir levels during the fall, it is unlikely these delays cause an overall reduction in the number of fish ascending the rivers to spawn. IF-1 represents a continuation of the existing instream flow regime and facility operations, and to date there is no empirical evidence that suggests existing operations limit the numbers of bull trout that ascend the Cedar and Rex Rivers to spawn. For more details, see HCP Section 4.5.6.

Redd inundation

Changes in water depth and hydraulic conditions at spawning sites in tributaries used by bull trout may occur with the current operation of Chester Morse Lake. These changes occur as lake levels increase during early spring and inundate redds that were established in channels during the fall drawdown period. If redds are covered by rising waters prior to fry emergence, reduced water velocity may affect survival of eggs or alevins in the redds. Effects depend on the timing, duration of lake water cover and the relative reduction in water velocity over the redds. Significant reduction in velocity would affect oxygen supply to the eggs or alevins in the redds.

Some of the spawning areas in the Cedar and Rex Rivers are in regions that can be flooded during high lake levels, especially in the Rex River. Because water levels occasionally rise in the winter during storm events and every spring during snow melt, these regions are occasionally flooded at some time during egg incubation. A lake level of 1,555 feet is considered to be the lowest level with potential to adversely affect redds in the Cedar River (R2 Resource Consultants, in preparation). Based on available survey data collected during 1993 (R2 Resource Consultants, in preparation), lake levels of 1,555 feet would potentially affect redds only in the Rex River, as those in the Cedar River were all at higher elevations. Water levels above 1,560 feet may affect a small portion of Cedar River redds (about 10 percent of those observed in 1993). Exceedance of the 1,560 feet lake elevation occurs only during mid-May under current normal operation (based on data from 1988 through 1995) after the majority of fry emergence has occurred in the Cedar River. At highest reservoir operation levels (1,563 feet), a significant portion of Cedar River redds would be inundated (about 35 percent of those observed in 1993).

In the Rex River, 95 percent of the observed redds in 1993 would be inundated at elevations of 1,557 feet. Lake level records during 1988 to 1995 indicate that during April or May water levels exceeded 1,557 feet elevation 8 of the 9 years. Only 2 of 40 redds were situated above the 1,557 feet level

Because most emergence in the Cedar River likely occurs prior to the end of April, and most redds are at relatively high elevations, few adverse effects to bull trout eggs or fry from rising water levels are expected to occur in this system. However, Rex River emergence may be affected because of lower redd elevations and emergence extending into May. But available data are not sufficient to determine the effects on emergence from lake level changes. Overall, effects on eggs and alevins survival in redds in both systems remains unknown.

Additional Instream Flow Management Provisions

Oversight of instream flow management

The IF-1 provides no formal forum for interested parties to provide general oversight and direction regarding the implementation of the non-binding IRPP flow regime. Although informal discussions regarding instream flow management strategies pertinent to current hydrological conditions and fish runs are conducted on a semi-regular basis between April and October, the Agencies and Tribe have no formal role in instream flow management decision making under the IF-1.

Ramping Rates

A recent analysis of the frequency and magnitude of instream flow changes on the Cedar River indicate that although the hydroelectric and water supply facilities are not operated as flow peaking facilities, flow reductions can occur quite frequently due to the need to make adjustments during normal operations. Fry and juvenile salmonids and other fishes are vulnerable to sudden flow reductions in the Cedar River. Fish can be killed by stranding on open gravel bars or by isolation in potholes or side channels that subsequently dry up. Through its operation of the Masonry Dam, Cedar Falls powerhouse, and the Landsburg Diversion, the Applicant can alter instream flows on the river that can create significant downramping events. Under IF-1, no formal downramping criteria or specific guidelines are used to guide flow control operations at any of the three control points on the river, thus increasing the risk of fish stranding and associated mortality.

Compliance Point and Effects of Accretion Flows

Flows in the Cedar River downstream of Landsburg are significantly influenced by natural inflows. Figure 4.4-2 demonstrates that under IF-1, the Applicant can reduce flows in the upper river significantly during much of the year while still meeting the IRPP stream flow targets at Renton. Because of this natural variation in inflows and non-binding flow requirements, IF-1 minimum flows at Landsburg may at times be somewhat greater or less than the median flows displayed in Figure 4.4-2. Although the effects of inflows and downstream compliance points rarely result in discharge below those required to maximize WUA for most species and life history stages under normal flow years, short term reductions between early September and the end of July can pose a significant risk to incubating salmon and steelhead.

Criteria for switching from normal to critical instream flow regime

During conditions of severe drought, the Applicant will be allowed to reduce stream flows to levels described by the critical flow regime (Table 4.4-4). Under IF-1, the decision to switch to critical instream flows is guided by SPU's Water Shortage Contingency Plan, which does not provide defined

hydrologic criteria that govern the decision to switch between normal and critical flow regimes nor does it provide a forum for the Agencies and the Tribe to assist in decisions to switch based on up to date monitoring data.

Flow management during favorable hydrologic conditions

IF-1 normal minimum flows are typically well above the levels required to provide maximum WUA. However, the CRIFC considered flows greater than those required to maximize WUA to be beneficial to salmon and steelhead during certain periods of the year. Although it is recognized that the Cedar River system exceeds the volumes needed to meet IF-1 minimum flow requirements and water supply needs during much of the year, the IF-1 regime does not contain provisions to supplement the minimum flow requirements under favorable hydrologic conditions.

Emergency flow continuation at Cedar Falls powerhouse

During much of the year water is delivered from Masonry Pool to the Cedar River at Cedar Falls via the Cedar Falls Hydroelectric Facility. Emergency shutdown of flows through the Hydroelectric Facility have the potential to cause short-term but significant reductions in flow and stage in downstream reaches of the river. Emergency shutdowns pose significant risk of juvenile fish stranding and dewatering redds throughout the Cedar River downstream of Cedar Falls.

During routine inspection, maintenance, repair, and other planned shutdowns of the Hydroelectric Facilities, water can be delivered to the river through the Masonry Dam lower outlet valve. However, in its original configuration, the Cedar Falls Hydroelectric Facility was not equipped with facilities to prevent an interruption in water delivery to the river during emergency shutdown of electrical generation equipment. Under the existing conditions, conversion of water delivery from Cedar Falls Hydroelectric Facility to the Masonry Dam may require several hours during which time a significant reduction in flow can occur.

Waters conservation program

Since the mid-1980s, SPU has initiated a wide variety of water conservation programs which encourage, through education and incentives, the efficient use of water. Collectively, these programs reduce costs in the long run by postponing (or eliminating) the need for additional water sources. In addition, during drought conditions, these efforts help maintain lake levels and may help keep more water in the river downstream from Landsburg.

Water conservation programs are currently guided by the *1996 Long Range Regional Conservation Plan* (Technical Appendix 9). This plan is the Applicants' strategy for continuing to develop conservation as a reliable water resource for the regional service area. The plan acknowledges the need to

aggressively pursue water conservation due to critical fish habitat provided in the Cedar River. Conservation programs are currently underway or under development for domestic use, landscape use, and commercial/industrial use and other non-revenue uses of waters. Conservation efforts so far have resulted in a decrease in overall consumption; the number of SPU customers has grown 20 percent in the last 10 years, while consumption has remained the same (SPU, unpublished data). In the future, total water consumption by 2005 is anticipated to be equivalent to that of 1995, assuming all conservation programs are implemented and are effective (Technical Appendix 9).

Under IF-1, the water conservation program will continue, with no amendments.

Emergency use of dead storage for instream flows and water supply

During drought conditions, if the level of Chester Morse Lake drops to below 1532 feet above mean sea level (MSL), the natural topography of the pre-existing lake prevents continued gravity flow of water. The volume of water that remains below the outlet elevation is referred to as dead storage. Under the IF-1, the Applicant can access and use the dead storage of Chester Morse Lake under a permit from the Department of Ecology only in the case of an emergency caused by an extremely severe drought. Under this emergency scenario, the expected frequency of dead storage use is estimated to be only 1 year in 50.

A temporary pumping plant was constructed on Chester Morse Lake in 1987 for this emergency purpose. Water can be pumped out of the lake and put back into the Masonry Pool, where it then follows the regular routing.

Under IF-1, access to the reservoir's dead storage is strictly limited to the emergency use.

Passage and Water Efficiency at the Chittenden Locks

The Hiram L. Chittenden Locks in Ballard form the outlet of Lake Washington. The locks have been identified as a significant source of mortality to out-migrating anadromous salmonids (ACOE, 1997). All anadromous fish in Lake Washington must pass through the locks twice during their life. Water flow at the locks must be shared between vessel traffic and upstream and downstream migrating fish. The Cedar River typically provides approximately half the flow into Lake Washington. Recent investigations suggest that a number of opportunities may exist to improve the efficiency with which freshwater is used at the locks (ACOE, 1991) and provide better conditions for downstream migrating anadromous fish (Goetz et al., 1997). Efforts to conserve water used for navigation can provide additional water for improved fish passage conditions. Under IF-1, no provisions are made to contribute to feasibility studies for designing and implementing long term water efficiency and fish passage improvements at the Locks.

Proposed HCP Alternative for Instream Flows (IF-2)

The Proposed HCP Alternative for Instream Flows is presented in detail in Chapter 4 of the Draft Cedar River Watershed Habitat Conservation Plan (City of Seattle, 1998). It is not the intent of this section to repeat all of the details provided in the original document. Instead, only the most relevant characteristics that differentiate the effectiveness of the proposed action from IF-1 are discussed.

Under this proposal, the Applicant would commit to a binding set of minimum instream flow requirements that would replace the current non-binding flow targets. As with the IF-1 regime, the IF-2 flow regime contains provisions for a normal flow schedule and a critical flow schedule which is implemented only under adverse conditions (Table 4.4-4). IF-2 offers two different normal flow curves during the fall in an effort to take advantage of favorable hydrologic conditions to provide additional benefits for spawning salmon. The critical flows would apply only under specific condition in which specified hydrologic criteria have been met and public notification and water conservation measures specified in the Applicant's water shortage contingency plan have been implemented (Technical Appendix 10). IF-2 critical flow regime has been designed around the IF-1, or IRPP, critical flow regime but differs in several ways (Figure 4.4-6 and 4.4-7). Proposed HCP critical flows will be slightly higher than IF-1 flows during the fall, winter and most of the spring and slightly lower than IF-1 flows during the summer.

The Applicant would also supplement the required normal minimum flows to meet biological objectives under specific conditions that reflect actual and forecasted water availability conditions. This approach realizes the need to manage and share risks for both stream flows and water supply that may result later in the year. Minimum instream flows represent requirements of the Applicant in this proposal and are referred to as "firm" flows or other quantities. Additional flows provided to supplement minimum flows under specified conditions and procedures represent goals of the Applicant and are referred to as "supplemental" flows. The compliance point for these stream flow commitments is the USGS stream gage #12117600, 1.4 miles downstream from the Landsburg Diversion Dam.

Instream Flows Downstream of Landsburg Diversion

For most of the year, IF-2 flows are greater than IF-1 flows, and substantially greater than flows required to provide maximum WUA for key species and life history stages as determined by the IFIM study (Figures 4.4-4 and 4.4-5 Although elevated flows can result in significant decreases in available habitat, the CRIFC believed they provide additional overriding benefits that result in a net gain for target species and life history stages. Note also that because the flow compliance point has been moved upstream to Landsburg, flows in the lower river are significantly influenced by natural inflows and will therefore exhibit a more natural pattern than under IF-1 (Figure 4.4-2).

Salmon spawning flows in the fall and winter

As with IF-1, flow guidelines under IF-2 begin to increase in mid-September. During the third week of September, IF-1 and IF-2 flows are nearly identical. Flows at this time exceed maximum WUA for sockeye spawning, but are below levels needed to create maximum WUA for chinook spawning habitat (77 percent of maximum WUA provided). By September 23, IF-2 flows exceed IF-1 flows. With an average of 16 percent of the chinook run in the river, IF-2 normal flows provide 95 percent of maximum WUA for chinook spawning, an increase of 19 percent over habitat provided by IF-1.

By October 8, with an average of 50 percent of the run in the river, low normal flows are slightly below IF-1 levels but provide 100 percent of maximum WUA for chinook spawning. In an effort to recruit additional edge habitat for spawning sockeye, high normal flows slightly exceed IF-1 and flows required to provide maximum WUA for chinook spawning. High normal flows remain at this level for the duration of chinook spawning and provide between 89 and 98 percent of maximum WUA. The decrease in chinook spawning habitat due to high flows occurs during the latter portion of the run after the majority of the chinook have spawned.

During September and October under the critical flow regime, IF-2 flows are nearly identical to IF-2 and provide 45 to 83 percent of the maximum WUA for chinook. By November 5, IF-2 flows increase and slightly exceed the IF-1 requirements, thus providing between 93 to 97 percent of the maximum WUA for the remainder of the spawning period.

By September 16, with 11 percent of the sockeye run in the river, IF-2 flows increase to a level that is slightly above the level required to provide maximum WUA for sockeye. Normal minimum flow requirement continue to increase through October 8. Although flow releases remain constant after October 8, minimum flows continue to increase along either a low normal or high normal regime due to increasing inflow to the river downstream of Landsburg. IF-2 flow releases from Landsburg remain elevated at levels equal to or greater than the flows required to provide maximum WUA for sockeye spawning habitat throughout the duration of the run. As high normal stream flows increase, as much as 49 percent of the WUA of sockeye spawning habitat can become unavailable.

Although significant amounts of sockeye spawning habitat are lost at these higher flows, the losses in static habitat are partially offset by increases in potential cumulative sockeye spawning habitat. A cumulative spawning analyses conducted as part of the CRIFC study program determined the feasibility of this “step” approach to flow regulation and sockeye spawning habitat maximization. The analysis showed that incrementally increasing flow through the sockeye spawning period can result in an increase in WUA compared to a constant flow throughout the spawning period (Cascades Environmental Services, 1991). Assuming that significant numbers of sockeye

have spawned during September, then flow increases in October through December will tend to encourage newly entering fish to spawn in new, previously unsuitable habitat away from areas that are already seeded. This step approach to flow regulation also accommodates the theory that edge spawning habitat is less vulnerable to damaging scours during flood events as described under the following subheading *Salmon incubation flows in the winter and spring.*

During September and October, IF-1 and IF-2 critical flows are nearly identical. During September both regimes provide approximately 97 percent of maximum WUA for sockeye spawning. Under both regimes, critical flows begin to increase on October 1 and exceed the level required to provide maximum WUA for sockeye spawning by the second week of October. With a smaller overall increase in flows during this period, critical flows provide less cumulative gains in sockeye spawning habitat and less edge habitat for sockeye spawning.

As with the IF-1 regime, IF-2 minimum normal flows throughout the entire coho spawning remain well above flows required to maximize available spawning habitat. Flows as measured at Landsburg are more than double than those required to maximize WUA during the peak of the coho spawning activity during the month of January. The IFIM study suggested that nearly 30 percent of the potentially available spawning habitat would be lost with IF-2 normal minimum flows in January. During the early spawning period of October through December, low normal flows provide 68 to 92 percent of maximum WUA; high normal flows provide 60 to 92 percent of maximum WUA. By the end of the spawning period in mid February, normal minimum flows provide only 52 percent of the maximum WUA. IF-2 critical flows also exceed the level required to provide maximum WUA for coho spawning from mid-October through February, but provide 93 to nearly 100 percent of maximum WUA through the period. The CRIFC considered the benefits for enhanced sockeye and chinook spawning, incubation, and outmigration flows outweighed the potential risk to the coho spawning habitat.

Salmon incubation flows in the winter and spring

Chinook and sockeye spawn in the fall and early winter when increased stream flows can occur during storm events typical of the season. During periods of naturally high flows in the fall, chinook and sockeye may spawn in areas that are at risk of being dewatered if flows subsequently drop to lower levels. To reduce the risk of redd dewatering and mortality of salmon eggs and alevins, proposed HCP minimum flows remain elevated above the level provided by the No Action Alternative to help ensure that nearly all available spawning habitat would remain inundated based on the effective spawning analysis developed by the CRIFC (Cascades Environmental Services, 1991). The Landsburg flow compliance point further reduces the risk of redd dewatering in the river near Landsburg. Unlike the IF-1 regime, flow releases at

Landsburg must remain elevated throughout the incubation period. This is especially valuable to sockeye salmon incubation, as the "step" approach to flow regulation may encourage spawning activity along channel margins that are more vulnerable to dewatering.

As addressed under IF-1, the timing and location of chinook and especially sockeye spawning make their redds vulnerable to scour during floods associated with large winter storm events typical of the western Cascade Mountains. Sockeye spawning habitat nearer the stream margins is believed to be somewhat less vulnerable to scour during flood events. To date there is insufficient empirical data to quantitatively determine the risk of redd scour under the two alternative flow regimes. The CRIFC found results of the risk zone analysis inconclusive for the purposes of quantitatively defining risk zones and safe zones. However, the results did indicate trends and phenomena that may be useful in understanding bed scour and its potential impact on sockeye redds in the Cedar River. These indications are that: scour of sockeye redds may be initiated at between 1,800 and 2,000 cfs; that short term high river flows can significantly reduce egg to fry survival; and safe and risk zones are not clearly delineated in terms of channel margin and mid-channel zones. For instance, a number of mid-channel redds incurred minimal scour at even the highest flood flows. Further analysis of the redd scour data by the CRIFC indicated a slight reduction in sockeye redd scour in spawning habitat near the edges of the stream. The IF-2 flow regime accommodates the theory that, provided the opportunity, sockeye will spawn in zones of less risk to scour near the stream margins. The IF-2 high normal flow curve provides more edge habitat than IF-1 throughout the sockeye spawning period. The IF-2 low normal curve provides more edge habitat after mid-November.

Sockeye outmigration flows in the spring

Elevated flows for incubation protection during the winter and spring also provide benefit for outmigrating sockeye. In contrast to IF-1, there is assurance that flows will remain elevated throughout the river, as Landsburg compliance point requires sustained flow releases throughout the outmigration period. Although the exact quantitative relationship between stream flow and the survival of outmigrating wild sockeye fry is not presently known, IF-2 contains provisions for 40 percent higher minimum flows at least 70 percent of the time during the peak of sockeye outmigration from early February through mid-April. These elevated flows can be in direct conflict with optimum habitat conditions for the early portions of the steelhead spawning period as described under the subheading *Steelhead spawning flows in the spring and summer.*

Chinook rearing and outmigration flows in the spring

The factors that may govern juvenile chinook migration behavior and survival are complex and include discharge, photoperiod, water temperature, turbidity, predator abundance, river system geography, food abundance, fish density, fish

size, and swimming ability. The relative importance and interaction of discharge in relation to these other factors that may govern juvenile chinook outmigration survival is unknown in the Cedar River.

In addition, the relative importance of conditions for chinook outmigration versus conditions for chinook instream rearing is unclear. Flow levels in the spring and early summer are well above the levels that provide maximum WUA for chinook juvenile rearing. Increased velocity and depth associated with these higher flows may provide benefits for outmigrating juvenile chinook. However, the increased velocity and depth also result in an overall reduction in available habitat for rearing juvenile chinook. Reductions in rearing habitat and elevated stream velocities could encourage newly emerged fry to move into the lake environment shortly after emergence when they are very small and have relatively limited swimming ability. "Ocean-type" chinook fry, such as found in the Cedar River, do not typically rear in large natural lakes and the effect of such movement (versus extended stream rearing) on fry survival is currently unknown.

Unlike other freshwater life history stages, such as spawning and rearing, there are no indices for evaluating the amount of flow required for successful and timely juvenile chinook outmigration. Under the proposed HCP Alternative, minimum flows during chinook outmigration are significantly greater than the levels that provide maximum WUA for chinook rearing. Minimum flows, as measured at Renton range from 578 cfs to 345 cfs and average 421 cfs. Higher flows result in a reduction in juvenile chinook rearing habitat, but may benefit outmigrating juvenile chinook. Flow management decisions during much of this period also consider the requirements for steelhead spawning and salmonid egg incubation. Because runoff in the lower 57 percent of the basin is not controlled by the SPU, heavy precipitation downstream of Chester Morse Lake during this period can periodically cause high flow events. Such events may induce and/or facilitate chinook outmigration and may or may not benefit juvenile chinook survival.

Steelhead spawning and incubation flows in the spring and summer

IF-2 normal flows during the late winter and spring are well above the levels that provide maximum WUA for spawning steelhead. From March 4 through April 14, normal minimum flows are supplemented by as much as 40 percent to enhance sockeye outmigration 70 percent of the time (see the previous *Sockeye outmigration flows in the spring).* This flow increase corresponds to a 22 percent decrease of available steelhead spawning habitat. On April 15, available habitat increases to 96 percent of maximum WUA under the normal flow regime. Without the supplemental incubation flows during the 3 out of 10 years, at least 93 percent available spawning habitat is provided throughout the entire spawning period.

In some years, high flows resulting from both natural spikes due to tributary and upriver inflows can force steelhead to spawn in areas that may be

subsequently exposed to significant risk of dewatering when flows are reduced in the early summer. This problem becomes particularly acute for steelhead that spawn in late April, in May and early June. Eggs and alevins from these later spawning fish will remain in the gravel during the period when flows naturally begin to recede to normal summer base flow levels and are especially vulnerable to dewatering. To address this issue, and provide the flexibility required to meet the changing needs of incubating steelhead, IF-2 provides an additional block of water to be allocated as directed by the Commission in normal years when the need exists for increased steelhead incubation protection and if specific hydrologic conditions and risk sharing mechanisms provide the flexibility to do so. Between June 17 and August 4, in addition to the normal minimum flows, and the 2500 acre foot block of water delivered in all normal years, the Applicant will expect to further supplement normal minimum flows by 3500 acre feet of water in 63 percent of all years.

In order to support decision making regarding the use and temporal distribution of this water and to minimize dewatering of steelhead redds, the Applicant will sponsor annual real time monitoring of steelhead redds for up to eight spawning seasons beginning in HCP Year One. The monitoring program will locate, characterize, and monitor steelhead redds from the time of their construction through the completion fry emergence.

The results of the monitoring program will be used by the Commission on a real time basis to help make decisions on the need for and temporal distribution of the 2500 acre foot and 3500 acre foot blocks of water during HCP years 1 through 8. The results of the study and the flow management experience gained during this period will be used to develop analytical tools that may be used to support subsequent decision making after HCP year 8.

Steelhead and coho rearing flows year round

Compared to other life history stages, WUA for juvenile rearing is less sensitive to flow in the Cedar River (Cascades Environmental Services, 1991). The flows that create maximum WUA for juvenile steelhead rearing are greater than analogous flows for juvenile coho. Therefore, the CRIFC selected juvenile steelhead as the primary target for rearing flow considerations. For most of the year, from mid-September through early August, the proposed HCP normal flow prescriptions are well above levels required to provide maximum WUA for juvenile steelhead rearing. Although flows at times are two to three times greater than the levels that provide maximum WUA, the loss in rearing habitat is relatively small. During August and the first two weeks in September, proposed HCP normal flows drop to levels that approach the existing IF-1 minimum flow levels. During this period, both regimes provide 98 to 99 percent of maximum WUA for steelhead rearing. Under the IF-2 critical flow regimes, flows remain below optimum levels from mid June through early October, but still provide between 95 to 99 percent of the

available habitat. The IF-2 and IF-1 critical flow regimes provide nearly identical available steelhead rearing habitat throughout the year.

Instream Flows Upstream of Landsburg Diversion

Landsburg to Lower Cedar Falls

Restoring access for chinook, coho and steelhead into the habitat upstream of the Landsburg Diversion Dam is a central component of the proposed HCP's conservation strategy for anadromous fish. The provision of beneficial flows in this reach is key to the success of this strategy. Due to the need to deliver water via this stream reach for diversion into the municipal water supply intake at Landsburg, flows immediately upstream of Landsburg will generally be greater than flows immediately downstream of Landsburg except when the diversion facilities are taken out of service. Interruptions in service at the intake are very infrequent and only occur when raw water turbidity thresholds are exceeded (which typically only occurs during the ascending leg of freshet flows in excess of 1,000 cfs) and during infrequent maintenance and repair activities.

In contrast to the IF-1 flow regimes, the Landsburg compliance point combined with the additional flows required for the Applicant's municipal water supply diversion, ensure that flow levels in the river upstream of the Landsburg Dam and below the Cedar Falls Powerhouse will be near or above the levels required to provide maximum WUA for chinook, coho, and steelhead spawning and rearing at all times. Table 4.4-5 provides an example of expected habitat conditions near the center point of the upper Cedar River Study Area (upstream of the Landsburg Diversion Dam) under the proposed HCP normal minimum flow regime.

Lower Cedar Falls to the Masonry Dam

IF-2 includes a commitment to provide rearing flows in the 0.5 mile bypass reach immediately upstream of the powerhouse and also provides protection for the reach between the powerhouse and Landsburg. The minimum flows for the bypass reach protect habitat within the bypass reach and provide a new floor below which flows cannot drop between Landsburg and the powerhouse.

A new stream gage will be established just upstream of the hydropower tailrace. This gage will be installed to monitor compliance with the Applicant's commitment to provide rearing flows for anadromous fish in the bypass reach between Lower Cedar Falls and the hydroelectric project once fish passage facilities are completed at the Landsburg Diversion Dam.

Effects of Instream Flows and Limited Use of the Reservoir's Dead Storage on Reservoir Fish Populations

The IF-2 flow regime generally ensures that, under normal minimum flow conditions, more water is provided for instream flows during the dry season as compared to IF-1. The IF-2 flow regime allows limited use of the reservoir's dead storage for anadromous fish flow by using the existing temporary pumps (for more details see HCP Section 4.5.6). Therefore in some years, water levels in Chester Morse Lake will be slightly lower during the summer and fall than under existing conditions. The differences in water level are expected to be relatively minor and the effects of these lower water levels on the aquatic community in Chester Morse Lake are difficult to predict and also are expected to be minor. During the winter, high lake levels and potential impacts associated with redd inundation will be consistent with levels under the IF-1.

Migration barriers

Analysis conducted by SPU revealed that over the 64 projected bull trout spawning seasons and 65 projected pygmy whitefish spawning seasons the modeled lake levels under the IF-2 flow regime average 0.41 and 0.23 foot lower respectively than under the IF-1 flow regime. The elevation at which the steeply sloped delta fans associated with the Cedar and Rex Rivers begin to be exposed is approximately 1,540 feet. The IF-2 flow regime results in modeled reservoir levels during projected bull trout spawning seasons below 1,540 feet elevation 6.4 percent of the time (54 weeks of 843 weeks) as compared to the 5.1 percent modeled occurrence under IF-1. Although the percentage weeks

Table 4.4-5. Summary of expected minimum flows in the Upper Cedar Study Area located upstream of Landsburg Diversion under IF-2.

Time period	Required HCP Minimum + Supplemental Flow at Landsburg (cfs)	Average Diversions Minus Inflow Flow Between Mid-point of Upper Cedar Study Area and Landsburg (cfs)	Resultant Flow Adjusted to Mid-point of Upper Cedar Study Area (cfs)	Key Species/Life History Stage	Percent of Maximum Weighted Usable Area Provided in the Upper Cedar Study Reach
Sept. 2 - Sept. 15	80	152	232	steelhead rearing	100
Sept. 16 - Sept. 22	133	131	264	chinook spawning	82
Sept. 23- Sept. 30	210	132	342	chinook spawning	93
Oct. 1- Oct. 7	210	118	328	chinook spawning	92
Oct. 8 - Oct. 14	330	118	448	chinook spawning	99
Oct. 15 - Oct 28	330	116	446	chinook spawning	99
Oct. 29 - Nov. 4	330	102	432	chinook spawning	99
Nov. 5 - Nov. 18	330	105	435	chinook spawning	99
Nov. 19 - Dec. 2	330	117	447*	coho spawning	85
Dec. 3 - Dec. 30	330	147	477*	coho spawning	81
Dec. 31 - Feb. 3	260	134	394*	coho spawning	92
Feb. 4 - Feb. 10	260	142	402*	coho spawning	91
Feb. 11 - Mar. 3	365	142	507*	coho spawning	78
Mar. 4 - Mar. 31	365	142	507*	steelhead spawning	100
April 1- April 14	365	143	508*	steelhead spawning	100
April 15 - May 5	260	160	420	steelhead spawning	97
May 6 - May 19	260	155	415	steelhead spawning	97
May 20 - June 2	250	155	405	steelhead spawning	97
June 3 - June 9	250	148	398	steelhead spawning	96
June 10 - June 16	225	151	376*	steelhead rearing	96
June 17 - June 30	225	186	411*	steelhead rearing	96
July 1- July 7	197	204	401*	steelhead rearing	96
July 8- July 14	186	205	391*	steelhead rearing	96
July 15 - Aug. 4	188	219	407*	steelhead rearing	96
Aug. 5 - Sept. 1	80	211	291*	steelhead rearing	99

*Flows exceed the level required to provide maximum weighted usable area.

that the delta toes would be exposed is increased under IF-2 modeled flows, the recurrence interval and duration of lake levels sufficiently low to expose the Cedar and Rex River deltas are similar under both IF-2 and IF-2.

During the pygmy whitefish spawning season, there is relatively little difference between the two alternative flow regimes in the amount of time that the modeled reservoir elevations fall below the 1,540 feet level. The IF-2 regime results in reservoir levels below 1,540 feet elevation 6.7 percent of the time (13 weeks), whereas the IF-1 regime results in steep delta fan exposure 6.2 percent of the time (12 weeks).

For both fish species it is believed that the incremental differences in lake levels projected under the proposed IF-2 regime will have no detectable influence on spawning migrations as compared to IF-1. Changes in the high and low reservoir levels are expected to be minimal under IF-2 and vary by less than a foot in most instances. While existing information suggests that small changes in existing reservoir operations would not result in a decline of bull trout population levels, no studies have been conducted to determine if reservoir operations currently limit bull trout abundance. Under IF-2, a monitoring and research program would be funded to track the relative status of the bull trout population and investigate the influence of reservoir operations on bull trout.

Additional Instream Flow Management Provisions

Oversight of instream flow management

The IF-2 will provide a forum for parties to the Instream Flow Agreement (IFA) to be formally involved in instream flow management decision making. A Cedar River Instream Flow Oversight Commission (Commission) will be established consisting of one member representing each of the signatories to the IFA. The purpose of the Commission will be to provide general oversight, coordination, and, where specifically authorized, direction regarding the implementation of the IFA. The Commission will serve as a forum for communication and coordination among the Parties to IFA of technical information on hydrologic conditions, facility and system operations, fish ecology, and such other subjects as may be beneficial in implementing the IF-2 flow regime.

That maintenance of the instream flow regime and other commitments of the IF-2 will benefit the fishery resources of the Cedar River by protecting, improving and increasing available habitat. The Applicant recognizes the importance of monitoring the condition of the habitat to assure that the purposes of the proposed HCP are met. The Applicant also acknowledges that available information on certain complex ecological and hydrologic processes is not complete. Therefore, the Applicant, in cooperation with the Commission, will sponsor and conduct certain studies and act on the results as

indicated. The Commission will serve as a forum for administering the responsibilities of the Parties to the IFA agreement in support of technical studies.

Ramping rates

The Applicant's small hydroelectric facilities at Cedar Falls and water supply facilities at Landsburg operate at relatively constant levels and are not operated in a manner that provides for diel peaking and associated flow oscillations. Therefore downramping is perhaps less of a concern on the Cedar than in other regulated rivers with large hydroelectric facilities that vary flows to meet varying electrical demands during the course of a day. Nevertheless, adjustments to the Applicant's water supply, and hydroelectric facilities do result in a significant number of stream flow reductions during the course of a year. Under the IF-2, defined rates for down ramping river flows would be established in order to avoid the stranding of juvenile fish in the river.

Stream flow gages positioned downstream of the three flow control points will be used to monitor and regulate ramping rates. The gage at river mile 20.4, 1.4 miles downstream of the Landsburg Diversion will be used to monitor the compliance of all upstream city facility water management operations with downramping prescriptions (the rate at which stream flows may be reduced as a result of project operations) as provided in Section 4.4.2 of the Draft HCP. To further reduce fish stranding risks associated with reductions in stream flow, the Applicant will commit to a second compliance point for downramping prescriptions at the USGS stream gage #12116500 located at river mile 33.3, 0.5 miles downstream of the Cedar Falls hydroelectric project tailrace. This compliance point will become effective immediately after fish passage facilities are completed at the Landsburg Diversion Dam and anadromous fish are allowed to pass upstream into the reach between Lower Cedar Falls and Landsburg (see Section 4.3.2).

Measurement point and effects of accretion flows

To more closely align the Applicant's accountability with its actual operations, improve operating precision and ensure better protection for fish habitat, the Applicant will replace the existing measurement point with several new instream flow measurement points. The new configuration of measurement points will provide improved conditions for anadromous fish in several ways. First, the measurement at Landsburg provides added protection for the upper portions of the lower river below Landsburg. Under the current IF-1 regime, actual flows at Landsburg can be varied in a quite unnatural manner to meet target flows 20 miles downstream at Renton. And, in fact, there are times when releases from Landsburg can approach zero, while still meeting IF-1 target flows at Renton. By moving the measurement point to Landsburg, the upper reaches of the river will be better protected and flows downstream of the Diversion Dam will vary in a much more natural manner according to changes

in natural inflows to the lower river. Secondly, the establishment of downramping measurement points at Landsburg and Cedar Falls will significantly reduce the risk of stranding juvenile fish during operational reductions in stream flow. And finally, the establishment of a minimum stream flow measurement point upstream of the Cedar Falls powerhouse will provide added protection for the bypass reach and upper portions of the Cedar River downstream from the powerhouse.

Accretion flow estimates developed in jointly overseen technical studies and further refined by the Cedar River Instream Flow Committee are used to represent the local inflows between Landsburg and Renton. Since accretion flow patterns can have a significant effect on fish habitat and since future accretion flow patterns may vary somewhat from those calculated from historical data, the Applicant will sponsor a long-term monitoring study to develop a better understanding of inflow patterns throughout the lower river. If the conclusions of the long term monitoring study show that actual local inflow patterns are clearly more or less than the previously assumed patterns for causes that cannot be reasonably attributed to factors such as land development and water withdrawals downstream of Landsburg, the Commission may agree to a procedure for adjusting the agreed-upon minimum flow commitments upward or downward by limited amounts.

Criteria for switching from normal to critical instream flow regime

During conditions of severe drought, the Applicant will be allowed to reduce stream flows to levels described by the critical flow regime (Table 4.4-4). Unlike the IF-1 flow regime, specific hydrologic criteria and conditions must be met in order to reduce to the critical minimum flow regime under the IF-2.

The Applicant may reduce flows to the critical minimum flow regime under specific condition in which specified hydrologic criteria have been met and public notification and water conservation measures specified in the Applicant's water shortage contingency plan have been implemented (Technical Appendix 10). Specific criteria described in sub-sections B.8.a.(1) and (2) of the Instream Flow Agreement (Technical Appendix 27) are hydrologic and reservoir conditions that indicate a degree of drought that triggers an "alert phase" in which the Applicant will initiate consultations with the other Parties in order to assess overall supply and fishery conditions, demand management, and forecasts. Based on the hydrologic record, these alert phase conditions are anticipated to occur more frequently than one year in ten, but some will not always result in switching to critical flows. Sub-sections B.8.a.(3) and (4) in the Instream Flow Agreement provide additional procedures and requirements that must be met before the Applicant may reduce flows from normal to critical. It is projected and intended that actual reductions would occur approximately one year in ten over the long term.

Flow management during favorable hydrologic conditions

In addition to the IF-2 minimum flow requirements, the Applicant will provide additional supplemental flows to meet biological objectives under specific conditions that reflect actual and forecasted water availability conditions. Although the minimum flows are typically well above the levels required to provide maximum WUA, the ancillary studies conducted during the collaborative study program indicate that additional biological benefits for other important aspects of salmonid life history are obtained at these higher flow levels. Committing to provide these additional higher flows at the same frequency as the minimum flows discussed above would result in an unacceptable loss of firm yield from the drinking water supply. However, in many years, hydrologic conditions are such that these additional flows can be provided if provisions are made to share subsequent risks of a water supply shortfall later in the year equally between stream flows for fish and municipal water supply. These supplemental flows are shown in Table 4.4-4 and have been incorporated into the discussion effects analysis of the IF-2 flow regimes downstream of Landsburg (Section 4.4.3.4.1).

Emergency flow continuation at Cedar Falls powerhouse

Under the IF-2, the Applicant would install new equipment to provide bypass flows around hydroelectric turbines during most emergency plant shut downs to prevent rapid downramping and dewatering downstream of the powerhouse. The construction of the emergency flow bypass facilities at the Applicant's Hydroelectric Facility will help reduce the risks of juvenile fish stranding and dewatering redds throughout the Cedar River downstream of Cedar Falls.

Waters conservation program

Water conservation programs under IF-2 will be generally similar to those of IF-1. The Applicant will continue a variety of water conservation programs guided by the *1996 Long Range Regional Conservation Plan* (Technical Appendix 9). Under IF-2, the plan will be supplemented by an additional $30,000 annually to pursue additional water conservation in an effort to further protect critical fish habitat in the Cedar River.

Environmental Evaluation of the Cedar Permanent Dead Storage Project

Potential benefits exist for augmentation of both stream flows and water supply through the development of permanent non-emergency access to water stored below the natural gravity outlet of Chester Morse Lake. Among the range of possible alternatives are the construction of a permanent drainage tunnel or the installation of permanent pumps. The Applicant will analyze the feasibility of reliable options for utilizing water stored below the natural gravity outlet of Chester Morse Lake. If, after considering environmental, economic, reliability, and other factors, the Applicant decides to develop such a project as a permanent water supply source, the instream flow regime will be

amended to apportion between instream flows and municipal water supply the additional water benefits made available by the project. The feasibility study for the Cedar Permanent Dead Storage Project will commence not later than the end of HCP year 1 and will require not more than 5 years to complete. Engineering studies will address design options, siting, water quality, geology and hydrology, yield analysis, costs and economics, constructability, reliability, and other factors. Environmental studies will address potential effects of the project on resident fish and wildlife populations and wetlands, and will evaluate alternative mitigation measures. For more details, see HCP Section 4.5.6.

Passage and water efficiency at the Chittenden Locks

As described in the Affected Environment section, the Hiram L. Chittenden Locks in Ballard have been identified as a significant source of mortality to out-migrating anadromous salmonids. Under the IF-2, the Applicant proposes to provide up to $625,000, or about 18 percent of the estimated total construction costs, to support implementation of passage improvement measures currently under consideration by the ACOE. The ACOE estimates that full implementation of these measures would substantially increase passage survival (ACOE, 1997). The increased survival of smolts passing through the Chittenden Locks is a clear benefit to the productivity of anadromous stocks within the Cedar River and throughout the Lake Washington basin.

In addition to passage improvements, the Applicant proposes to provide up to $1.25 million for improvements to the salt-water drain at the locks. The saltwater drain is designed to reduce the movement of salt water into Lake Washington when the locks are opened. These improvements are expected to save approximately 6,000 acre-feet of fresh water each year. Consequently, the savings could be used for other beneficial uses such as passage flows at the locks.

4.4.4 Summary

A summary of environmental consequences for fisheries habitat and resources is presented in Table 4.4-6. These consequences are summarized here individually for each of the Watershed Management, Anadromous Fish Mitigation, and Instream Flows Alternatives.

Conservation and mitigation measures common to all alternatives would avoid further alteration of the ecological processes critical in creating and maintaining fish habitat under any of the alternatives evaluated. However, the risk of road-related sediment delivery from previous timber harvest will remain Alternative WM-1, which does not includes a funding commitment for road maintenance stabilization and decommissioning. Road-related sediment delivery from previous timber harvest would be expected to decrease for alternatives WM-2, WM-3, WM-4, and WM-5. Stream reaches devoid of

inchannel habitat forming features may remain so until riparian forests mature and again serve as an effective recruitment source for large woody debris. Under all of the alternatives except for the No Action Alternative, the Applicant would commit to a program of watershed restoration targeted at rehabilitation of fluvial and upslope processes influential to fish habitat, including road, riparian, and inchannel rehabilitation.

Compared to the No Action Alternative, all of the other anadromous fish mitigation alternatives will provide substantial benefits to the anadromous and resident fish species in the Cedar River and are likely to meet Objectives 1 through 5. However, each of these alternatives still contains some level of uncertainty and risk. Risks of adverse genetic risks, although low, are relatively greater for the alternatives with substantial hatchery production, whereas demographic risks to the sockeye population, although unknown, are relatively greater with alternatives relying more on habitat acquisition, restoration, and enhancement. The Proposed HCP Alternative (AFM-2) has the greatest likelihood, of meeting all of the objectives.

On a relative basis, AFM-4 has a moderate likelihood, and AFM-3 and AFM-5 have lower likelihoods for meeting the Applicant's legal obligations for sockeye mitigation (Objective 6). The major concerns discussed above with AFM-3, AFM-4, and AFM-5 result in a substantive level of uncertainty that conditions could be met that would allow these alternatives to meet Objective 6. The Proposed HCP Alternative provides the greatest certainty that Objective 6 would be met with the highest level of productivity and, possibly, the highest harvest rate.

The habitat acquisition, protection, restoration, and enhancement projects under AFM-5 will have substantial benefits for salmonids and the ecosystem in general. However, the ability of these projects to produce enough additional fry in the lower river to fully meet the sockeye mitigation goal is unlikely. AFM-3 spreads out the risk by implementing both habitat and hatchery measures at moderate levels immediately, but the Applicant's mitigation goal for sockeye salmon might be met only under very favorable spawning conditions and conditions of project implementation that are unlikely to be achieved. In contrast, AFM-4 reduces the risk of not meeting the sockeye mitigation goal by potentially ultimately implementing both habitat and hatchery measures at low to moderate levels and monitoring the incremental response of the system to these measures. Under AFM-4, the risk of negative environmental consequences is reduced, but the demographic risk to the sockeye population could be greater, and the risk of negative financial effects (and consequently negative effects to other parts of the mitigation plan) is increased. AFM-4 also risks some potential benefits in the short term to provide greater certainty of benefits in the long term.

The uncertainty surrounding the carrying capacity of Lake Washington suggests there is a risk that all of the action alternatives could exceed the lake's capacity during some years and conditions. It is also possible that none of the

alternatives will exceed the carrying capacity. Regardless of the carrying capacity, the level of the hatchery component will affect the productivity of the stock and potentially the harvest rate set by WDFW and the Muckleshoot Indian Tribe. Consequently, AFM-2 has the highest potential harvest rate while AFM-5 has the lowest. The potential harvest rate from AFM-3 would be intermediate to AFM-2 and AFM-5. The potential harvest rate under AFM-4 would also lie somewhere in that intermediate range, but ultimately would depend upon the decisions made in Year 10 of the HCP.

Table 4.4-4 presents a comparison of the flow regimes for IF-1 and IF-2. The relationship between flow regimes and flows for maximizing available habitat for species and life history are provided in Figures 4.4-4, 4.4-5, 4.4-6, and 4.4-7.

IF-1 and IF-2 flow regimes are similar in that each make provisions for a normal flow schedule and a critical flow schedule which is implemented during periods of severe drought. In addition, flows under each alternative generally exceed the levels required to maximize species and life history stage habitats throughout much of the year. However, the IF-1 regime provides no opportunity to establish higher stream flow commitments during periods of favorable hydrologic conditions. In contrast, the proposed HCP regime provides opportunities for increased stream flows when favorable hydrologic conditions occur during periods of key importance to anadromous fish. The precise timing and distribution of these flows will vary from year to year depending on conditions, biological need and direction from the interagency Cedar River Instream Flow Commission comprised of one member representing each of the Parties to the IFA (Technical Appendix 27).

The flow regime outlined as part of the IF-2 is intended to resolve continuing flow issues and establish greater long-term certainty for fish habitat conditions and water supply planning throughout the Cedar River both above and below the Landsburg Diversion. Under the IF-2, the Applicant would commit to a binding set of minimum instream flow requirements that replace the current non-binding flow targets. Under IF-1, the Applicant would use the IRPP flow regime as an operating target and a water supply planning assumption. As these guidelines are non-binding, there is no assurance that the minimum flows of the IF-1 regime would actually be in the river during dry periods in the future.

Key elements of the IF-2 regime that differentiate it from the IF-1 regime include:

- Binding flow commitments
- Higher flows during fall to provide increased cumulative spawning habitat and edge spawning habitat for sockeye
- Higher flows during winter to help prevent redd dewatering
- Higher flows during spring for improved conditions for downstream migrating sockeye

- Higher flows during the early summer for increased dewatering protection for incubation steelhead
- Supplemental water to augment minimum instream flow for additional benefits to fish
- Relocation of flow measurement point for improved habitat protection and to encourage a more natural hydrologic regime
- Downramping prescriptions to moderate sudden flow fluctuations and reduce the risk of fish stranding
- Funding for smolt passage facilities and saltwater drain improvements at the Ballard Locks
- Studies to develop improved criteria for switching to different flow curves, and to evaluate assumptions concerning accretion flows into the Cedar River below Landsburg.

Table 4.4-6 Summary of Environmental Consequences Evaluated for Fisheries Habitat and Resources (page 1 of 10)

Potential Impact Evaluated	Environmental Consequences					Comments
	Watershed Management Alternatives					
	WM-1	WM-2	WM-3	WM-4	WM-5	
Potential effects on resident fisheries resources from timber harvesting within the Cedar River Municipal Watershed	Unknown Effects	Positive Effects	Positive Effects	Positive Effects	Positive Effects	In general, the large reserve areas with extensive stream buffers found as part of every alternative are expected to provide a great deal of protection to fisheries resources. Localized sedimentation within the Taylor subbasin could have a slight effect on fisheries resources depending on deliverability.
Potential effects on resident fisheries resources from road maintenance and decommissioning	Unknown Effects	Positive Effects	Positive Effects	Positive Effects	Positive Effects	The road maintenance and decommissioning activities proposed for every alternative are expected to provide a positive effect on fisheries resources. The effects for WM-1 are listed as unknown because funding for road maintenance and decommissioning under the No Action Alternative is uncertain.
Potential effects on resident fisheries resources from stream and riparian restoration projects (large woody debris placement, stream bank armoring, stream bank revegetation, etc.)	No Effects	Positive Effects	Positive Effects	Positive Effects	Positive Effects	Stream and riparian restoration projects (large woody debris placement, stream bank armoring, stream bank re-vegetation, etc.) are expected to have a positive effect on fisheries resources for alternatives WM-2, WM-3, WM-4 and WM-5. These projects are not proposed as part of WM-1, the No Action Alternative.

Table 4.4-6 Summary of Environmental Consequences Evaluated for Fisheries Habitat and Resources (page 2 of 10)

Potential Impact Evaluated	Environmental Consequences					Comments
	Anadromous Fish Mitigation Alternatives					
	AFM-1	AFM-2	AFM-3	AFM-4	AFM-5	
Effects on current runs of chinook, coho, and steelhead	Unknown Effects	Positive Effects	Positive Effects	Positive Effects	Positive Effects	Chinook and coho salmon, and steelhead trout will gain access to available spawning habitat through passage over the Landsburg Diversion Dam under alternatives AFM-2, AFM-3, AFM-4, and AFM-5. The effects from AFM are unknown because it is not certain that passage would be provided under the No Action Alternative.
Effects on genetics and domestication of sockeye salmon in the Cedar River	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Fish produced by the interim and replacement hatcheries are intended to be genetically, physiologically, behaviorally, and ecologically similar to those produced naturally and cannot be distinguished by appearance from naturally reproducing fish. Because the sockeye stocks in Lake Washington managed as a single stock, there are risks of domestication to the Cedar River stock. Risks of domestication are considered to be negligible or low, because the primary objective of the sockeye hatchery program is to minimize domestication effects; changes in genetics, fish characteristics, and return rates will be monitored; the hatchery will be operated adaptively to minimize such impacts; and the hatchery program can be abandoned by agreement of the parties to the Landsburg Mitigation Agreement if such problems cannot be solved.

Table 4.4-6 Summary of Environmental Consequences Evaluated for Fisheries Habitat and Resources (page 3 of 10)

Potential Impact Evaluated	Environmental Consequences					Comments
	Anadromous Fish Mitigation Alternatives (cont.)					
	AFM-1	AFM-2	AFM-3	AFM-4	AFM-5	
Effects of disease on sockeye	Positive Effects	Positive Effects	Positive Effects	Positive Effects	Negligible Effects	The production of IHN-free sockeye fry in the hatchery, plus the concept of a composite population, has the potential to reduce the incidence of IHN infection throughout the watershed. It is possible that IHN could build up in groundwater-fed side channels, which are not flushed by storm flows, but this risk is considered negligible for the population as a whole.
Effects of straying to naturally reproducing fish stocks	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Unknown Effects	The available evidence from Hendry et al. (1996) suggests that no substantial introgression has occurred to date between Cedar River and the naturally reproducing stocks in Bear and Cottage Creeks. The effects of straying on non-Cedar sockeye stocks in the basin are expected to be negligible, because straying will be monitored; procedures for detecting and minimizing impacts will be followed; and hatchery operations will be altered too if such problems occur. Because sockeye produced from the Cedar River by habitat restoration will not be otolith-marked, and their straying cannot be easily monitored, effects of increased production from the Cedar by natural means are not known.
Effects of sockeye harvest on naturally reproducing stocks	Negligible Effects	Uncertain Effects	Uncertain Effects	Uncertain Effects	Uncertain Effects	According to the Wild Salmonid Policy, enhanced production that could lead to increased harvest might negatively effect native stocks. This was noted to be especially true for systems such as the Lake Washington System where all anadromous stocks are already depressed. Overall, it is expected the negative effects of harvest to naturally reproducing stocks will be minimized as a result of the implementation of an

Table 4.4-6 Summary of Environmental Consequences Evaluated for Fisheries Habitat and Resources (page 4 of 10)

Potential Impact Evaluated	Environmental Consequences					Comments
						appropriate
	Anadromous Fish Mitigation Alternatives (cont.)					
	AFM-1	AFM-2	AFM-3	AFM-4	AFM-5	
						harvest management strategy by WDFW and the Muckleshoot Indian Tribe, including monitoring during and after the sport harvest. In addition, evidence suggests that harvest of stocks from the north end of Lake Washington can be segregated from harvest of Cedar River stock by restricting timing and site of allowed fishing in the lake.
Competition with naturally reproducing fish for limited resources above Landsburg	No Effects	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	After passage of chinook, coho, and steelhead above the Landsburg Diversion Dam, competition can be expected to occur with cutthroat and rainbow trout. The magnitude of these effects is unknown. However, because these three anadromous species were present historically in the reach above Landsburg before the diversion dam was constructed, the effects on resident trout, and other native fish in this area of the watershed, are considered to be acceptable. The potential effects are considered negligible because providing passage would restore fish communities closer to their natural structure before Landsburg was constructed.
Effect of broodstock collection practices on reproductive success of naturally reproducing salmonids	Neglible Effects	Negligible Effects	Negligible Effects	Negligible Effects	No Effects	The sockeye broodstock collection program has two primary objectives: i) to capture an adequate number of adult sockeye salmon in a manner that provides a representative subset of the entire Cedar River sockeye population and ii) to avoid and minimize any impacts the program may have on naturally reproducing salmonids in the Cedar River. The City believes that the potential risks associated with installation, operation, and

Table 4.4-6 Summary of Environmental Consequences Evaluated for Fisheries Habitat and Resources (page 5 of 10)

Potential Impact Evaluated	Environmental Consequences					Comments
						removal of interim and long-term broodstock
	Anadromous Fish Mitigation Alternatives (cont.)					
	AFM-1	AFM-2	AFM-3	AFM-4	AFM-5	
						collection facilities can be minimized and avoided through the development of rigorous broodstock collection protocol and implementation of improved broodstock collection practices beginning in Year 1 of the HCP. The design and implementation of sockeye broodstock collection facilities and practices will be addressed during the development of sockeye mitigation program guidelines in Year 1 of the HCP. Under AFM-2, AFM-3, or AFM-4, ongoing evaluation, analyses and design activities will determine the precise method of broodstock collection for the final sockeye fry production program. Interim and long-term broodstock collection facilities will be designed and operated in a manner that avoids and minimizes potential negative impacts on naturally reproducing fish in the Cedar River. Specific aspects of the long-term broodstock collection program will be further addressed during project specific environmental review prior to initiating construction of a final facility.

Table 4.4-6 Summary of Environmental Consequences Evaluated for Fisheries Habitat and Resources (page 6 of 10)

Potential Impact Evaluated	Environmental Consequences					Comments
	Anadromous Fish Mitigation Alternatives (cont.)					
	AFM-1	AFM-2	AFM-3	AFM-4	AFM-5	
Competition with naturally reproducing fish for limited resources below Landsburg	Unknown Effects	Unknown Effects	Unknown Effects	Unknown Effects	Unknown Effects	Any measures, artificial production facility or habitat improvements, that increase production of sockeye could lead to increased competition with naturally reproducing stocks in the basin. An important assumption implicit to the hatchery proposal is that sockeye fry from the hatchery will not limit naturally reproduced fry production from the Cedar River or the northern Lake Washington tributaries through competition for resources (e.g., space or food) in the lake. Ongoing and proposed investigations are designed to test this assumption and are an important component to the adaptive management strategy pursued in the HCP.
Other ecological effects of increased sockeye production on other salmonid species	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Waples (1998) has suggested that spawning female sockeye could affect the redds (nests) of other species (by excavating), and that sockeye could transfer diseases to other species. Note that the potential for these effects is independent of the kind of measures used to increase production of sockeye. Because hatchery produced fish are expected to be more disease-free than naturally produced fish, there is little risk of disease transfer as a result of the artificial production program. The effects of spawning competition from increased sockeye are expected to be negligible, because harvest is expected to keep sockeye populations within escapement goals; steelhead and many coho spawn after sockeye; chinook are aggressive at redds, and are much larger than sockeye; and chinook mostly spawn in deeper water than sockeye, and place their eggs deeper in the gravel than sockeye.

Table 4.4-6 Summary of Environmental Consequences Evaluated for Fisheries Habitat and Resources (page 7 of 10)

Potential Impact Evaluated	Environmental Consequences					Comments
	Anadromous Fish Mitigation Alternatives (cont.)					
	AFM-1	**AFM-2**	**AFM-3**	**AFM-4**	**AFM-5**	
Effects on egg-to-fry survival in sockeye	No Effects	Positive Effects	Positive Effects	Positive Effects	Positive Effects	The natural mortality of incubating eggs in the gravel can be considerable. Egg-to-fry sockeye survival rates are typically below 20 percent and averaged near 10.5 percent for six Alaska populations reported by Foerster (1968), but can be substantially higher or lower in a given year or river. In contrast, egg-to-fry survival within a hatchery can exceed 90 percent. Because redds in groundwater-fed side channels will be protected from flood flows, egg-to-fry survival can be also expected to be relatively higher than in the mainstem of the Cedar River.
	Instream Flow Alternatives					
	IF-1			**IF-2**		
Instream Flows Below the Landsburg Division Dam						
Salmon spawning flows in the fall and winter	Positive and Negative Effects			Positive Effects		Target species are sockeye and chinook spawning. During this period WUA is higher or flows are higher than IF-1. Cumulative habitat and edge habitat for sockeye spawning is greater than in IF-1.
Salmon incubation flows in the winter and spring	Positive and Negative Effects			Positive Effects		Target species chinook, sockeye, and coho. Based on the effective spawning analysis IF-2 flows remain elevated to ensure that most of the available spawning area remains inundated until emergence.
Sockeye outmigration flows in the spring	Negative Effects			Positive Effects		IF-2 contains provisions for 40% higher minimum flows at least 70% of the time during the peak of sockeye outmigration.

Table 4.4-6 Summary of Environmental Consequences Evaluated for Fisheries Habitat and Resources (page 8 of 10)

Potential Impact Evaluated	Environmental Consequences		Comments
	Instream Flow Alternatives (cont.)		
	IF-1	IF-2	
Chinook rearing and outmigration flows in the spring	Uncertain	Uncertain	IF-2 provides up to 213 cfs more flow than the IF-1 during this period to benefit sockeye outmigration. Chinook outmigration may be benefited under IF-2. As a consequence of higher flows, chinook rearing WUA is diminished under the IF-2.
Supplemental Steelhead spawning and incubation flows in the spring and summer with option to recover water by using temporary pumps or by reducing instream flows	Negative Effects	Positive and Negative Effects	From early March through mid-May, higher flows under IF-2 reduce WUA for steelhead spawning. After mid-May, IF-2 flows provide more WUA for steelhead spawning and reduce the risk of subsequent redd stranding. For steelhead incubation, IF-2 provides an additional block of water to be allocated as directed by the Commission in normal years when the need exists for increased steelhead incubation protection.
Instream Flows Below the Landsburg Diversion Dam			
Steelhead and coho rearing flows year round	Positive Effects	Positive Effects	Under IF-2, WUA or instream flows are equal to or greater than IF-1.
Instream Flows Upstream of Landsburg Diversion Dam			
Landsburg to Lower Cedar Falls	No Effects	Positive Effects	IF-2 flows or WUA are equal to or greater than that under IF-1.
Lower Cedar Falls to Masonry Dam	Negative Effects	Positive Effects	IF-2 provides a minimum flow through this reach for resident trout and rearing salmon and steelhead whereas IF-1 does not.
Reservoir fish populations potentially impacted by reservoir operations	Negligible Effects	Negligible Effects	The minor changes in reservoir pool elevations necessary to meet the IF-2 flow commitments will have negligible effects on bull trout and pigmy whitefish habitat.

Table 4.4-6 Summary of Environmental Consequences Evaluated for Fisheries Habitat and Resources (page 9 of 10)

Potential Impact Evaluated	Environmental Consequences		Comments
	Instream Flow Alternatives (cont.)		
	IF-1	IF-2	
Additional Flow Management Provisions			
Oversight of instream flow management	Does Not Apply	Positive Effects	Commission monitoring of instream flows and certain instream flow related studies of the HCP will assure that the full effect of SPU's flow commitments are realized by Cedar River fish populations.
Juvenile and fry stranding	Negative Effects	Positive Effects	Under IF-2 ramping rates will protect against stranding of fry and juveniles throughout the Cedar River below Masonry Pool. Under IF-1 there are no ramping rate requirements.
Additional Flow Management Provisions			
Relocating compliance point	Does Not Apply	Positive Effects	Under IF-1 the measurement point at Landsburg will improve SPU's ability to reregulate and meet instream flows throughout the lower Cedar River.
New criteria and procedures for switching	Does Not Apply	Positive Effects	New switching criteria and procedures will help ensure that critical instream flow regimes are implemented only when warranted.
Flow management during favorable hydrologic conditions	Does Not Apply	Positive Effects	Supplemental flows under IF-2 will provide additional biological benefits for anadromous fish that are not provided under IF-1.

Table 4.4-6 Summary of Environmental Consequences Evaluated for Fisheries Habitat and Resources (page 10 of 10)

Potential Impact Evaluated	Environmental Consequences		Comments
	Instream Flow Alternatives (cont.)		
	IF-1	IF-2	
Emergency flow continuation at Cedar Falls powerhouse	Negative Effects	Positive Effect	Under IF-2, installation of flow continuation capabilities at Cedar Falls powerhouse will reduce the impacts of rapid flow fluctuations on aquatic resources downstream.
Water conservation program	Positive Effects	Positive Effect	An addition of $30,000 would go towards the City's current conservation program.
Use of Cedar dead storage on a permanent basis for instream flows and water supply	No Effects	Negative Effect	Under IF-2 the SPU will investigate the feasibility of reliable options for utilizing water stored below the natural gravity outlet of Chester Morse Lake. Potential benefits exist for augmentation of both stream flows for anadromous fish and water supply from this source. Potential small negative effects on bull trout, pigmy whitefish, and loons.
Additional Flow Management Provisions			
Improve passage and water efficiency at the Chittenden Locks	No Effects	Positive Effect	Under IF-2 the applicant proposes to provide up to $625,000 toward the estimated costs of improving fish passage at the locks. The applicant also proposes to provide up to $1.25 million for improvements to the salt-water drain at the locks. Both these initiatives will benefit fisheries resources in the Cedar River as well as in the Lake Washington Basin.

4.5 Wildlife

The section discusses the anticipated environmental consequences of the five Watershed Management Alternatives on the wildlife habitats and species communities, and key wildlife species of concern in the Cedar River Municipal Watershed. Because the five alternatives build upon one another in the protective features they entail (from the No Action Alternative, WM-1, through WM-5), environmental consequences are likewise discussed in a stepwise progression building from the No Action Alternative (WM-1).

Effects to key wildlife communities and species with individual conservation strategies are based primarily on an evaluation and comparison of the quality and quantity of wildlife habitat expected to be present at Year 0 of the HCP, at Year 20 of the HCP (i.e., the short term), and at Year 50 of the HCP (i.e., the long term) in each of the five alternatives (see Maps 14, 17, 19, 21, 23, and 24). Expected changes in the quantity of certain habitats under each alternative are based on the results of forest growth projection modeling of forest seral stages (Section 4.4, Forest Resources). Expected changes in habitat quality under each alternative are based on a qualitative evaluation of management actions to enhance habitat proposed under each alternative. These actions include, but are not necessarily limited to, restoration thinning, ecological thinning, precommercial thinning, commercial thinning, restoration planting, and various aquatic and riparian restoration projects. Details of these actions are presented in Chapter 2.

The potential detrimental and beneficial effects of the proposed HCP on all 73 wildlife species of concern are discussed at length in the HCP itself (Chapter 4). These "effects analyses" are broken down into habitat effects, disturbance effects, and direct take. Effects are based primarily on the expected changes in the quantity of certain habitats over the 50-year life of the proposed HCP, as well as expected changes in habitat quality based on a qualitative evaluation of management actions to enhance habitat under the proposed HCP.

The determination that proposed management actions would benefit wildlife habitat is based on a large body of scientific literature related to management of Pacific Northwest forests, streams, wetlands, and riparian areas. In

particular, the determination that various thinning treatments are beneficial to wildlife habitat is based largely on the "Biodiversity Pathway for Forest Management" paradigm developed by A.B. Carey as part of the Washington Forest Landscape Management Project (WFLMP) (see Carey, 1994; Carey and Curtis, 1996; Carey et al., 1995). The original conceptual model for this pathway was based on extensive field research related to the ecology and management of western Washington forests. The biodiversity pathway was refined, further developed, and evaluated in landscape-level computer simulations conducted by the WFLMP team (Carey et al., 1996).

The environmental consequences of the Watershed Management Alternatives on key habitats and wildlife communities are discussed in Section 4.5.1. The environmental consequences of the Watershed Management Alternatives on other habitats are discussed in Section 4.5.2. Habitat fragmentation and connectivity consequences are found in Section 4.5.3. The environmental consequences of the Watershed Management Alternatives on individual species, including northern spotted owl, marbled murrelet, northern goshawk, common loon, gray wolf, grizzly bear, bald eagle, and peregrine falcon are presented in Section 4.5.4.

The environmental consequences of the Anadromous Fish Mitigation alternatives are presented in Section 4.5.5. The environmental consequences of the Instream Flow Alternatives on the river delta vegetation and common loon from fluctuations in reservoir levels is presented in Section 4.5.6. Section 4.5.7 provides a summary of the environmental consequences for wildlife and all of the alternatives.

4.5.1 Key Habitats and Wildlife Communities

This section discusses the effects of the five Watershed Management Alternatives on the distribution, abundance and quality of the three key wildlife habitats (aquatic and riparian, old growth forest, and special habitats), and the wildlife communities associated with those habitats in the Cedar River Municipal Watershed.

Aquatic and Riparian

No Action Alternative for Watershed Management (WM-1)

The No Action Alternative (WM-1) would protect stream, pond, lake, and reservoir buffers, wetlands and wetland buffers, and all riparian vegetation in a Reserve which would be expected to immediately protect all species in the aquatic and riparian community. Risk of effect from episodic mass wasting or erosional events would be expected to be higher in WM-1 than the four other alternatives as a result of the smaller Reserve area and forest management guidelines. Gains in the quality and quantity of aquatic and riparian habitats resulting from the natural maturation of younger seral stage forest in buffers would be expected to be the same in WM-1 as in WM-2 through WM-5.

Restoration of more-natural aquatic and riparian ecosystem functioning would be expected to occur more slowly in WM-1 than in the four other alternatives because no aquatic and riparian restoration projects are included in WM-1.

WM-1 would protect all stream, pond, lake, and reservoir buffers, wetlands and wetland buffers, and all riparian vegetation in a Reserve (17,913 acres of stream buffers, 1,339 acres of pond, lake, and reservoir buffers, 236 acres of palustrine emergent wetlands, 464 acres of palustrine scrub-shrub wetlands, 1,063 acres of forested wetlands, 2,610 acres of aquatic and wetland complexes, and 720 acres of riparian vegetation). Aquatic buffers are based on FEMAT guidelines (USDA Forest Service and USDI Bureau of Land Management, 1993) which are designed to protect all aquatic and riparian ecosystem functions. As a result, all species in the aquatic and riparian community, including all 39 wildlife (i.e., non-fish) species of concern, would be expected to receive immediate protection under this alternative. The SMA, which adds an additional 300-foot buffer to certain aquatic habitats, would be expected to offer greater protection to certain species that (a) are highly mobile and use riparian areas as travel corridors (e.g., fisher); or (b) require aquatic or riparian areas and minimal disturbance from humans (e.g., harlequin duck, common loon).

The higher level of timber harvest and clearcut harvest methods called for under WM-1 compared to the four other alternatives means that there would be a somewhat higher risk of effect from episodic mass wasting events or erosional events that might occur. The effects of such events, although likely to be localized and short-lived, could affect low-mobility aquatic invertebrates (e.g., pebblesnails) or certain amphibians (e.g., egg and larval stages of highly aquatic forms such as the tailed frog).

Regeneration timber harvest units up to 120 acres in size and on a rotation of 40 to 80 years would create openings adjacent to aquatic buffers and riparian areas. These openings could affect microclimate within aquatic buffers, thereby affecting species composition in the buffer due to what are termed "edge effects." These effects would occur for a period of at least 30 years, when regrowth in the unit (i.e., development of a closed canopy) would bring microclimatic conditions closer to background levels (i.e., levels within the buffer). In the first decade of the No Action Alternative, approximately 623 acres of regeneration harvest would occur per year, while in the second decade approximately 524 acres would be harvested by regeneration methods per year. The amount of edge created by these harvests would depend upon a number of factors such as size, shape, and location of the cut. Noise and human activity associated with regeneration timber harvesting, including industrial clear cutting adjacent to buffers, could disturb species utilizing aquatic buffers or riparian habitats. This effect would likely be most pronounced for nesting birds (e.g., willow flycatcher, harlequin duck, common loon).

Short-term and long-terms gains in the quality and quantity of aquatic and riparian habitats would be expected under WM-1 as a result of the natural

maturation of extensive younger seral stage forest in buffer areas. This growth into mature and late successional forests would restore more-natural ecosystem functioning because of elimination of commercial timber harvest, and would benefit a number of aquatic and riparian species, ranging from invertebrates (e.g., papillose taildropper) to nesting birds (e.g., willow flycatcher) to small mammals (e.g., water shrews). At present, approximately 2,652 acres of early seral forests (0 to 29 years), 11,680 acres of mid seral forests (30 to 79 years), and 227 acres of mature forest occur in the aquatic buffers proposed in WM-1. Natural maturation would result in approximately 6,527 acres of mature and late successional forest in buffers by Year 20, and approximately 11,907 acres of mature and late successional forest in buffers by Year 50.

Because no aquatic or riparian restoration projects, restoration planting, restoration thinning or ecological thinning would take place under this alternative, restoration of more-natural ecosystem functioning would be expected to occur more slowly than in the four other alternatives.

Proposed HCP Alternative for Watershed Management (WM-2)

The Proposed HCP Alternative for Watershed Management (WM-2) would protect stream, pond, lake, and reservoir buffers, wetlands and wetland buffers, and all riparian vegetation in a Reserve which would be expected to immediately protect all species in the aquatic and riparian community. Risk of effect from episodic mass wasting events or erosional events, though very low, would be expected to be less than WM-1, but higher than the other alternatives. Gains in the quality and quantity of aquatic and riparian habitats as a result of the natural maturation of younger seral stage forest in buffers would be expected to be the same in WM-2 as in all four other alternatives. Because WM-2 includes aquatic and riparian restoration projects, restoration of more- natural aquatic and riparian ecosystem functioning would be expected to occur more rapidly than in WM-1, and the same as in the other three alternatives (all of which also include aquatic and riparian restoration projects).

As in WM-1, WM-2 would immediately protect stream, pond, lake, and reservoir buffers, wetlands and wetland buffers, and all riparian vegetation in a Reserve. Aquatic buffers and the SMA would be the same width as in WM-1, thus conferring the same complete degree of protection to aquatic and riparian species as WM-1. As in WM-1, the SMA would further protect certain species that (a) are highly mobile and use riparian areas as travel corridors; or (b) require aquatic or riparian areas and minimal disturbance from humans.

WM-2 calls for a lower level of retention timber harvesting, combined with commercial thinning, more protective timber harvest management prescriptions, and a greater amount of road abandonment and stabilization activities than WM-1. This would be expected to confer a slightly higher level of protection to aquatic and riparian habitats than in WM-1 by tending to lower the probability of erosion and mass wasting associated with timber harvest

activities in localized areas. Species standing to benefit from this additional protection would include low-mobility aquatic invertebrates and certain amphibians.

The lower level of retention harvesting would mean that fewer early seral habitats would be created immediately adjacent to buffer zones, thereby lessening the edge effect associated with this transition in habitats. This would provide some minor benefits for some species associated with riparian habitats in forested areas (especially mature, late successional, and old growth forests). WM-2 has lower overall levels of commercial timber harvesting (i.e., retention cut and commercial thinning) than WM-1 in decades one, two, three, and five. This would be expected to result in lower levels of human disturbance, on average, in areas adjacent to buffer zones in those decades. Riparian-nesting birds in particular would benefit from a reduction in human disturbance.

As in WM-1, short-term and long-term gains in aquatic and riparian habitat quality and quantity would be expected under WM-2 as a result of natural maturation of younger seral stage forest in these areas. However, gains would accrue more rapidly under WM-2 than under WM-1, because WM-2 includes management actions designed to help restore and enhance aquatic and riparian habitats (steam bank stabilization projects, placement of large woody debris, a stream bank revegetation program, and a program of restoration thinning in riparian areas). These actions would help accelerate the restoration of more-natural aquatic and riparian ecosystem functioning and the development of mature or late successional characteristics in younger second-growth forests in buffer areas.

Long-term Sustainable Thinning Alternative (WM-3)

The Long-term Sustainable Thinning Alternative (WM-3) would protect stream, pond, lake, and reservoir buffers, wetlands and wetland buffers, and all riparian vegetation in a Reserve which would be expected to immediately protect all species in the aquatic and riparian community. Risk of effect from episodic mass wasting events or erosional events would be expected to be less than WM-1 and WM-2, but higher than WM-4 or WM-5. Gains in the quality and quantity of aquatic and riparian habitats resulting from the natural maturation of younger seral stage forests in buffers would be the same in WM-3 as in all four other alternatives. Because WM-3 includes aquatic and riparian restoration projects, restoration of more-natural aquatic and riparian ecosystem functioning would be expected to occur more rapidly than in WM-1, and the same as in the other three alternatives.

WM-3 would have many of the same environmental consequences as WM-1 and WM-2. As in WM-1 and WM-2, WM-3 would immediately protect stream, pond, lake, and reservoir buffers, wetlands and wetland buffers, and all riparian vegetation in a Reserve. Aquatic buffers and the SMA in WM-3 would be the same as in WM-1 and WM-2, conferring the same degree of protection to aquatic and riparian species.

Since WM-3 calls for no clearcut or retention harvesting of timber, it would provide a slightly higher level of protection to aquatic and riparian habitats than WM-2 by further lowering the probability of erosion and mass wasting associated with timber harvest activities in localized areas. No new early seral habitats would be created immediately adjacent to buffer zones under WM-3, thus no new edges would be created.

As in WM-1 and WM-2, short-term and long-term gains in aquatic and riparian habitat quality and quantity would be expected under WM-3 as a result of natural maturation of younger seral stage forest in these areas. And, since WM-3 includes the same aquatic and riparian restoration projects and road abandonment and stabilization activities included in WM-2, short-term and long-term gains in habitat quantity and quality due to these management actions would be expected to be the same under WM-3 and WM-2.

Thinning Alternative with Phased Out Commercial Timber Harvest (WM-4)

The Thinning Alternative with Phased Out Commercial Timber Harvest (WM-4) would protect stream, pond, lake, and reservoir buffers, wetlands and wetland buffers, and all riparian vegetation in a Reserve which would be expected to immediately protect all species in the aquatic and riparian community. Risk of effect from episodic mass wasting events or erosional events would be expected to be less than WM-1 through WM-3, but higher than WM-5. Gains in the quality and quantity of aquatic and riparian habitats as a result of the natural maturation of younger seral stage forest in buffers would be the same in WM-3 as in all four other alternatives. WM-4 includes aquatic and riparian restoration projects. Thus, restoration of more-natural aquatic and riparian ecosystem functioning would be expected to occur more rapidly than in WM-1, and the same as in the other three alternatives.

WM-4 would have many of the same environmental consequences as WM-1 through WM-3. As in WM-1 through WM-3, WM-4 would immediately protect stream, pond, lake, and reservoir buffers, wetlands and wetland buffers, and all riparian vegetation in a Reserve. Aquatic buffers and the SMA in WM-4 would be the same as in WM-1 through WM-3.

Since WM-4 calls for no clear clearcut or retention harvesting of timber and only single-entry thinning on a non-reserve land base smaller than that in WM-2 or WM-3, it would confer a slightly higher level of protection to aquatic and riparian habitats than WM-2 or WM-3 by further lowering the probability of erosion and mass wasting associated with timber harvest activities in localized areas. No new early seral habitats would be created immediately adjacent to buffer zones under WM-4, thus no new edges would be created.

As in WM-1 through WM-3, short-term and long-term gains in aquatic and riparian habitat quality and quantity would be expected under WM-4 as a result of natural maturation of younger seral stage forest in these areas. WM-4

includes the same aquatic and riparian restoration projects and road abandonment and stabilization activities as in WM-2 and WM-3. Thus, short-term and long-term gains in habitat quantity and quality due to these management actions would be expected to be the same under these three alternatives.

No Commercial Timber Harvest Alternative (WM-5)

WM-5 would protect stream, pond, lake, and reservoir buffers, wetlands and wetland buffers, and all riparian vegetation in a Reserve which would be expected to immediately protect all species in the aquatic and riparian community. Risk of effect from episodic mass wasting events or erosional events that might occur is less than WM-1 through WM-4. Gains in the quality and quantity of aquatic and riparian habitats resulting from natural maturation of younger seral stage forest in buffer areas would be the same in WM-5 as in all four other alternatives. Under WM-5, restoration of more-natural aquatic and riparian ecosystem functioning would be expected to occur more rapidly than in WM-1, and the same as in the other three alternatives.

As in WM-1 through WM-4, WM-5 would immediately protect stream, pond, lake, and reservoir buffers, wetlands and wetland buffers, and all riparian vegetation in a Reserve. However, since WM-5 calls for no commercial timber harvest anywhere in the Watershed, no edge effects would be created by this alternative.

Since WM-5 has no commercial timber harvest whatsoever, it would confer a slightly higher level of protection to aquatic and riparian habitats than WM-1 through WM-4 by further lowering the probability of erosion and mass wasting associated with timber harvest activities, retention harvest, or thinnings in localized areas. No new early seral habitats would be created immediately adjacent to buffer zones under WM-5, thus no new edges would be created.

As in WM-1 through WM-4, short-term and long-term gains in aquatic and riparian habitat quality and quantity would be expected under WM-5 as a result of natural maturation of younger seral stage forest in these areas. WM-4 includes the same aquatic and riparian restoration projects and road abandonment and stabilization activities as in WM-2 through WM-4. Thus, short-term and long-term gains in habitat quantity and quality due to these management actions would be expected to be the same in WM-5 as under the other three alternatives.

Old growth Forest

No Action Alternative for Watershed Management (WM-1)

WM-1 would protect all existing old growth forest, an old growth forest buffer, and additional acres of second growth forest with late successional or old growth characteristics in a Reserve which would be expected to immediately

protect all species in the old growth forest community. No new old growth forest would develop naturally over the 50-year time frame of the No Action Alternative, WM-1. Gains in the quantity of mature and late successional forest habitats resulting from natural maturation of second-growth forests would be less under WM-1 than under the four alternatives. Under WM-1, there would be no management actions designed to accelerate development of late successional or old growth characteristics in second-growth forests (as would take place in WM-2 through WM-5).

WM-1 would protect all 13,889 acres of existing old growth forest, a 200-foot old growth forest buffer, and approximately 2,592 additional acres of second-growth forest with late successional or old growth characteristics (primarily in the Taylor Creek subbasin, Williams Creek subbasin, and near the overflow dike on the west side of Chester Morse Lake) in the Reserve. As a result, all species in the old growth forest community would receive immediate protection under this alternative.

The old growth forest buffers in WM-1 are intended to provide additional protection to the old growth forest. Without buffers, the clearcut timber harvest allowed under WM-1 could create openings immediately adjacent to old growth forests. These openings could affect microclimate and species composition within the forest due to edge effects. Species of wildlife that have evolved under interior forest conditions tend to be sensitive to the influence of edge effects. Edge, therefore, tends to provide more habitat for generalist species than for forest interior species. Edge habitat also facilitates predation and nest parasitism on interior species. Such edge effects could persist until regrowth in the unit would bring microclimatic conditions to near background levels (i.e., levels within the old growth forest). This time period could be as long as 30 years, the amount of time required for development of closed canopy forest. One purpose of the old growth forest buffer is to ameliorate the edge effects associated with clearcut harvesting so that effects on old growth forest functioning are minimized compared to conditions without the buffer.

A second purpose of old growth forest buffers in WM-1 is to lessen the impact of noise and human activity associated with timber harvesting adjacent to old-growth forests. Without buffers, noise and human activity could disturb species utilizing the forest. This effect would likely be most pronounced for nesting birds such as northern goshawks (undetected nests only) and olive-sided flycatchers.

No new old growth forest would develop naturally over the 50-year life of the No Action Alternative, WM-1 (see Table 4.3-2). Short-term and long-term gains in the quantity of mature and late successional forest habitats would be expected under WM-1 as a result of natural maturation of second-growth forests (Table 4.3-2). Most of this would take place within the Reserve (e.g., CHU and aquatic buffers). Because no precommercial, commercial, restoration, or ecological thinning would take place under this alternative, there would be no acceleration of the development of late successional or old

growth characteristics in second-growth forests (as would take place in WM-2 through WM-5).

Proposed HCP Alternative for Watershed Management (WM-2)

WM-2 would protect all existing old growth forest, an old growth forest buffer, and additional acres of second growth forest with late successional or old growth characteristics in a Reserve which would be expected to immediately protect all species in the old growth forest community. No new old growth forest would develop naturally over the 50-year life of the Proposed HCP Alternative, WM-2. Gains in the quantity of mature and late successional forest habitats resulting from natural maturation of second-growth forests would be expected to be greater under WM-2 than under WM-1, but less than under the other three alternatives. Under WM-2, management actions designed to accelerate development of late successional or old growth characteristics in second-growth forests would be expected to be produce greater benefits than WM-1, WM-4, and WM-5, but fewer benefits than WM-3.

As in WM-1, WM-2 would protect all 13,889 acres of existing old growth forest, a 200-foot old growth forest buffer, and approximately 2,592 acres of second growth with late successional characteristics (primarily in the Taylor Creek subbasin, Williams Creek subbasin, and near the overflow dike on Chester Morse Lake) in the Reserve. WM-2 would protect additional acreage of second-growth forest with late successional characteristics (see Resource Map 16). Thus, all species in the old growth forest community would receive immediate protection under this alternative.

As in WM-1, the old growth forest buffers in WM-2 are intended to provide additional protection to old growth forest by reducing edge effects associated with the boundary between old growth forest and earlier-seral habitats created by retention timber harvesting. Edge effects are likely to be less pronounced in WM-2 than in WM-1, because retention timber harvest methods are used in WM-2 (versus clearcut harvest in WM-1). Buffers would also lessen the impact of noise and human activity associated with retention timber harvesting and commercial thinning (scheduled for decade one and decade four under WM-2) in the vicinity of old growth forests.

No new old growth forest would develop naturally over the 50-year life of the Proposed HCP Alternative, WM-2 (Table 4.3-2). Gains in the quantity of mature and late successional forest habitats resulting from natural maturation of second-growth forests would be greater in the short term and long term under WM-2 than under WM-1, because considerably fewer acres would be harvested each year by retention cut methods under WM-2 (Table 4.3-2). This is especially reflected in the quantity of mature and late successional forest habitat outside the Reserve.

Additional short-term and long-term benefits would accrue under WM-2 as a result of management actions designed to accelerate the development of late successional and old growth characteristics in second-growth forests both within and outside the Reserve (WM-1 does not include these management actions). These management actions include ecological thinning and restoration thinning within the Reserve and precommercial and commercial thinning outside the Reserve. Thinning techniques would be applied in a manner intended to enhance biodiversity, based upon the conceptual foundation and management recommendations of Carey (1994) and Carey et al. (1995).

The Applicant expects that about 4,000 acres would be treated by restoration thinning, all within the first 16 years of the Proposed HCP Alternative. In addition, the Applicant expects that about 2,000 acres would be treated by ecological thinning, about half of which would be treated within the first 16 years of the Proposed HCP Alternative. Restoration thinning will be done in upland areas when needed in young second-growth stands, while ecological thinning will be done in upland areas where needed in selected older second-growth stands.

Management action would be especially valuable along the upper mainstem and North and South Forks of the Cedar River in the CHU. There, ecological thinning and restoration thinning in second-growth forests could hasten the development of late successional and old growth characteristics, thereby effectively connecting all extant patches of old growth forest in the CHU within the lifetime of the Proposed HCP Alternative.

Approximately 3,690 acres would be commercially thinned in the first decade of the Proposed HCP Alternative, and approximately 5,880 acres in the fourth decade. Restoration thinning, ecological thinning, precommercial thinning and commercial thinning would also be valuable for wildlife habitat in the extremely dense, second-growth forest stands in the lower two-thirds of the Rex River drainage and lower Boulder Creek.

Long-term Sustainable Thinning Alternative (WM-3)

WM-3 would protect all existing old growth forest, an old growth forest buffer, and additional acres of second growth forest with late successional or old growth characteristics in a Reserve which would be expected to immediately protect all species in the old growth forest community. No new old growth forest would develop naturally over the 50-year timeline under Alternative WM-3. Gains in the quantity of mature and late successional forest habitats resulting from maturation of second-growth forests would be expected to be greater under WM-3 than under WM-1 or WM-2, and the same as in WM-4 and WM-5. Under WM-3, management actions designed to accelerate development of late successional or old growth characteristics in second-growth forests would be expected to be produce greater benefits than WM-1 through WM-5.

As in WM-1 and WM-2, WM-3 would protect all 13,889 acres of existing old growth forest, a 200-foot old growth forest buffer, and approximately 2,592 acres of mature second-growth with late successional characteristics (primarily in the Taylor Creek subbasin, Williams Creek subbasin, and near the overflow dike on Chester Morse Lake) in the Reserve. As in WM-2, WM-3 would protect additional acreage of mature second-growth forest with late successional characteristics. Thus, all species in the old growth forest community would receive immediate protection under WM-3.

Also as in WM-1 and WM-2, the old growth buffers in WM-3 are intended to provide additional protection to old growth forests. However, since no clearcut or retention timber harvesting would be allowed under WM-3, this buffer would serve primarily to limit the amount of noise and human activity associated with commercial thinning within stands in the vicinity of old growth forests.

No new old growth forest would develop naturally over the 50-year timeline under Alternative WM-3 (Table 4.3-2). Gains in the quantity of mature and late successional forest habitats resulting from natural maturation of second-growth forests would be greater in the short term and long term under WM-3 than under either WM-1 or WM-2, because no clearcut or retention timber harvest would be utilized under WM-3 (Table 4.3-2).

As in WM-2, additional short-term and long-term benefits would accrue under WM-3 as a result of management actions designed to accelerate the development of late successional and old growth characteristics in second-growth forests both within and outside the Reserve. These management actions include ecological thinning and restoration thinning within the Reserve and pre-commercial and commercial thinning outside the Reserve. As in WM-2, these thinning techniques would be applied in a manner intended to enhance biodiversity. Ecological thinning and restoration thinning would be especially valuable along the upper mainstem and North and South Forks of the Cedar River within the Reserve.

Approximately 3,480 acres would be commercially thinned in the first decade and approximately 16,180 acres in the fourth decade.

Thinning Alternative with Phased Out Commercial Timber Harvest (WM-4)

WM-4 would protect all existing old growth forest, an old growth forest buffer, and additional acres of second growth forest with late successional or old growth characteristics in a Reserve which would be expected to immediately protect all species in the old growth forest community. No new old growth forest would develop naturally over the 50-year timeline under Alternative WM-4. Gains in the quantity of mature and late- successional forest habitats resulting from natural maturation of second-growth forests would be expected to be greater under WM-4 than under WM-1 or WM-2, and the same as in

WM-3 and WM-5. Under WM-4, management actions designed to accelerate development of late successional or old growth characteristics in second-growth forests would be expected to be produce greater benefits than WM-1, essentially the same benefits as WM-5, but significantly less benefit than WM-2 or WM-3.

As in WM-1 through WM-3, WM-4 would protect all 13,889 acres of existing old growth forest, a 200-foot old growth forest, and approximately 2,592 acres of second growth with late successional characteristics in the Reserve. WM-4 would also protect additional acreage of second-growth forest with late successional characteristics in the Reserve. Thus, all species in the old growth forest community would receive immediate protection under WM-4. WM-4 has the additional provision of adding forest stands to the Reserve after they are thinned. This would result in the entire Watershed being designated as a Reserve by the end of 50 years.

The old growth buffers in WM-4 are intended to provide additional protection to old growth forests. However, since no clearcut or retention timber harvesting would be allowed under WM-4, this buffer would serve primarily to limit the amount of noise and human activity associated with commercial thinning within stands in the vicinity of old growth forests.

No new old growth forest would develop naturally over the 50-year timeline under WM-4 (Table 4.3-2). Gains in the quantity of mature and late successional forest habitats resulting from natural maturation of second-growth forests would be expected to be greater in the short term and long term under WM-4 than under WM-1 and WM-2, because no lands would be harvested by clearcut or retention harvest methods under WM-4 (Table 4.3-2). Effects for WM-4 and WM-3 would be the same in this regard.

As in WM-2 and WM-3, additional short-term and long-term benefits would be expected to accrue under WM-4 as a result of management actions designed to accelerate the development of late successional and old growth characteristics in second-growth forests both within and outside the Reserve. These management actions include ecological thinning and restoration thinning within the Reserve and precommercial and commercial thinning outside the Reserve. As in WM-2 and WM-3, these thinning techniques would be applied in a manner intended to enhance biodiversity. This would be especially valuable within the CHU (along the upper mainstem and North and South Forks of the Cedar River).

Although WM-4 would commercially thin considerably more acreage in the first three decades of the alternative (11,380 acres in the first decade and 1,970 acres in the third decade) than either WM-2 or WM-3, its single-entry thinning only provision would be less beneficial to wildlife habitat than the multiple-entry thinning allowed under WM-2 and WM-3.

No Commercial Timber Harvest Alternative (WM-5)

WM-5 would protect all existing old growth forest, an old growth forest buffer, and additional acres of second-growth forest with late successional or old growth characteristics in a Reserve; this would be expected to immediately protect all species in the old growth forest community. No new old growth forest would develop naturally over the 50-year timeline under WM-5. Gains in the quantity of mature and late- successional forest habitats resulting from maturation of second-growth forests would be expected to be greater under WM-5 than under WM-1 or WM-2, and the same as in WM-3 and WM-4. Under WM-5, management actions designed to accelerate development of late successional or old growth characteristics in second-growth forests would be expected to be produce slightly greater benefits than WM-1, less benefits than WM-4, and significantly less benefits than WM-2 and WM-3.

WM-5 would protect all 13,889 acres of existing old growth forest plus all second-growth forest with late successional or old growth characteristics in the Watershed. Since no commercial timber harvest would be allowed under WM-5, the designation of buffers would be unnecessary. As in all other alternatives, all species in the old growth forest community would receive immediate protection under WM-5.

Gains in the quantity of mature and late successional forest habitats resulting from natural maturation of second-growth forests would be greater in the short term and long term under WM-5 than under WM-1 and WM-2, because no lands would be harvested by clearcut or retention harvest methods under WM-5. Effects for WM-5 would be the same as WM-4 and WM-3 in this regard.

As in WM-2 through WM-4, additional short-term and long-term benefits would accrue under WM-5 as a result of management actions (ecological thinning, restoration thinning) designed to accelerate the development of late successional and old growth characteristics in second-growth forests within the Reserve. This would be especially valuable within the CHU (along the upper mainstem and North and South Forks of the Cedar River).

Special Habitats

No Action Alternative for Watershed Management (WM-1)

WM-1 would protect all special habitats in the Reserve, which would be expected to immediately protect all species in the special habitat community. Some new mature and late successional forest habitats would be expected to develop naturally in the vicinity of special habitats under WM-1, but less than in the other four alternatives. Under WM-1, there would be no management actions designed to accelerate development of late successional or old growth characteristics in second-growth forests near special habitats (as would take place in WM-2 through WM-5).

Special habitats protected under WM-1 would include 54 acres of rock outcrops and cliffs, 1,518 acres of talus/felsenmeer, 110 acres of upland grass-forb meadows, 93 acres of upland persistent shrub, and 33 acres of non-forested habitat. As a result, all species in the special habitat community would receive immediate protection under this alternative.

Most special habitats are embedded within other elements of the Reserve. However, during watershed operations near special habitats, variable-width buffers will be created to minimize the effects of those operations. The special habitat buffers in WM-1 are intended to provide additional protection to the special habitats. Without buffers, the clearcut timber harvest allowed under WM-1 could create timber harvest openings near or adjacent to some special habitats such as caves or talus/felsenmeer. These openings could affect microclimatic conditions (e.g., relative humidity, temperature) within the special habitats, thereby affecting their suitability for certain species (e.g., bats in caves). Such effects could persist until regrowth in the unit would bring microclimatic conditions to near background levels. One purpose of the special habitat buffers is to ameliorate the microclimatic effects associated with clearcut harvesting so that the suitability of special habitats is not compromised.

A second purpose of the special habitat buffers in WM-1 is to lessen the impact of noise and human activity associated with timber harvesting adjacent to special habitats. Without buffers, noise and human activity could disturb species utilizing the special habitat. This effect would likely be most pronounced for cliff-nesting birds, and bats which utilize caves for breeding (maternity roosts) and hibernation.

Many species which use special habitats also require other key habitats (aquatic and riparian and old growth forest) nearby. For example, a species that requires talus/felsenmeer might also require old growth forests in close proximity. WM-1 would protect all other existing key habitats in the Watershed. Although no new old growth forest would develop naturally, some new mature and late successional forest habitats would be expected to develop naturally in the vicinity of special habitats under WM-1. Because no commercial, restoration, or ecological thinning would take place under this alternative, there would be no acceleration of the development of late successional or old growth characteristics in second-growth forests near special habitats.

Proposed HCP Alternative for Watershed Management (WM-2)

WM-2 would protect all special habitats in the Reserve, which would be expected to immediately protect all species in the special habitat community. Gains in the quantity of mature and late successional forests in the vicinity of special habitats resulting from natural forest maturation would be expected to be greater under WM-2 than under WM-1, but less than under the other three alternatives. Under WM-2, management actions designed to accelerate

development of late successional or old growth characteristics in second-growth forests near special habitats would be expected to produce greater benefits than WM-1, WM-4, and WM-5, and approximately the same benefit as WM-3.

As in WM-1, WM-2 would immediately protect all special habitats in the Reserve. Buffers during watershed operations would be the same width as in WM-1, thus conferring the same degree of protection to species that utilize special habitats. As in WM-1, all species in the special habitat community would receive immediate protection under this alternative.

WM-2 would also protect all other existing key habitats in the Watershed. No new old growth forest would develop naturally over the 50-year life of the Proposed HCP Alternative, WM-2. Gains in the quantity of mature and late successional forest habitats in the vicinity of special habitats would be greater under WM-2 than under WM-1, because WM-2 calls for less intrusive retention harvesting than the regeneration harvesting under WM-1 and includes management actions designed to enhance late successional and old growth characteristics in second growth forests (WM-1 does not).

Long-term Sustainable Thinning Alternative (WM-3)

WM-3 would protect all special habitats in the Reserve, which would be expected to immediately protect all species in the special habitat community. Gains in the quantity of mature and late successional forest habitats in the vicinity of special habitats resulting from natural forest maturation would be expected to be greater under WM-3 than under WM-1 or WM-2, and the same as in WM-4 and WM-5. Under WM-3, management actions designed to accelerate development of late successional or old growth characteristics in second-growth forests would be expected to produce greater benefits than WM-1, WM-4, and WM-5, and approximately the same benefit as WM-2.

As in WM-1 and WM-2, WM-3 would immediately protect all special habitats in the Reserve. Buffers during watershed operations would be the same width as in WM-1 and WM-2, thus conferring the same degree of protection to species that utilize special habitats. As in WM-1 and WM-2, all species in the special habitat community would receive immediate protection under this alternative.

WM-3 would also protect all other existing key habitats in the Watershed. No new old growth forest would develop naturally over the 50-year timeline under WM-3. Gains in the quantity of mature and late successional forest habitats in the vicinity of special habitats would be greater under WM-3 than under WM-1, because WM-3 calls for no clearcut or retention harvesting and includes management actions designed to enhance late successional and old- growth characteristics in second-growth forests. Gains realized under WM-3 would slightly exceed those realized under WM-2, largely as a result of the more-extensive commercial thinning in WM-3.

Thinning Alternative with Phased Out Commercial Timber Harvest (WM-4)

WM-4 would protect all special habitats in the Reserve, which would be expected to immediately protect all species in the special habitat community. Gains in the quantity of mature and late successional forest habitats in the vicinity of special habitats resulting from natural forest maturation would be expected to be greater under WM-4 than under WM-1 or WM-2, and the same as in WM-3 and WM-5. Under WM-4, management actions designed to accelerate development of late successional or old growth characteristics in second-growth forests near special habitats would be expected to be produce greater benefits than WM-1 and WM-5, but slightly less than WM-2 or WM-3.

As in WM-1 through WM-3, WM-4 would immediately protect all special habitats in the Reserve. Buffers during watershed operations would be the same width as in WM-1 through WM-3, thus conferring the same degree of protection to species that utilize special habitats. All species in the special habitat community would receive immediate protection under this alternative.

WM-4 would also protect all other existing key habitats in the Watershed. No new old growth forest would develop naturally over the 50-year timeline under WM-4. Gains in the quantity of mature and late successional forest habitats in the vicinity of special habitats would be greater under WM-4 than under WM-1, because WM-4 calls for no clearcut or retention harvesting and includes management actions designed to enhance late successional and old growth characteristics in second-growth forests. Gains realized under WM-4 would be slightly less than those realized under WM-2 and WM-3.

No Commercial Timber Harvest Alternative (WM-5)

Under WM-5, the entire Watershed would be placed in an Ecological Reserve, which would be expected to immediately protect all species in the special habitat community. Gains in the quantity of mature and late successional forest in the vicinity of special habitats as a result of natural forest maturation would be expected to be greater under WM-5 than under WM-1 or WM-2, and the same as in WM-3 and WM-4. Under WM-5, management actions designed to accelerate development of late successional or old growth characteristics in second-growth forests near special habitats would be the same as Alternative WM-1, but less than WM-2 through WM-4.

As in WM-1 through WM-4, WM-5 would immediately protect all special habitats in the Reserve. Since no commercial timber harvest would be allowed under WM-5, the designation of buffers would be unnecessary. All species in the special habitat community would receive immediate protection under this alternative.

WM-5 would also protect all other existing key habitats in the Watershed. No new old growth forest would develop naturally over the 50-year timeline under WM-5. Gains in the quantity of mature and late successional forest habitats in

the vicinity of special habitats would be expected to be greater under WM-5 than under WM-1, because WM-5 calls for no commercial timber harvest and includes management actions designed to enhance late successional and old growth characteristics in second-growth forests. Gains realized under WM-5 would be expected to be less than those realized under WM-2 through WM-4, because no commercial thinning would take place under WM-5.

4.5.2 Other Habitats

Other habitats refers to early seral (0 to 29 years), mid seral (30 to 79 years), mature (80 to 119 years) and late successional (120 to 189 years) forests. Some of these other habitats have been discussed in previous sections (second-growth forests in aquatic buffers, second-growth forest with late successional or old growth characteristics), but are mentioned again here for the sake of completeness.

No Action Alternative for Watershed Management (WM-1)

More early seral habitats (grass/forb/shrub and open canopy) and young mid seral habitats would be created through clearcut harvest under WM-1 than the other alternatives, three of which (WM-3, WM-4, and WM-5) do not include clearcut or retention harvesting. As a result, fewer late mid seral forests would develop into mature and late successional forests on non-reserve areas (matrix lands) under WM-1 than under the other four alternatives. In addition, fewer mid seral, mature and late successional forests would be protected in a Reserve under WM-1 than other alternatives. Thus, overall, there would be fewer acres of mature and late successional forests in the short term and long term under WM-1 than the other alternatives.

At Year 0 under WM-1, the Cedar River Municipal Watershed would have 15,610 acres of early seral forest habitat, 54,592 acres of mid seral forest, 1,074 acres of mature forest, and 91 acres of late successional forest habitat (see Section 4.3 and Table 4.3-2). Forests within the Reserve would be allowed to mature naturally under WM-1. Early seral habitats would continue to be created in the short term and long term through commercial clearcut timber harvest on non-reserve areas (matrix lands). Harvest units would retain wildlife Reserve trees, green recruitment trees, and downed logs according to Washington FPA standards. Harvest would be structured to create an uneven stand age distribution across the landscape. WM-1 would create approximately 457 to 623 acres of early seral habitat annually through clearcut harvest methods.

Under this management scenario, the following other habitats would be present at Year 20 and Year 50: (1) early seral forest–19,180 acres at Year 20 and 15,612 acres at Year 50; (2) mid seral forest–31,029 acres at Year 20 and 27,269 acres at Year 50; (3) mature forest–20,961 acres at Year 20, and 18,818 acres at Year 50; and (4) late successional forest–12 acres at Year 20, and 9,483 acres at Year 50 (Table 4.3-2). Wildlife species which utilize early seral

habitats (e.g., western bluebirds) or early seral habitats interspersed with later-seral habitats (e.g., elk and black-tailed deer) would derive short-term and long-term benefits from this management scenario (and benefits would be greater under WM-1 than under any of the other alternatives).

Wildlife species associated with later-seral forest habitats would not be expected to benefit as much in the short term or long term under WM-1 as they would under other alternatives because (1) fewer acres of mature and late successional forest habitats would be expected to develop through natural forest maturation under WM-1 than under the other alternatives (because of ongoing clearcut harvesting), and (2) no management actions designed to accelerate the development of mature, late successional, or old growth characteristics in second-growth forests (i.e., restoration thinning and ecological thinning on Reserve lands and precommercial thinning and commercial thinning on non-reserve areas [matrix lands]) are included in WM-1. Thus, fewer acres of forest would be expected to be in the mature and late successional seral stages under WM-1 than under the other alternatives, and fewer acres would be expected to exhibit mature, late successional, or old growth characteristics under WM-1 than under the other alternatives.

Proposed HCP Alternative for Watershed Management (WM-2)

Fewer early seral habitats (grass/forb/shrub and open canopy) and young mid seral habitats would be created through retention harvest under WM-2 than WM-1. This would still exceed the other alternatives, none of which includes clearcut or retention harvesting. As a result, fewer late mid seral forests would develop into mature and late successional forests on non-reserve areas (matrix lands) under WM-2 than under the other three alternatives (but more than WM-1). More mid seral, mature and late successional forests would be protected in the Reserve under WM-2 than WM-1, the same amount in WM-2 and WM-3, and less in WM-2 than WM-4 and WM-5. Thus, overall, there would be more acres of mature and late successional forests under WM-2 than WM-1, but less under WM-2 than the other three alternatives.

At Year 0 under WM-2, the Cedar River Municipal Watershed would have 15,610 acres of early seral forest habitat, 54,592 acres of mid seral forest, 1,074 acres of mature forest, and 91 acres of late successional forest habitat (see Section 4.3 and Table 4.3-2). Early seral habitats would continue to be created in the short term and long term through retention timber harvest outside the Reserve. Harvest units would retain wildlife Reserve trees, green recruitment trees, and downed logs in excess of WFPA standards (exceeding WM-1). Harvest would be structured to create an uneven stand age distribution across the landscape. WM-2 would create approximately 45 to 242 acres of early seral habitat annually through retention timber harvest methods. On average, 162 acres would be harvested annually under WM-2, resulting in a total harvest of 8,100 acres over the 50-year lifetime of the HCP.

This is approximately nine percent of the entire Watershed or 25 percent of the land base available for timber harvest.

Under this management scenario, the following other habitats would be present at Year 20 and Year 50: (1) early seral forest–8,518 acres at Year 20 and 5,528 acres at Year 50; (2) mid seral forest–33,458 acres at Year 20 and 19,706 acres at Year 50; (3) mature forest–29,112 acres at Year 20 and 30,664 acres at Year 50; and (4) late successional forest–94 acres at Year 20, and 15,284 acres at Year 50 (Table 4.3-2). Wildlife species which utilize early seral habitats (e.g., western bluebirds) or early seral habitats mixed with later-seral habitats (e.g., elk and black-tailed deer) would derive short-term and long-term benefits from this management scenario. Benefits would be less under WM-2 than under WM-1, but greater under WM-2 than under WM-3 through WM-5.

Wildlife species associated with later-seral forest habitats would be expected to derive more short-term and long-term benefits under WM-2 than under WM-1, but less under WM-2 than WM-3. The relative benefits of WM-2 versus WM-4 and WM-5 would depend upon the species under consideration and the location within the Watershed. More acres of forest would be in mature and late successional seral stages under WM-2 than under WM-1, but fewer in WM-2 than WM-3 through WM-5 (Table 4.3-2). However, WM-2 would be expected to have more acres exhibiting late successional or old growth characteristics than all alternatives except WM-3.

Long-term Sustainable Thinning Alternative (WM-3)

No new early seral habitats (grass/forb/shrub and open canopy) and young mid seral habitats would be created through clearcut or retention harvest under WM-3. As a result, more late mid seral forests would develop into mature and late successional forests on non-reserve areas (matrix lands) under WM-3 than under WM-1 or WM-2 (but the same amount as in WM-4 and WM-5). The same amount of mid seral, mature and late successional forests would be protected in the Reserve under WM-3 as in WM-2 (more than WM-1, but less than WM-4 and WM-5). Thus, overall, there would be more acres of mature and late successional forests under WM-3 than under WM-1 and WM-2 (and the same amount as in WM-4 and WM-5).

At Year 0 under WM-3, the Cedar River Municipal Watershed would have 15,610 acres of early seral forest habitat, 54,592 acres of mid seral forest, 1,074 acres of mature forest, and 91 acres of late successional forest habitat (see Section 4.3 and Table 4.3-2). No new early seral habitats would be created under WM-3. Under this management scenario, the following other habitats would be present at Year 20 and Year 50: (1) early seral forest–1,249 acres at Year 20 and 0 acres at Year 50; (2) mid seral forest–33,924 acres at Year 20 and 12,558 acres at Year 50; (3) mature forest–35,819 acres at Year 20 and 34,706 acres at Year 50; and (4) late successional forest–190 acres at Year 20, and 23,918 acres at Year 50 (Table 4.3-2). Because no new early

seral habitats are created under WM-3, wildlife species which utilize early seral habitats or early seral habitats mixed with later-seral habitats would be negatively affected by this alternative in the short term and, especially, the long term.

Wildlife species associated with later-seral forest habitats would be expected to derive more short-term and long-term benefits under WM-3 than under all other alternatives. WM-3 would have more forest in mature and late successional seral stages than WM-1 and WM-2, and approximately the same acreage as WM-4 and WM-5 (Table 4.3-2). However, more acres would be expected to exhibit late successional or old growth characteristics under WM-3 than under all other alternatives.

Thinning Alternative with Phased Out Commercial Timber Harvest (WM-4)

No new early seral-habitats (grass/forb/shrub and open canopy) and young mid seral habitats would be created through clearcut or retention harvest under WM-4. As a result, more late mid seral forests would develop into mature and late successional forests on non-reserve areas (matrix lands) under WM-4 than under WM-1 or WM-2 (the same amount as in WM-3 and WM-5). Over the long term, more mid seral, mature and late successional forests would be protected in the Reserve under WM-4 than WM-1 through WM-3 (and less than WM-5). However, overall, there would be same acreage of mature and late successional forests under WM-4 as in WM-3 and WM-5 (and more than in WM-1 and WM-2).

At Year 0 under WM-4, the Cedar River Municipal Watershed would have 15,610 acres of early seral forest habitat, 54,592 acres of mid seral forest, 1,074 acres of mature forest, and 91 acres of late successional habitat (see Section 4.3 and Table 4.3-2). No new early seral habitats would be created under WM-4. Under this management scenario, the following other habitats would be present at Year 20 and Year 50: (1) early seral forest–1,164 acres at Year 20 and 0 acres at Year 50; (2) mid seral forest–34,009 acres at Year 20 and 12,331 acres at Year 50; (3) mature forest–35,819 acres at Year 20 and 34,933 acres at Year 50; and (4) late successional forest–190 acres at Year 20, and 23,918 acres at Year 50 (Table 4.3-2). Because no new early seral habitats are created under WM-4, wildlife species which utilize early seral habitats or early seral habitats mixed with later-seral habitats would be negatively affected by this alternative in the short term and, especially, the long term.

Wildlife species associated with later-seral forest habitats would be expected to derive more short-term and long-term benefits under WM-4 than under WM-1, but less under WM-4 than WM-3. The relative benefits of WM-4 versus WM-2 and WM-5 would depend upon the species under consideration and the location within the Watershed. WM-4 would be expected to have approximately the same acreages of forest in mature and late successional seral stages as WM-3 and WM-5, and considerably more than WM-1 and WM-2

(Table 4.3-2). However, WM-4 would be expected to have fewer acres exhibiting late successional or old growth characteristics than WM-2 and WM-3, but slightly more than WM-5.

No Commercial Timber Harvest (WM-5)

No new early seral habitats (grass/forb/shrub and open canopy) and young mid seral habitats would be created through clearcut or retention harvest under WM-5. All mid seral, mature and late successional forests would be protected in the Reserve under WM-5; this amount is more than in WM-1 through WM-4. However, overall, there would be same acreage of mid seral, mature and late successional forests under WM-5 as in WM-3 and WM-4 (and more than in WM-1 and WM-2).

At Year 0 under WM-5, the Cedar River Municipal Watershed would have 15,610 acres of early seral forest habitat, 54,592 acres of mid seral forest, 1,074 acres of mature forest, and 91 acres of late successional forest habitat (see Section 4.3 and Table 4.3-2). No new early seral habitats would be created under WM-5. Under this management scenario, the following other habitats would be present at Year 20 and Year 50: (1) early seral forest–1,164 acres at Year 20 and 0 acres at Year 50; (2) mid seral forest–34,009 acres at Year 20 and 12,331 acres at Year 50; (3) mature forest–35,819 acres at Year 20 and 34,933 acres at Year 50; and (4) late successional forest–190 acres at Year 20, and 23,918 acres at Year 50 (Table 4.3-2). Because no new early seral habitats are created under WM-5, wildlife species which utilize early seral habitats or early seral habitats mixed with later-seral habitats would be negatively affected by this alternative in the short term and, especially, the long term. Negative effects would be the same as in WM-4, and slightly greater than in WM-3.

Wildlife species associated with later-seral forest habitats would be expected to derive more short-term and long-term benefits under WM-5 than under WM-1, but less under WM-5 than WM-3. The relative benefits of WM-5 versus WM-2 and WM-4 would depend upon the species under consideration and the location within the Watershed. WM-5 would be expected to have approximately the same acreages of forest in mature and late successional seral stages as WM-3 and WM-4, and considerably more than WM-1 and WM-2 (Table 4.3-2). However, WM-5 would be expected to have fewer acres exhibiting late successional or old growth characteristics than WM-2 and WM-3, and slightly less than WM-4.

4.5.3 Habitat Fragmentation and Connectivity

Within the Cedar River Municipal Watershed

No Action Alternative for Watershed Management (WM-1)

Under WM-1, virtually all elements of the 51,657-acre Reserve (i.e., aquatic and riparian habitats, old growth forests, second-growth forests with late successional characteristics, and special habitats) would be directly connected with one another, primarily by aquatic and riparian corridors (Resource Map 13). Only a few wetlands would be completely isolated from other elements. Thus, the Reserve would be more or less continuous from the east end of the Watershed to the west end (especially along the Cedar River), and from the northern boundary to the southern boundary in a number of places (especially within the CHU at the east end of the Watershed). The Reserve would be a continuous block at the east end of the Watershed, but would resemble a branching network of veins in the center and west end of the Watershed. The Reserve would be quite narrow in some places (e.g., along the Cedar River in the lower municipal watershed), and would have considerable edge (edge = the ratio of perimeter to area).

Natural maturation of second-growth forests would slightly improve forest connectivity (especially connectivity of mature, late successional, and old growth forests) over the life of this alternative. Much of this would occur within the CHU, where 30 to 50 year-old mid seral forests would mature into 80 to 100 year-old mature forests, thereby helping connect the four largest patches of old growth forest in the CHU (a patch west of Meadow Mountain, a large patch south of Mt. Baldy and Tinkham Peak, a patch around Goat Mountain, and a patch around Findley Lake). Additional connectivity would also be realized in Reserve elements in the Rex River subbasin.

Road decommissioning included in WM-1 would further improve forest connectivity.

Proposed HCP Alternative for Watershed Management (WM-2)

Under WM-2, as in WM-1, virtually all elements of the Reserve would be directly connected with one another. However, the 56,223-acre Ecological Reserve created by WM-2 would be 4,566 acres larger than the Reserve in WM-1 (Resource Map 15). The additional lands would improve the connectivity of Reserve elements in several areas: (1) north of the Cedar River and Chester Morse Lake in the area from approximately Mt. Gardner to Green Point Creek; (2) on the south boundary of the Watershed between Marmot Peak and the headwaters of Boulder Creek; and (3) in the area connecting old growth forests in the headwaters of Taylor Creek (North and Middle Forks) with old growth forests between Shotgun and Rack Creeks; and (4) in the Williams and Rock Creek areas. As in WM-1, the Reserve would be more or less continuous from the east end of the Watershed to the west end, and from

the north boundary to the south in several places (principally at the east end of the Watershed). The Reserve in WM-2 would have less edge than WM-1.

Natural maturation of second-growth forests would improve forest connectivity (especially connectivity of mature, late successional, and old growth forests) to a greater degree under WM-2 than WM-1, especially in non-reserve areas due to the lower level of retention harvest in WM-2. In addition, WM-2 includes management actions (restoration thinning, ecological thinning, precommercial thinning, commercial thinning) designed to facilitate the development of mature, late successional, and old growth forest characteristics in second- growth forests, both within and outside the Reserve. These management actions would result in greater increases in the connectivity of mature, late successional, and old growth forest habitats over WM-1. For example, ecological thinning and restoration thinning in second-growth forests in the CHU could hasten the development of late successional and old growth characteristics in those forests, thereby effectively connecting all extant patches of old growth forest in the CHU within the lifetime of the Proposed HCP Alternative. Under WM-1, the second-growth forests would still be in the mature stage.

WM-2 calls for more roads to be decommissioned than under WM-1. This would result in greater connectivity among habitat patches, especially in the long term.

Long-term Sustainable Thinning Alternative (WM-3)

The Reserve in WM-3 is the same as in WM-2 (56,223 acres), so gains in connectivity over WM-1 would be the same as in WM-2 (Resource Map 18).

Natural maturation of second-growth forests would improve forest connectivity (especially mature, late successional, and old growth forests) more under WM-3 than either WM-1 or WM-2, because no clearcut or retention harvesting is included in WM-3. In addition, WM-3 includes management actions similar to those in WM-2 (restoration thinning, ecological thinning, precommercial thinning, multiple-entry commercial thinning), so increases in connectivity resulting from these management actions would be similar between WM-3 and WM-2.

WM-3 calls for essentially the same level of road decommissioning as in WM-2, so gains in connectivity resulting from this would be the same for these alternatives.

Thinning Alternative with Phased Out Commercial Timber Harvest (WM-4)

The initial size of the Reserve in WM-4 (60,019 acres) is 3,796 acres larger than in WM-2 and WM-3, with most gains being realized in the Walsh Lake and Rock Creek areas (Resource Map 20). Thus, connectivity of Reserve

elements is greater in WM-4 than in the first three alternatives. Connectivity of elements would increase over the short term and long term under WM-4 as lands are added to the Reserve after thinning.

Natural maturation of second-growth forests would improve forest connectivity (especially mature, late successional and old growth forests) more under WM-4 than either WM-1 or WM-2, and the same as in WM-3, because no clearcut or retention harvesting is included in WM-4. Since WM-4 includes management actions similar to those in WM-2 and WM-3 (restoration thinning, ecological thinning, precommercial thinning, commercial thinning), increases in connectivity resulting from management action would occur (slightly less in WM-4 than the other two).

Finally, WM-4 calls for essentially the same level of road decommissioning as in WM-2 and WM-3, so gains in connectivity resulting from this would be the same for these alternatives.

No Commercial Timber Harvest Alternative (WM-5)

The Reserve in WM-5 includes nearly 100 percent of the Watershed (Resource Map 22). Thus, connectivity of Reserve elements is greatest in WM-5. Natural maturation of second-growth forests would improve connectivity more under WM-5 than either WM-1 or WM-2, and the same as in WM-3 and WM-4, because no clearcut or retention harvesting is included in WM-5. Since WM-5 includes some management actions similar to those in WM-2 and WM-3 (restoration thinning, ecological thinning, precommercial), some increases in connectivity resulting from management action would occur (slightly less in WM-5 than WM-4)

Finally, WM-5 calls for essentially the same level of road decommissioning as in WM-2, WM-3, and WM-4, so gains in connectivity resulting from this would be the same for these alternatives.

Regional Connectivity

All five alternatives protect all key habitats and habitat buffers in a Reserve that would be more or less continuous from the west end of the Watershed to the east end and from the northern boundary to the southern boundary in several locations. Thus, all five alternatives would have an immediate positive effect on the maintenance of regional habitat connectivity, although the other four alternatives would result in progressively greater connectivity of Reserve elements within the Watershed. The following regional linkages would be established under all five alternatives: (1) the CHU at the east end of the Watershed would directly link the Reserve with a Forest Service LSR centered around Humpback Mountain immediately north of the Watershed with the Smay Creek drainage in the Green River Watershed to the south; (2) the Rattlesnake Lake viewshed would connect the Reserve to Washington DNR lands on Rattlesnake Mountain to the north; and (3) riparian and old- growth

areas along upper Webster Creek link the Reserve with Washington DNR lands to the northwest. Alternatives WM-2 through WM-5 would establish progressively greater connection between Reserve elements and state or federal lands outside the Watershed.

Regional habitat connectivity would be enhanced in the short term and long term by natural maturation of forests and by management actions designed to produce more key habitat (especially riparian habitats and mature, late successional and old growth forests), increase habitat connectivity, and decrease habitat fragmentation within the Watershed. Two management actions are important in this regard: (1) timber harvest management to produce mature, late successional, and old growth forest characteristics in second-growth forests, especially within riparian areas and between existing patches of old growth forest; and (2) road decommissioning. Alternatives WM-2 and WM-3 would be most beneficial in this regard, followed by WM-4, then WM-5 and WM-1.

4.5.4 Species with Individual Conservation Strategies

This section discusses the environmental consequences of the alternatives on species with individual conservation strategies.

Northern Spotted Owl

The Reserve established under all five alternatives would be expected to give immediate protection to the northern spotted owl population in the Watershed, as would adherence to Washington FPA rules required under all alternatives. No direct injury or death of any spotted owl would be expected under any alternative. The likelihood of disturbance to any actively nesting spotted owl pairs due to timber harvest management would be expected to be low in all alternatives. However, any such disturbance would constitute “take” under the ESA. WM-1 would be expected to have the highest probability of take (because it has the highest level of timber harvesting among the alternatives) while WM-5 would be expected to have the lowest (because no commercial timber harvest is included in this alternative). No net loss of suitable spotted owl nesting habitat would be expected over the 50-year time period under any alternative. Alternatives WM-2, WM-3, WM-4 and WM-5 would be expected to result in greater short-term and long-term benefits to northern spotted owls than WM-1, through: (1) natural maturation of second-growth forests into mature and late successional seral stages; (2) management actions designed to accelerate the development of mature, late successional, and old growth characteristics in second-growth forests; (3) road decommissioning; and (4) research and monitoring. The relative order of alternatives in relation to their overall benefit for northern spotted owls may be debatable, but it appears that WM-3 would have the most benefits in the short term and long term, followed by WM-4, then WM-5, and finally, WM-2.

The northern spotted owl is known to occur in the Cedar River Municipal Watershed. Its key habitats in the Watershed are mature, late successional and old growth forests. The eastern end of the Watershed is part of a federally designated CHU and a state-designated spotted owl special emphasis areas (SOSEA) for the spotted owl. Because all five alternatives include all old growth forest, the old growth forest buffer, and the entire CHU in a Reserve, all five alternatives would be expected to give immediate protection to the northern spotted owl population in the Watershed. The CHU would be especially important because it has the largest remaining patches of old growth forest in the Watershed, has some of the lowest road densities in the Watershed, and is where most spotted owl detections have occurred in recent years. Also, because of its proximity to Alpine Lakes Wilderness Area and Forest Service lands designated as LSR, the CHU is the area most likely to be encountered first by spotted owls dispersing from those areas.

Although no new old growth forest would develop naturally over the 50-year timeframe under any of the five alternatives, changes in the quantity of mature and late successional forest seral stages would be expected under all alternatives as a result of natural maturation of second-growth forests (gains) and clearcut or retention timber harvesting (losses). Expected short-term and long-term gains in the quantity of mature and late successional forest seral stages resulting from natural forest maturation would be greater under certain alternatives than under others. In the lower municipal watershed, mature and late successional forests would be expected to increase substantially in the short term and long term under alternatives WM-3, WM-4, and WM-5. Expected increases would be considerably less under WM-2, because of retention timber harvesting in the Taylor Creek, Lower Cedar River, and Walsh Ditch subbasins. Expected increases would be even less under WM-1 (with an actual slight decrease in the Walsh Ditch subbasin) because of the more-extensive clearcut harvesting in this alternative. In the upper municipal watershed, mature and late successional forests would be expected to increase substantially in the short term and long term under alternatives WM-3, WM-4, and WM-5. While WM-2 would also have substantial gains, they would be expected to be slightly lower than WM-3 through WM-5 because of some limited retention timber harvesting in the Chester Morse Lake subbasin. WM-1 would be expected to have the least gains because of clearcut timber harvesting in the Chester Morse Lake, Rex River, and Upper Cedar River subbasins.

Not all of the mature, late successional, or old growth forest in the Watershed would be expected to be of equal value in providing nesting, roosting, foraging, and dispersal (N/R/F/D) habitat for northern spotted owls in the short term or long term under the five alternatives. Forest characteristics (e.g., species composition canopy closure, number of canopy layers, average tree diameter) not only vary naturally as a result of different site conditions and elevation, but also vary as a result of past harvest practices and recent management regimes. The northern spotted owl population in the Watershed

would be expected to derive greater short-term and long-term benefits from alternatives that include management actions intended to produce second-growth forests with the "old forest habitat" characteristics needed by owls for N/R/F/D (as defined in WAC 222-16-085(1)) or "sub-mature habitat" characteristics needed by owls for roosting, foraging, and dispersal (R/F/D) (as defined in WAC 222-16-085(1)). Two management actions are important in this regard: (1) use of timber harvest techniques (ecological thinning, restoration thinning, pre-commercial thinning, commercial thinning) designed to accelerate the development of mature, successional, and old growth characteristics in second-growth forests; and (2) road decommissioning (which has the additional benefit of reducing human disturbance in an area).

All of the alternatives except for the No Action Alternative, WM-1, call for ecological thinning and restoration thinning within the Reserve. This would be especially beneficial to spotted owls within the CHU (along the upper mainstem and North and South Forks of the Cedar River) and in the extremely dense, second-growth forest stands in the lower two-thirds of the Rex River drainage and lower Boulder Creek. Ecological thinning and restoration thinning in second-growth forests in the CHU could hasten the development of late successional and old growth characteristics in those forests, thereby effectively connecting all extant patches of old growth forest during the 50 year time period. In addition, alternatives WM-2, WM-3, and WM-4 include precommercial and commercial thinning in non-reserve areas. These management actions would be expected to have additional benefits for spotted owls by hastening the development of late successional or old growth characteristics in second-growth forests in non-reserve areas.

While all alternatives call for road decommissioning, alternatives WM-2, WM-3, WM-4, and WM-5 would decommission more roads than WM-1, thereby having more benefits for spotted owls. Road decommissioning in the upper municipal watershed would be especially important for three reasons: (1) most owl detections in recent years have occurred in the upper municipal watershed; (2) the amount of existing old growth forest occurs in the upper municipal watershed; and (3) the greatest opportunity to increase the connectivity of key habitats through selective road decommissioning also occurs in the upper municipal watershed.

Considering only the two alternatives which allow for the clearcut or retention harvest of timber (WM-1 and WM-2), WM-2 would be more favorable for northern spotted owls in the very long term because its management prescriptions (harvest unit size and tree retention rates) would tend to preserve more "biological legacy" trees than WM-1.

Marbled Murrelet

The Reserve established under all five alternatives would be expected to give immediate protection to the marbled murrelet population in the Watershed, as would adherence to Washington FPA rules required under all alternatives. No

direct injury or death of any marbled murrelet would be expected under any alternative. The likelihood of disturbance to any actively nesting marbled murrelet pairs due to timber harvest management would be expected to be low in alternatives. However, any such disturbance would constitute take under the ESA. WM-1 would be expected to have the highest probability of take, while WM-5 would be expected to have the lowest. No net loss of suitable marbled murrelet nesting habitat would be expected over the 50-year time period under any alternative. Alternatives WM-2, WM-3, WM-4, and WM-5 would be expected to result in greater short-term and long-term benefits to marbled murrelets than WM-1, through: (1) natural maturation of second-growth forests into mature and late successional seral stages; (2) management actions designed to accelerate the development of mature, late successional, and old growth characteristics in second-growth forests; (3) road decommissioning; and (4) research and monitoring. The relative order of alternatives in relation to their overall benefit for marbled murrelets may be debatable, but it appears that WM-3 would have the most benefits in the short term and long term, followed by WM-4, then WM-5, and finally, WM-2.

The marbled murrelet has been detected once in the Cedar River Municipal Watershed in recent years. The species utilizes mature, late successional and old growth forests as key habitats; the species is known to nest up to 40 miles inland from marine waters. Because all five alternatives protect all old growth forests and an old growth forest buffer in a Reserve, all five alternatives would be expected to give immediate protection to the marbled murrelet population in the Watershed. Especially important in this regard would be Reserve elements in the lower municipal watershed, because the lower municipal watershed is lower in elevation, has vegetation types more suitable to marbled murrelets (e.g., Douglas-fir and western hemlock) and considerably closer to marine waters (and, therefore, to sources of potential colonizing murrelets) than the upper municipal watershed.

Although no new old growth forest would develop naturally over the 50 years under any of the five alternatives, changes in the quantity of mature and late successional forest seral stages would be expected under all alternatives as a result of natural maturation of second-growth forests (gains) and clearcut or retention timber harvesting (losses). Expected short-term and long-term gains in the quantity of mature and late successional forest seral stages resulting from natural forest maturation would be greater under certain alternatives than under others. In the lower municipal watershed, mature and late successional forests would be expected to increase substantially in the short term and long term under alternatives WM-3, WM-4, and WM-5. Expected increases would be considerably less under WM-2 because of retention timber harvesting in the Taylor Creek, Lower Cedar River, and Walsh Ditch subbasins. Expected increases would be even less under WM-1 (with an actual slight decrease in the Walsh Ditch subbasin) because of the more extensive clearcut harvesting in this alternative. In the upper municipal watershed, mature and late successional forests would be expected to increase substantially in the short

term and long term under alternatives WM-3, WM-4, and WM-5. While WM-2 would also have substantial gains, they would be expected to be slightly lower than WM-3 through WM-5 because of some limited retention timber harvesting in the Chester Morse Lake subbasin. WM-1 would be expected to have the least gains, because of clearcut timber harvesting in the Chester Morse Lake, Rex River, and Upper Cedar River subbasins.

Not all of the mature, late successional, or old growth forest in the Watershed would be expected to be of equal value in providing suitable habitat for marbled murrelets in the short term or long term under the five alternatives. Forest characteristics (e.g., species composition canopy closure, number of canopy layers, average tree diameter) not only vary naturally as a result of different site conditions and elevation, but also vary as a result of past harvest practices and recent management regimes. The marbled murrelet population in the Watershed would be expected to derive greater short-term and long-term benefits from alternatives that include management actions intended to produce second-growth forests with the characteristics needed by marbled murrelets for nesting (as defined in WAC 222-16-010). Two management actions are important in this regard: (1) use of timber harvest techniques (ecological thinning, restoration thinning, pre-commercial thinning, commercial thinning) designed to accelerate the development of mature, late successional, and old growth characteristics in second-growth forests; and (2) road decommissioning (which has the additional benefit of reducing human disturbance in an area). All of the alternatives except for the No Action Alternative, WM-1, call for ecological thinning and restoration thinning within the Reserve. This would be especially beneficial to marbled murrelets in areas of the lower municipal watershed where dense stands of second-growth forest are included in the Reserve. In addition, alternatives WM-2, WM-3, and WM-4 include pre-commercial and commercial thinning in non-reserve areas. These management actions would be expected to have additional benefits for marbled murrelets by hastening the development of late successional or old growth characteristics in second-growth forests in non-reserve areas.

Considering only the two alternatives which allow for the clearcut or retention harvest of timber (WM-1 and WM-2), WM-2 would be more favorable for marbled murrelets in the very long term because its management prescriptions (harvest unit size and tree retention rates) would tend to preserve more biological legacy trees than WM-1.

Northern Goshawk

Effects of the alternatives on northern goshawks are anticipated to be very similar to those for northern spotted owls. Thus, much of the discussion in this subsection is essentially the same as discussion in the northern spotted owl subsection. The Reserve established under all five alternatives would be expected to give immediate protection to the northern goshawk population in the Watershed, as would adherence to Washington FPA rules required under

all alternatives. No direct injury or death of any northern goshawk would be expected under any alternative. The likelihood of disturbance to any actively nesting goshawk pairs would be expected to be low in alternatives. WM-1 would be expected to have the highest probability of disturbance, while WM-5 would be expected to have the lowest. No net loss of suitable northern goshawk nesting habitat would be expected over the 50 years under any alternative. These alternatives would be expected to result in greater short-term and long-term benefits to northern goshawks than WM-1, through: (1) natural maturation of second-growth forests into mature and late successional seral stages; (2) management actions designed to accelerate the development of mature, late successional, and old growth characteristics in second-growth forests; (3) road decommissioning; and (4) research and monitoring. The relative order of alternatives in relation to their overall benefit for northern goshawks may be debatable, but it appears that WM-3 would have the most benefits in the short term and long term, followed by WM-4, then WM-5, and finally, WM-2.

The northern goshawk is known to occur in the Cedar River Municipal Watershed (one nesting territory has been documented in the CHU). Its key habitats in the Watershed are mature, late successional and old growth forests. Because all five alternatives include all old growth forest, the old growth forest buffer, and the entire CHU in a Reserve, all five alternatives would be expected to give immediate protection to the northern goshawk population in the Watershed. Especially important in this regard would be the CHU in the eastern end of the Watershed, because it has the largest remaining patches of old growth forest in the Watershed, has some of the lowest road densities in the Watershed, and is where the northern goshawk nesting territory was detected. Also, the eastern end of the Watershed is the area most likely to be encountered first by northern goshawks dispersing from the Alpine Lakes Wilderness Area or Forest Service lands designated as LSR (immediately northeast of the Watershed).

Although no new old growth forest would develop naturally over the 50 years under any of the five alternatives, changes in the quantity of mature and late successional forest seral stages would be expected under all alternatives as a result of natural maturation of second-growth forests (gains) and clearcut or retention timber harvesting (losses). Expected short-term and long-term gains in the quantity of mature and late successional forest seral stages resulting from natural forest maturation would be greater under certain alternatives than under others. In the lower municipal watershed, mature and late successional forests would be expected to increase substantially in the short term and long term under alternatives WM-3, WM-4, and WM-5. Expected increases would be considerably less under WM-2 because of retention timber harvesting in the Taylor Creek, Lower Cedar River, and Walsh Ditch subbasins. Expected increases would be even less under WM-1 (with an actual slight decrease in the Walsh Ditch subbasin) because of the more extensive clearcut harvesting in this alternative. In the upper municipal watershed, mature and late

successional forests would be expected to increase substantially in the short term and long term under alternatives WM-3, WM-4, and WM-5. While WM-2 would also have substantial gains, they would be expected to be slightly lower than WM-3 through WM-5 because of some limited retention timber harvesting in the Chester Morse Lake subbasin. WM-1 would be expected to have the least gains, because of clearcut timber harvesting in the Chester Morse Lake, Rex River, and Upper Cedar River subbasins.

Not all of the mature, late successional, or old growth forest in the Watershed would be expected to be of equal value in providing suitable nesting and foraging habitat for northern goshawks in the short term or long term under the five alternatives. Forest characteristics (e.g., species composition canopy closure, number of canopy layers, average tree diameter) not only vary naturally as a result of different site conditions and elevation, but also vary as a result of past harvest practices and recent management regimes. The northern goshawk population in the Watershed would be expected to derive greater short-term and long-term benefits from alternatives that include management actions intended to produce second-growth forests with the late successional or old growth forest characteristics. Two management actions are important in this regard: (1) use of timber harvest techniques (ecological thinning, restoration thinning, pre-commercial thinning, commercial thinning) designed to accelerate the development of mature, late successional, and old growth characteristics in second-growth forests; and (2) road decommissioning (which has the additional benefit of reducing human disturbance in an area).

All of the alternatives except for the No Action Alternative, WM-1, call for ecological thinning and restoration thinning within the Reserve. This would be especially beneficial to northern goshawks within the CHU (along the upper mainstem and North and South Forks of the Cedar River) and in the extremely dense, second-growth forest stands in the lower two-thirds of the Rex River drainage and lower Boulder Creek. Ecological thinning and restoration thinning in second-growth forests in the CHU could hasten the development of late successional and old growth characteristics in those forests, thereby effectively connecting all extant patches of old growth forest within 50 years. In addition, alternatives WM-2, WM-3, and WM-4 include pre-commercial and commercial thinning in non-reserve areas. These management actions would be expected to have additional benefits for northern goshawks by hastening the development of late successional or old growth characteristics in second-growth forests in non-reserve areas.

Since recent studies have shown northern goshawks to be sensitive to human disturbance, alternatives which lead to a reduction in human disturbance would have an additional positive effect on goshawks. Particularly important in this regard are road densities and road usage. While all alternatives call for road decommissioning, the alternatives WM-2, WM-3, WM-4, and WM-5 would decommission more roads than WM-1, thereby having more positive effects for goshawks. Road decommissioning in the upper municipal watershed

(within the CHU) would be especially important because goshawks have been documented there. Reductions in human disturbance could also be accomplished by decreases in road usage. Alternatives which reduce or eliminate timber harvest would tend to decrease road usage, hereby reducing human disturbance. In this regard, WM-5 would have the greatest positive effect, followed by WM-4, then WM-3 and WM-2, with WM-1 having the least positive effect.

Common Loon

Because all five alternatives establish buffers around all ponds, lakes, and reservoirs, all five alternatives would give immediate protection to the common loon population in the Watershed. The relatively lower level of noise and human disturbance associated with WM-5 and WM-4 would also benefit nesting common loons in the Watershed.

Additional short-term and long-term benefits would accrue to the common loon through natural maturation of second-growth forests in the buffers around open water bodies and wetlands, and the human-assisted restoration of riparian areas. These benefits would be slightly greater under alternatives WM-2, WM-3, WM-4, and WM-5, because they include management actions to help restore aquatic and riparian areas and WM-1 does not.

For information on the potential effects of reservoir operations on common loon nesting, see Section 4.5.6.

Gray Wolf

The Reserve established under all five alternatives would be expected to give immediate protection to whatever gray wolves presently utilize the Watershed, as would strict adherence to Washington FPA rules required under all alternatives. No direct injury or death of any gray wolf would be expected under any alternative. The likelihood of disturbance to any denning gray wolf (itself a low-probability event) would be expected to be low in all alternatives. Any such disturbance would be considered take under the ESA. WM-1 would be expected to have the highest probability of take (because it has the highest level of timber harvesting among the alternatives) while WM-5 would be expected to have the lowest (because no commercial timber harvest is included in this alternative). The alternatives WM-2, WM-3, WM-4, and WM-5 would be expected to result in greater short-term and long- term benefits to gray wolves than WM-1, through: (1) natural maturation of second-growth forests into mature and late successional seral stages, especially in riparian areas; (2) management actions designed to accelerate the development of mature, late successional, and old growth characteristics in second-growth forests; (3) road decommissioning and lower timber harvest levels, resulting in a reduction in human disturbance; and (4) research and monitoring. The relative order of alternatives in relation to their overall benefit to gray wolves may be debatable,

but it appears that WM-2 would have the most benefits in the short term and long term, followed by WM-3, then WM-4, and finally, WM-5.

Gray wolves are not known to occur in the Cedar River Municipal Watershed at present, although occasional individuals may use the Watershed as a travel/dispersal corridor. Although the gray wolf utilizes a wide variety of habitat types, its key habitats in the Watershed are meadows, riparian areas, and old growth forests. Because all five alternatives protect all existing meadows, riparian areas, and old growth forests and their buffers in a Reserve, all five alternatives would be expected to give immediate protection to any undocumented resident or transient (including potential colonizers) gray wolves in the Watershed. Especially important in this regard would be the CHU in the eastern end of the Watershed. This is the remotest part of the Watershed and, because of its proximity to Alpine Lakes Wilderness Area, would be the area most likely traversed by dispersing/transient wolves or occupied by colonizing wolves.

Alternatives which promote the restoration or development of key habitats would be expected to produce additional positive effects for wolves. Therefore, alternatives which call for habitat restoration in riparian areas (WM-2, WM-3, WM-4, and WM5) would tend to restore more-natural ecosystem functioning in riparian areas more rapidly than those that do not (WM-1), and would thus produce greater benefits for any resident or transient gray wolves in both the short term and long term than would the No Action Alternative. And because gray wolves utilize old growth forests, alternatives which include management actions to promote the development of late successional and old growth characteristics in second-growth forests (WM-3 and WM-2, followed by WM-4) would produce greater benefits than those that include limited management actions (WM-5) or no management actions (WM-1).

Because gray wolves require areas away from human disturbance (especially at higher elevations for denning) alternatives which lead to a reduction in human disturbance would be expected to have an additional benefits for wolves. Particularly important in this regard are road densities and road usage. Areas greater than 0.3-mile from a road are termed “security” or “core” habitat and are considered most important for wolves. While all alternatives call for road decommissioning, the alternatives WM-2, WM-3, WM-4, and WM-5 would decommission more roads than WM-1, thereby having more positive effects for wolves. Road decommissioning in the upper municipal watershed (within the CHU) would be especially important for three reasons – (1) wolves are more likely to occur in the upper municipal watershed, (2) the greatest amount of existing core habitat occurs in the upper municipal watershed, and (3) the greatest opportunity to produce additional core habitat through selective road decommissioning also occurs in the upper municipal watershed.

Reductions in human disturbance could also be accomplished by decreases in road usage. Alternatives which reduce or eliminate timber harvest would tend

to decrease road usage, hereby reducing human disturbance. In this regard, WM-5 would have the greatest benefit, followed by WM-4, then WM-3 and WM-2, with WM-1 having the least benefit.

Finally, because gray wolves require adequate populations of their main prey species, elk and black-tailed deer, alternatives which maintain healthy populations of these species would be expected to benefit wolves. Healthy elk and black-tailed deer populations require a mix of open habitats and closed forests. Thus, the alternatives which promote this mixture through the ongoing creation of early seral habitats—WM-1 and WM-2—would have greater benefits for wolves than alternatives which promote the development of a closed forest canopy throughout the Watershed.

Grizzly Bear

The Reserve established under all five alternatives would be expected to give immediate protection to whatever grizzly bears presently utilize the Watershed, as would strict adherence to Washington FPA rules required under all alternatives. No direct injury or death of any grizzly bear would be expected under any alternative. The likelihood of disturbance to any grizzly bears would be expected to be low in all alternatives. Any such disturbance would be considered take under the ESA. Alternatives WM-2, WM-3, WM-4, and WM-5 would be expected to result in greater short-term and long-term benefits to grizzly bears than WM-1, through: (1) natural maturation of second-growth forests into mature and late- successional seral stages, especially in the vicinity of special habitats; (2) management actions designed to accelerate the development of mature, late successional, and old growth characteristics in second-growth forests, especially in the vicinity of special habitats; (3) road decommissioning; and (4) research and monitoring. The relative order of alternatives in relation to their overall benefit to grizzly bears may be debatable, but it appears that WM-2 would have the most benefits in the short term and long term, followed by WM-3, then WM-4 and finally, WM-5.

Grizzly bears are not known to occur in the Cedar River Municipal Watershed at present. Although the grizzly bear utilizes a wide variety of habitat types, its key habitats in the Watershed are naturally non-forested habitats (especially talus/felsenmeer and meadows), riparian areas and old growth forests. Because all five alternatives protect all naturally open, riparian and old growth habitats and their buffers in a Reserve, all five alternatives would be expected to give immediate protection to any undocumented resident or transient (including potential colonizers) grizzly bears in the Watershed. Especially important in this regard would be the CHU at the eastern end of the Watershed. This is the remotest part of the Watershed and, because of its proximity to Alpine Lakes Wilderness Area, would be the area most likely to be traversed by dispersing/transient bears or occupied by colonizing bears.

Alternatives which promote the restoration/development of key habitats would be expected to produce additional benefits for grizzly bears. Thus, alternatives which call for habitat restoration in riparian areas (WM-2, WM-3, WM-4, and WM5) would tend to restore more natural ecosystem functioning in riparian areas more rapidly than those that do not (WM-1). These alternatives would produce greater benefits for extant or transient grizzly bears in both the short term and long term. And because grizzly bears utilize old growth forests, alternatives which include management actions to promote the development of late successional and old growth characteristics in second-growth forest (WM-2, WM-3, and WM-4) would produce greater benefits than those that include only limited management actions (WM-5) or none at all (WM-1).

Because grizzly bears require areas away from human disturbance (especially at higher elevations for denning) alternatives which lead to a reduction in human disturbance would be expected to produce additional benefits for grizzly bears. Particularly important in this regard are road densities and road usage. Areas greater than 0.3-mile from a road are termed core habitat and are considered most important for grizzlies. While all alternatives call for road decommissioning, alternatives WM-2, WM-3, WM-4, and WM-5 would decommission more roads than WM-1, thereby having more benefits for bears. Road decommissioning in the upper municipal watershed (within the CHU) would be especially important for three reasons – (1) bears are more likely to occur in the upper municipal watershed, (2) the greatest amount of existing core habitat occurs in the upper municipal watershed, and (3) the greatest opportunity to produce additional core habitat through selective road decommissioning also occurs in the upper municipal watershed.

Reductions in human disturbance could also be accomplished by decreases in road usage. Alternatives which reduce or eliminate timber harvest would reduce human disturbance. In this regard, WM-5 would have the greatest benefit, followed by WM-4, WM-3, WM-2, and WM-1.

Bald Eagle

Bald eagles occur in the Cedar River Municipal Watershed as transient and migrant individuals. Key habitats for bald eagles in the Watershed are lakes and ponds, riparian areas, and old growth forests. Because all five alternatives protect all aquatic, riparian and old growth forest habitats and/or their buffers in a Reserve, all five alternatives would be expected to give immediate protection to bald eagles in the Watershed. The likelihood of disturbance to any bald eagles would be expected to be low in all alternatives. Any such disturbance would be considered take under the ESA.

Furthermore, human-assisted restoration of stream and riparian areas and natural maturation of second-growth forests in lake, river, and stream buffers would be expected to produce additional benefits for bald eagles in both the short term and long term. These benefits would be greater under alternatives

which call for habitat restoration in riparian areas (WM-2, WM-3, WM-4, and WM-5).

Peregrine Falcon

Peregrine falcons have not been documented to occur in the Cedar River Municipal Watershed. Cliffs, rock outcrops, and naturally open areas are key habitats for peregrines in the Cedar River Municipal Watershed. Because all five alternatives protect all key habitats in a Reserve, all five alternatives would be expected to give immediate protection to any peregrine falcons in the Watershed. The likelihood of disturbance to any peregrine falcons would be expected to be low in all alternatives. Any such disturbance would be considered take under the ESA.

Additional benefits would be expected to accrue over the short term and long term for all five alternatives as a result of restoration of more-natural ecosystem functioning brought about by protection and/or development of mature, late successional, and old growth forests in the vicinity of special habitats. Gains through natural maturation of second-growth forest would be expected to be greatest under WM-3, WM-4, and WM-5. Alternatives which include management actions to promote the development of old growth characteristics in second-growth forests (WM-2, WM-3 WM-4) would produce more benefits than those that include only limited management actions (WM-5) or no management actions (WM-1).

4.5.5 Anadromous Fish Mitigation Alternatives

The purpose of this section is to evaluate potential environmental consequences for wildlife from the Anadromous Fish Mitigation Alternatives. These alternatives include the No Action Alternative, AFM-1; the Proposed HCP Alternative, AFM-2; the Down-sized Sockeye Hatchery with Savings Going Towards Downstream Habitat Restoration, AFM-3; Deferred Hatchery Construction Contingent on Evaluation of More Information, AFM-4; and the All Downstream Habitat Restoration and Protection Alternative, AFM-5. The potential consequences evaluated include: (1) the potential to attract bald eagles to the lower municipal watershed from the passage of chinook salmon, coho salmon, and steelhead trout above the Landsburg blockage; (2) the contribution of nutrients and organic carbon to freshwater benthic communities from fish passage above Landsburg; (3) potential to increase food resources for heron and other predators from increases in sockeye fry production resulting from either the hatchery facility or downstream habitat restoration projects; and (4) potential increases in foraging habitat and wildlife habitat diversity from the installation of downstream habitat restoration projects.

Potential to Attract Bald Eagles to the Lower Watershed from the Passage of Chinook Salmon, Coho Salmon, and Steelhead Trout over the Landsburg Diversion Dam

Bald eagles currently do not utilize available habitat on the lower municipal watershed. It is possible that decaying salmon carcasses may attract bald eagles to the lower municipal watershed. The potential environmental consequences are unknown for the No Action Alternative (AFM-1) because the timing of passage, if provided at all under this alternative, is uncertain. Fish passage would be provided as part of all other Anadromous Fish Mitigation Alternatives. The potential attraction of bald eagles is considered a positive consequence.

Potential to Contribute Nutrients and Organic Carbon to Freshwater Benthic Macroinvertebrate Communities from the Passage of Chinook Salmon, Coho Salmon, and Steelhead Trout over the Landsburg Diversion Dam

Nutrients and organic carbon which can enter the water column from decaying salmon carcasses have been shown to adsorb to stream bottom substrates (Bilby, 1996). The potential environmental consequences are unknown for the No Action Alternative (AFM-1) because the timing of passage, if provided at all under this alternative, is uncertain. Fish passage would be provided as part of all other Anadromous Fish Mitigation Alternatives. The potential contribution of nutrients and organic carbon for utilization by benthic macroinvertebrate communities is considered a positive consequence.

Potential to Increase Food Resources Available to Heron and Other Predators from Increases to the Number of Sockeye Fry Raised in the Hatchery Facility Produced by Downstream Habitat Restoration Projects

Sockeye fry released by the proposed hatchery operation could potentially be available in the Cedar River for heron and other predators. However, this consequence would be considered negligible for two reasons. First, sockeye fry generally migrate in one night once they are released into the Cedar River. Second, the production goal of 34 million fry is intended to be equivalent to what could be produced if available spawning habitat above Landsburg was fully utilized. As a result, there would not be any net increase in the number of fry that could potentially be available under natural conditions.

Potential Increases in Foraging Habitat and Wildlife Habitat Diversity from the Installation of Habitat Restoration Projects Downstream of Landsburg

The implementation of downstream habitat restoration projects would increase the foraging habitat diversity of wildlife habitat available within the Cedar River corridor between Landsburg and Lake Washington. It is not known if any downstream habitat restoration projects would be implemented as part of

the No Action Alternative (AFM-1). However, habitat restoration projects would be installed as part of the other alternatives ranging from the 1.6 million dollars that would be spent as part of the Proposed HCP Alternative, AFM-2, up to the All Downstream Habitat Alternative, AFM-5.

4.5.6 Instream Flow Alternatives

The purpose of this section is to evaluate potential environmental consequences for wildlife from the Instream Flow Alternatives, including the No Action Alternative, IF-1, and the Proposed HCP Alternative, IF-2. The potential consequences evaluated include: (1) potential effects of reservoir operations on river delta vegetation; and (2) potential effects of reservoir operations on common loon nesting.

Potential Effects of Reservoir Operations on River Delta Vegetation

In 1987, a 10-year study was initiated to document baseline conditions in the extensive wetland communities of the Cedar River and Rex River deltas (Raedeke, 1997; Technical Appendix 20). Although the study was designed to document changes to vegetation communities resulting from both modified fill and drawdown regimes on the Chester Morse Lake/Masonry Pool reservoir system, particular attention was given to potential effects of extended drawdown conditions created by use of emergency pumps during low water supply conditions at cessation of gravity flow. Drawdown conditions did not approach extended low levels during the 10-year study, so it was not possible to measure effects to the delta vegetation communities resulting from extended low levels. However, effects to delta wetland vegetation communities resulting from higher late winter and early spring water levels and extended fill regimes were documented, including recession of delta sedge and willow communities, and death of mature deciduous and coniferous trees on some of the Cedar River floodplain (Raedeke, 1997; Technical Appendix 20). These incremental changes could have a relatively small effect on the suitability of the delta areas as common loon nesting habitat (see section below on common loon nesting).

If the Permanent Cedar Dead Storage Project is constructed (see Section 4.4.3), both fill and drawdown regimes in the reservoir system may be significantly modified. A key element of those modifications would be a potential new minimum drawdown elevation significantly lower than the natural gravity outlet of the lake at an elevation of 1,532 feet. Potential new extremes of fill and drawdown could create conditions such as inundation, exposure, and desiccation, which could significantly affect delta vegetation communities. However, the Raedeke (1997) report suggests that the seasonal timing and especially the duration and persistence of particular conditions may be of even greater significance, as evidenced by the recession of sedges after prolonged inundation during the growing season (Technical Appendix 20).

As part of the Cedar Permanent Dead Storage Project evaluation, the Applicant will model the new reservoir operating regime, make comparisons to past conditions, and evaluate the potential for future negative effects on the delta plant communities (including floodplains). In addition, the Applicant will evaluate the results of the delta vegetation monitoring project (Raedeke, 1997; Technical Appendix 20) in relation to new reservoir fill and drawdown regimes predicted by modeling exercises. Based on these evaluations and other additional pertinent information, the Applicant will decide if continued monitoring of the delta plant communities is needed. If continued monitoring is necessary, the Applicant then will design and implement the appropriate studies.

Potential Effects of Reservoir Operations on Common Loon Nesting

Both the proposed HCP instream flow regime and the Permanent Cedar Dead Storage Project under IF-2 may alter current levels of Chester Morse lake and the timing of those levels (see Section 4.4.3.5 for a more-detailed discussion of instream flows). Both operating scenarios (but particularly the Permanent Cedar Dead Storage Project) may have potential negative effects on common loons. Potential effects of both operating scenarios on key common loon habitat—delta vegetation of the Cedar and Rex Rivers—are discussed under Aquatic and Riparian Habitats in this Chapter.

Common loons typically nest at the water's edge (WDFW, 1991). On natural lakes and ponds, loons can compensate for small changes in water levels. However, large fluctuations in reservoir levels that can inundate or strand nests, can have substantial negative effects on the reproductive success of loons. Nesting habitat is potentially available in willow-dominated zones of the Cedar and Rex river deltas and in small areas of Masonry Pool. However, this nesting habitat is currently subject to springtime water level fluctuations over the course of the nesting season (April through mid-June) of up to 10 feet under the present reservoir operating regime.

To assess the incremental effect of IF-2 on Chester Morse Lake reservoir levels and common loon nesting, a simplified numerical water balance model of the Cedar River system was used that incorporated representations of (1) the Proposed HCP Alternative for Instream Flows (IF-2), and (2) the No Action Alternative (IF-1) as defined by the nonbinding 1979 Washington State IRPP minimum instream flow regime. This model was used to compare modeled weekly Chester Morse Lake reservoir levels resulting from the two different instream flow scenarios. Both modeled scenarios used simplified assumptions about the Cedar River system and operational constraints. The results from the model are not intended to precisely predict actual future levels in Chester Morse Lake, but rather are used to predict if there will be significant differences in reservoir levels as a result of implementing IF-2 as opposed to IF-4, the No Action Alternative instream flow regime. (For more details, see HCP Section 4.5.6.)

Over the 64 common loon nesting seasons that were modeled, lake levels under IF-2 averaged 0.01 foot lower than under the No Action Alternative flow regime. The differences between the projected lake levels for the two operating regimes varies less than 1 foot (higher or lower) 94.9 percent of the time for the common loon nesting season. It is believed that the incremental differences in lake levels projected under IF-2 will probably have little additional negative effect on common loon nesting success.

In many years the predicted amplitude of reservoir fluctuation during the common loon nesting season are nearly identical under the two instream flow regimes. Over the 64 loon nesting seasons, the mean amplitude of the modeled reservoir fluctuations under IF-2 (6.37 feet) is 0.38 foot greater than under IF-1, No Action Alternative flow regime (5.99 feet).

The additional incremental effect of the fluctuations in reservoir levels during the common loon nesting season due to IF-2 is probably relatively small. Averaged over the 3 weeks (April 8 to April 28) of potential nest establishment for the 64 years of record, the average maximum increase in modeled reservoir levels under IF-2 (4.24 feet) is 0.22 foot greater than the average maximum increase in reservoir levels under IF-1 (4.02 feet). Averaged over the 3 weeks of potential nest establishment for the 64 years of record, the average maximum decrease in modeled reservoir levels under IF-2 (0.07 foot) is actually 0.05 foot less than the average maximum decrease in reservoir levels under IF-1 (0.12 foot).

But, the overall negative effect of the large seasonal fluctuations in reservoir water levels during the loon nesting season under either the IF-1 Alternative or the IF-2 Alternative flow scenarios is much more significant. Under these circumstances, common loon pairs that select floating nest platforms (natural or artificial) are more likely to be successful.

The Proposed HCP Alternative, IF-2 includes provisions for a multiyear evaluation of the Cedar Permanent Dead Storage Project. Although the Dead Permanent Storage Project has many potential benefits for anadromous and resident fish downstream of the Masonry Dam, the primary focus of the environmental portion of the study and evaluation will be on the potential impacts of the Cedar Permanent Dead Storage Project on resident fish and wildlife upstream of the Dam. These evaluations would form the basis of future environmental review under SEPA if any decision was made to pursue the Dead Storage Project. (For more details, see HCP Section 4.5.6.)

4.5.7 Summary

The environmental consequences of all of the alternatives for Watershed Management, Anadromous Fish Mitigation and Instream Flows are summarized in Table 4.5-1 and discussed below.

Watershed Management Alternatives

All five alternatives would establish a Reserve which would immediately protect all key wildlife habitats (aquatic and riparian, old growth forest, special habitats) in the Cedar River Municipal Watershed. Overall, Reserve size increases from WM-1 to WM-5, primarily through the addition of progressively larger areas of second-growth forest. The Reserve in WM-1 would be 51,657 acres in size, WM-2 and WM-3 would be 56,223 acres, WM-4 would be 60,019 acres initially (expanding to 88,328 acres by the end of the 50 year time period), and WM-5 would be 88,328 acres. In all five alternatives, virtually all Reserve elements would be directly connected with one another, primarily by aquatic and riparian corridors, although the degree of connectivity of Reserve elements increases from WM-1 to WM-5. Natural maturation of second-growth forests would improve the connectivity of forest habitats in the short term and long term under all alternatives, however WM-3 through WM-5 would be expected to have greater increases in connectivity than WM-1 or WM-2 (because these two alternatives include clearcut or retention harvesting and the other three do not).

Short- and long-term gains in the quantity and quality of aquatic and riparian habitats would be expected under all alternatives as a result of natural maturation of younger seral-stage forest in buffer areas. In addition, WM-2 through WM-5 include management actions designed to restore and enhance aquatic and riparian habitats (steam bank stabilization projects, placement of large woody debris, a stream bank revegetation program, and a program of restoration thinning in riparian areas). Thus, gains would be expected to accrue more rapidly under these alternatives than under WM-1.

No new old growth forest would develop naturally over the 50 years under any alternative. Gains in the quantity of mature and late successional forest seral stages resulting from natural maturation of second-growth forests would be greater in the short and long term under WM-3 through WM-5 than under WM-2 or WM-1. WM-2 would exceed WM-1 because it would implement retention harvesting as opposed to regeneration harvesting.

Additional short- and long-term benefits would accrue under WM-2 through WM-5 as a result of management actions designed to accelerate the development of late successional and old growth characteristics in second-growth forests both inside and outside the Reserve (WM-1 does not include these management actions). These benefits would be greatest in WM-3, followed by WM-2, then WM-4 and WM-5.

No new special habitats would be expected to develop naturally over the 50 years, although some previously unknown special habitats may be discovered. Under all alternatives, these newly-discovered special habitats would receive the same level of protection as special habitats in the Reserve. Some special habitats would benefit from the development of mature or late successional forests in their vicinity. More acres of these forests would be expected to

develop under alternatives WM-3 through WM-5. WM-3 would be expected to have more forest exhibiting mature, late successional, or old growth characteristics than the other alternatives, followed by WM-2, WM-4 and WM-5 which have similar amounts.

Short- and long-term changes in the quantity and quality of earlier seral stage forests (i.e., early seral, mid seral, mature, late successional) would be expected under all alternatives as a result of (1) natural maturation of second-growth forests, (2) regeneration or retention harvesting included in some alternatives, and (3) management actions (various thinning regimes) designed to accelerate the development of late successional and old growth characteristics in second-growth forests. Among the alternatives, only WM-1 and WM-2 would continue to create early seral forest habitats over the 50 years, because only these two alternatives include regeneration or retention harvesting, respectively. As mentioned in a previous paragraph in this summary, WM-1 would be expected to have the least forest in mature and late successional seral stages, while WM-3 through WM-5 would be expected to have the most in these seral stages (Table 4.3-2). WM-3 would be expected to have more forest exhibiting mature, late successional, or old growth characteristics than the other alternatives.

All alternatives would be expected to give immediate protection to extant populations of all seven species with individual conservation strategies (northern spotted owl, marbled murrelet, northern goshawk, common loon, gray wolf, grizzly bear, bald eagle, peregrine falcon). In general, Alternatives WM-2, WM-3, WM-4, and WM-5 would be expected to result in greater short- and long-term benefits to these species than WM-1. The relative order of alternatives in relation to their overall benefit for each of the seven species may be debatable. However, it appears that: (1) northern spotted owls, marbled murrelets, and northern goshawks would benefit most from WM-3 followed by WM-4, WM-5, and WM-2; 2) common loons, bald eagles, and peregrine falcons would benefit equally from all of the alternatives except the No Action Alternative; and (3) gray wolves and grizzly bear would benefit most from WM-2, followed by WM-3, then WM-4 and, finally, WM-5.

Anadromous Fish Mitigation Alternatives

The environmental consequences for wildlife resources from the Anadromous Fish Mitigation Alternatives involve effects of passing chinook, coho, and steelhead above the Landsburg Diversion Dam and increasing the number of sockeye fry produced downstream of Landsburg, through different combinations of artificial supplementation and downstream habitat restoration.

The potential effects on wildlife resources upstream of Landsburg for the No Action Alternative are unknown because the timing of passage, if provided at all under this alternative, is uncertain.

The potential effects on wildlife from passage are considered positive for alternatives AFM-2, AFM-3, AFM-4 and AFM-5. In general, passage would return these species to habitat that was accessible prior to the construction of the diversion dam almost a century ago. Passage upstream of Landsburg and the spawning of more sockeye downstream of Landsburg has the potential to attract bald eagles, bears, and other scavengers and predators. In addition, decaying salmon carcasses contribute nutrients and organic carbon to benthic invertebrate communities.

Increases in the production of sockeye fry from either artificial supplementation or the downstream habitat projects would have negligible effects on wildlife. Predation by wildlife on these additional sockeye fry is limited because the fry migrate during the hours of darkness and usually complete their journey to Lake Washington in one night. The construction of habitat restoration projects downstream of Landsburg would result in increases in foraging habitat for riparian and wetland dependent species along the Cedar River. These effects on wildlife are considered positive for alternatives AFM-2, AFM-3, AFM-4 and AFM-5 with benefits increasing as more habitat restoration is implemented for the alternatives.

Instream Flows Alternatives

Potential environmental consequences for wildlife from the Instream Flow Alternatives include effects on river delta vegetation and on common loon nesting resulting from fluctuations in reservoir levels caused by the proposed flow regimes. When compared to the No Action Alternative, IF-1, the effects of the proposed Proposed HCP Alternative, IF-2, on river delta vegetation is unknown at this time but would be monitored throughout implementation of the HCP. Effects on common loon nesting from the Proposed HCP Alternative, IF-2, are considered negligible.

Table 4.5-1 Summary of Environmental Consequences Evaluated for Wildlife Resources

Potential Impact Evaluated	Environmental Consequences					Comments
	Watershed Management Alternatives					
	WM-1	WM-2	WM-3	WM-4	WM-5	
Potential effects to aquatic, wetlands and riparian habitats	Positive Effects	Positive Effects	Positive Effects	Positive Effects	Positive Effects	All of the Watershed Management alternatives provide the same level of protection for aquatic and riparian habitats. Although the reserves vary in size among the alternatives, buffers for streams, wetlands and riparian areas are the same. Additional aquatic and riparian habitat restoration projects will be implemented as part of alternatives WM-2, WM-3, WM-4 and WM-5.
Potential effects to old growth forest habitat	Positive Effects	Positive Effects	Positive Effects	Positive Effects	Positive Effects	Old growth habitat and buffers are included in the reserve designs for every alternative.
Potential effects to special habitats, including rock outcroppings, rock cliffs, non-vegetated talus/ felsenmeer slopes, vegetated talus/felsenmeer slopes, known caves, upland meadows and upland persistent shrub habitat	Positive Effects	Positive Effects	Positive Effects	Positive Effects	Positive Effects	Special habitats are included in the reserve designs for every alternative.
Potential to facilitate the development of older forest habitat	Positive Effects	Positive Effects	Positive Effects	Positive Effects	Positive Effects	From the perspective of the entire watershed, the development of older forest habitat will occur across the landscape for all of the alternatives as a result of the large ecological reserves. Older forest development would be expected to be enhanced for alternatives WM-2, WM-3, WM-4 and WM-5 which include restoration thinning, ecological thinning, precommercial and commercial thinning activities. For WM-1, fewer mid seral - closed canopy stands on non-reserve, matrix lands would develop into mature and late successional forests than the other alternatives.

Potential Impact Evaluated	Environmental Consequences					Comments
	Watershed Management Alternatives (cont.)					
	WM-1	**WM-2**	**WM-3**	**WM-4**	**WM-5**	
Potential to increase habitat connectivity across the landscape	Positive Effects	Positive Effects	Positive Effects	Positive Effects	Positive Effects	The large reserve areas will result in an overall increase in habitat connectivity across the landscape for all alternatives. It is also important to note that habitat providing additional connectivity would also be available on non-reserve, matrix lands, for alternatives WM-1, WM-2, WM-3, and WM-4 through the natural maturation of second growth forests. (Under WM-5 the entire watershed is in a reserve.)
Potential effects on individual species addressed by the Habitat Conservation Plan, including: Northern spotted owl Marbled murrelet Northern goshawk Common loon Gray wolf Grizzly bear Bald eagle Peregrine Falcon	Positive Effects	Positive Effects	Positive Effects	Positive Effects	Positive Effects	The large reserve areas increase in habitat connectively, and natural maturation of second growth forests will increase habitat availability for all 8 species under all alternatives. Habitat restoration/enhancement measures under all alternatives except WM-1 would further increase the quantity and quality of habitat available for these species.
	Anadromous Fish Mitigation Alternatives					
	AFM-1	AFM-2	AFM-3	AFM-4	AFM-5	
Potential to attract bald eagles to the lower watershed from the passage of chinook salmon, coho salmon, and steelhead trout over the Landsburg Diversion Dam	Unknown Effects	Positive Effects	Positive Effects	Positive Effects	Positive Effects	Bald Eagles currently do not utilize available habitat on the lower watershed. It is possible that decaying salmon carcasses may attract bald eagles to the lower watershed. The potential environmental consequences are unknown for the No Action Alternative (AFM-1) because the timing of passage, if provided at all under this alternative, is uncertain. Fish passage would be provided as part of all other anadromous fish mitigation alternatives. The potential attraction of bald eagles is considered a positive consequence.

Potential Impact Evaluated	Environmental Consequences					Comments
	Anadromous Fish Mitigation Alternatives (cont.)					
	AFM-1	AFM-2	AFM-3	AFM-4	AFM-5	
Potential to contribute nutrients and organic carbon to stream bottom substrates from the passage of chinook salmon, coho salmon, and steelhead trout over the Landsburg Diversion Dam	Unknown Effects	Positive Effects	Positive Effects	Positive Effects	Positive Effects	Nutrients and organic carbon which can enter the water column from decaying salmon carcasses have been shown to adsorb to stream bottom substrates (Bilby, 1996). The potential environmental consequences are unknown for the No Action Alternative (AFM-1) because the timing of passage, if provided at all under this alternative, is uncertain. Fish passage would be provided as part of all other anadromous fish mitigation alternatives. The potential contribution of nutrients and organic carbon for utilization by benthic macroinvertebrate communities is considered a positive consequence.
Potential to increase food resources available to heron and other predators from increases in the number of sockeye fry raised in the hatchery facility or produced by downstream habitat restoration projects	Negligible Effects	Positive Effects	Positive Effects	Positive Effects	Positive Effects	Increases in sockeye fry production resulting from AFM1, AFM2, AFM3 and AFM4 would be available in the Cedar River for a variety of aquatic and terrestrial predators.

Potential Impact Evaluated	Environmental Consequences					Comments
	Anadromous Fish Mitigation Alternatives (cont.)					
	AFM-1	AFM-2	AFM-3	AFM-4	AFM-5	
Potential increases in foraging habitat and wildlife habitat diversity from the installation of habitat restoration projects downstream of Landsburg	No effects	Positive Effects	Positive Effects	Positive Effects	Positive Effects	The implementation of downstream habitat restoration projects would increase the foraging habitat diversity of wildlife habitat available within the Cedar River corridor between Landsburg and Lake Washington. It is not known if any downstream habitat restoration projects would be implemented as part of the No Action Alternative (AFM-1). However, habitat restoration projects would be installed as part of the other alternatives ranging from the 1.6 million dollars that would be spent as part of the proposed HCP Alternative, AFM-2, up to the all downstream habitat alternative, AFM-5
	Instream Flow Alternatives					
	IF-1			**IF-2**		
Potential effects of reservoir operations on river delta vegetation	No effects			Negligible Effects		The potential incremental effects of the Proposed HCP Alternative for reservoir operations is considered negligible when compared to the No Action Alternative. However, the delta vegetation communities have been observed to change in response to changes in reservoir operations conducted over the past decade. (see Section 4.5.6)

Potential Impact Evaluated	Environmental Consequences		Comments
	Instream Flow Alternatives (cont.)		
	IF-1	IF-2	
Potential effects of reservoir operations on common loon nesting	Negative Effects	Negligible Effects	Alternative IF-1 is considered to have negative effects on common loon nesting but those effects can be mitigated with the use of floating nest platforms. For Alternative IF-2, incremental effects relative to IF-1 are considered negligible. Modeling of 64 common loon nesting seasons indicate that lake levels under the proposed HCP Alternative, IF-2, would average approximately 0.01 feet lower than under the No Action Alternative, IF-1. The differences between the two flow regimes varied by less than 1 foot about 95 percent of the time. It is believed that incremental differences in lake levels projected under the proposed HCP Alternative, IF-2, will have little additional negative effects on common loon nesting success.

4.6 Cultural Resources

Cultural resources could be affected by activities associated with the Watershed Management Alternatives, Anadromous Fish Mitigation Alternatives, and Instream Flow Alternatives. Potential effects to cultural resources are identified in Table 4.6-1. In general, however, the existing cultural resources inventory and the Cultural Resources Management Plan for the Watershed would avoid or mitigate potential effects.

4.6.1 Cultural Resources Policy and Management

The Cultural Resources Management Plan (CRMP) for the Watershed would be implemented to mitigate potential adverse effects which could occur in any of the proposed alternatives. In addition, the Applicant would be responsible for studies outside of the Watershed for possible adverse effects from construction associated with downstream habitat restoration and protection on the Cedar River.

The Watershed Cultural Resource Management Plan (CRMP) is being prepared to comply with federal, state, and City of Seattle cultural resource laws and regulations as well as stewardship obligations of the Watershed's staff. The framework for the CRMP was outlined in the Cedar River Municipal Watershed Secondary Use Policies, an ordinance adopted by the City of Seattle in 1989. Seattle City Light (SCL) is responsible for cultural resources associated with production of hydroelectric power at Cedar Falls. The CRMP is being developed by Larson Anthropological Archaeological Services Limited (LAAS) and the Watershed's staff. The CRMP was generated over a three-year period by LAAS and the Watershed's staff as summary cultural resource data tables were prepared and reviewed and recommendations were developed regarding management of each resource item. The Watershed's staff is currently reviewing a draft of the CRMP. The final CRMP will be implemented by the Watershed's staff as part of daily watershed operations after review and approval by the Seattle City Council.

City policies and management practices would ensure compliance with procedures outlined in the CRMP to evaluate and manage cultural resources, including Section 106 consultations under the National Historic Preservation

Act. Unknown hunter-fisher-gatherer archaeological deposits, historic archaeological deposits, and traditional cultural properties would be documented, evaluated, and managed using procedures in the CRMP. Three management recommendations are outlined in the CRMP and recommendations have been extended for each recorded hunter-fisher-gatherer archaeological site, historic archaeological site, and historic structure. Resources assigned management recommendation A would require consultation with the Washington State Office of Archaeology and Historic Preservation (OAHP) and a professional cultural resource specialist to determine evaluation and/or mitigation. Management recommendation B would require field assessment by a cultural resources technician and/or evaluation by a professional archaeologist. Management recommendation C would require a Determination of Effect in consultation with OAHP or a determination that a property is not eligible for listing on the National Register of Historic Places (NRHP).

The CRMP outlines procedures to identify unknown cultural resources in areas that have not been surveyed by a professional through the use of the Watershed GIS database, development of a predictive model for archaeological resources, consultation with affected Tribes, and preparation of a traditional cultural property study of the Watershed. Cultural resource technicians and professional archaeologists would conduct field assessments for projects that involve modification of ground surfaces or alteration of vegetation to determine if cultural resources occur in areas which have a high probability for hunter-fisher-gatherer archaeological deposits, historic locations identified in archival investigations, or areas identified in the traditional cultural property study. This section reviews appropriate mitigation measures for each of the proposed alternatives.

4.6.2 Watershed Management Alternatives

Cultural resources could be adversely affected through daily operations and long-term management of the Watershed. Watershed operations such as road maintenance and thinning of tree stands, as well as fluctuating levels of Chester Morse Lake could adversely affect hunter-fisher-gatherer archaeological sites, historic archaeological sites, and/or traditional cultural properties. Archaeological deposits within the operating elevation of Chester Morse Lake would be eroded by waves as the lake level fluctuates seasonally. Historic archaeological sites, historic trails, stripped cedar trees, traditional use areas, and hunter-fisher-gatherer archaeological sites could be adversely affected when tree stands are thinned. Effects can include ground disturbance by logging equipment, removal of stripped cedar trees, or noise from heavy equipment and chain saws in areas used for traditional cultural activities such as vision quests. Road construction and maintenance could increase noise from road building or maintenance equipment, watershed vehicles, or logging trucks in areas used for traditional cultural activities. Logging could adversely affect hunter-fisher-gatherer archaeological sites, historic archaeological sites,

and traditional cultural properties through direct ground disturbance, removal of economically important plants or trees, or through noise and dust, which disturbs traditional cultural activities. The CRMP for the Watershed would be implemented to avoid and/or mitigate potential adverse impacts on cultural resources under all of the Watershed Management Alternatives.

No Action Alternative for Watershed Management (WM-1)

Unknown hunter-fisher-gatherer archaeological deposits, historic archaeological deposits, and traditional cultural properties could be adversely affected through implementation of the No Action Alternative.

Twenty-eight recorded cultural resources, including 15 hunter-fisher-gatherer sites and five historic towns, would be in the Reserve. Eleven of the hunter-fisher-gatherer sites have not been evaluated (Table 2 in Appendix A). Seventy-seven historic locations identified in archival research would be in the Reserve for the No Action Alternative and could be adversely affected by ecological or restoration thinning (Table 3 in Appendix A).

Numerous recorded historic resources would be outside of the proposed Reserve and could be adversely affected by forest stand thinning and logging. The Japanese Camp townsite, the Sherwood townsite and the Bay View Brewing Company, which have not been evaluated, and nine additional recorded historic properties are outside of the proposed Reserve (Table 2 in Appendix A). Portions of four historic trails would cross areas which could be thinned or logged. Thirty-two historic locations identified in archival records would be outside the proposed Reserve and could be adversely affected by tree stand thinning and logging (Table 3 in Appendix A). Six historic locations outside of the proposed Reserve have been inventoried in field investigations and could also be adversely affected by tree stand thinning and logging operations (Table 3 in Appendix A).

Unknown hunter-fisher-gatherer archaeological sites, historic archaeological sites, and traditional cultural properties outside of the proposed Reserve could be adversely affected by road construction, road maintenance, tree stand thinning, and logging operations. Traditional cultural properties could be adversely affected by noise from logging equipment, road construction equipment, or increased vehicle traffic on maintained roads.

Potential impacts to cultural resources from tree stand thinning, logging, road construction, and road maintenance in the No Action Alternative would be avoided or mitigated through implementation of the CRMP. SPU personnel would review the cultural resources data on the watershed GIS to determine if recorded or potential cultural resources occur in project areas which would include modification of vegetation and/or ground disturbance. Management recommendations A, B, and C, outlined in Section 4.6.1, would be implemented to identify and manage cultural resources in proposed project areas. The SPU would consult with professional archaeologists and the OAHP

as directed in the CRMP. Traditional cultural properties would be identified through consultation with affected Tribes and in a traditional cultural property study. Landforms with a high probability for hunter-fisher-gatherer resources would be identified in a predictive model.

Proposed HCP Alternative for Watershed Management (WM-2)

Unknown hunter-fisher-gatherer archaeological deposits, historic archaeological deposits, and traditional cultural properties could be adversely affected through implementation of the Proposed HCP Alternative. In addition, recorded hunter-fisher-gatherer and historic archaeological sites could be adversely affected by logging and tree thinning.

Fifteen hunter-fisher-gatherer archaeological sites and three historic towns are within the proposed Reserve. Adverse effects could result from tree thinning, fluctuating levels of Chester Morse Lake, and road maintenance. An additional 21 historic properties identified within the proposed Reserve have not been identified through a field assessment and/or have not been evaluated by a professional archaeologist (Table 2 in Appendix A). One hunter-fisher-gatherer archaeological site and five historic sites within the proposed Reserve have been evaluated as not significant (Table 2 in Appendix A). Eighty-two historic locations identified in archival records would be within the proposed Reserve and ten historic locations have been inventoried in field investigations (Table 3 in Appendix A). Cultural resources could be adversely affected within the proposed Reserve in areas where ecological or restoration thinning occurs.

The Proposed Alternative would have the same number and type of recorded cultural resources outside of the Reserve as the No Action Alternative. The cultural resources outside the Reserve could be adversely affected by forest stand thinning and logging. Unknown hunter-fisher-gatherer archaeological sites, historic archaeological sites, and traditional cultural properties outside of the proposed Reserve could be adversely affected by road construction, road maintenance, tree stand thinning, and logging operations.

SPU would implement the CRMP to avoid or mitigate potential impacts to cultural resources from logging, tree stand thinning, road construction, and road maintenance. The same procedures would be used as described for the No Action Alternative.

Long-term Sustainable Thinning Alternative (WM-3)

Unknown hunter-fisher-gatherer archaeological sites, historic archaeological sites, and traditional cultural properties could be adversely affected during thinning of forest stands throughout the Watershed, including the proposed Reserve. The Reserve would be the same as in the Proposed HCP Alternative (Section 4.6.2), with the same recorded cultural resources and historic locations described for the Proposed HCP Alternative. Cultural resources

could be adversely affected within the proposed Reserve in areas where ecological or restoration thinning occurs.

The same cultural resources described outside of the Reserve for the Proposed HCP Alternative (Section 4.6.2) could be adversely affected by tree stand thinning in the proposed Long-term Sustainable Thinning Alternative.

SPU would implement the CRMP to avoid or mitigate potential impacts to cultural resources from tree stand thinning, road construction, and road maintenance. The same procedures would be used as described for the No Action Alternative.

Unknown hunter-fisher-gatherer archaeological sites, historic archaeological sites, and traditional cultural properties outside of the proposed Reserve could be adversely affected by road construction, road maintenance, and tree stand thinning.

Thinning with Phased Out Commercial Timber Harvest Alternative (WM-4)

Unknown hunter-fisher-gatherer archaeological deposits, historic archaeological sites, and traditional cultural properties could be adversely affected during thinning of forest stands. The Reserve would be the same as the Proposed HCP Alternative. The same resources identified within the Reserve for the Proposed HCP Alternative (Section 4.6.2) would be in the Reserve for the Long-term Sustainable Thinning Alternative and would be adversely affected if ecological or tree stand thinning occur in the Reserve.

The same cultural resources described outside of the Reserve for the Proposed HCP Alternative (Section 4.6.2) could be adversely affected by tree stand thinning in the Long-term Sustainable Thinning Alternative.

Unknown hunter-fisher-gatherer archaeological sites, historic archaeological sites, and traditional cultural properties outside of the proposed Reserve could be adversely affected by road construction, road maintenance, and tree stand thinning.

SPU would implement the CRMP to avoid or mitigate potential impacts to cultural resources from tree stand thinning, road construction, and road maintenance. The same procedures would be used as described for the No Action Alternative.

No Commercial Timber Harvest Alternative (WM-5)

Under this alternative, no logging, or ecological or restoration thinning would occur in the Watershed and the entire Watershed would be part of the Reserve. Consequently, there would be no logging related activities to affect these resources. SPU would still implement the CRMP to mitigate potential impacts

from incidental activities related to road maintenance and removal of hazard trees or blowdown across roads.

4.6.3 Anadromous Fish Mitigation Alternatives

No Action Alternative (AFM-1)

No archaeological resources would be adversely affected downstream from Landsburg by the Applicant as part of the No Action Alternative. Additionally, no traditional cultural properties associated with anadromous fish runs could be adversely affected because this would be a continuation of the existing conditions.

Proposed HCP Alternative for Anadromous Fish Mitigation (AFM-2)

Construction excavation and movement of heavy construction equipment into downstream habitat restoration areas or areas for habitat protection could adversely affect unknown hunter-fisher-gatherer archaeological sites, historic archaeological sites, and/or traditional cultural properties.

The Applicant is conducting separate cultural resource studies for the Landsburg vicinity as part of upgrading the intake facilities and planning of a salmon hatchery. Cultural resource overviews would be required in the planning stages of downstream habitat restoration areas and habitat protection areas to identify areas with known cultural resources and/or areas with a high probability for cultural resources. Consultation with affected Tribes would be conducted to identify traditional cultural properties downstream from Landsburg in areas proposed for habitat restoration or habitat protection. Field investigations by a professional archaeologist could be necessary to identify cultural resources in areas proposed for habitat restoration or protection. The Applicant would evaluate identified cultural resources and would consult with the OAHP.

Down-sized Sockeye Hatchery Alternative with Savings Going Towards Downstream Habitat Restoration (AFM-3)

Unknown cultural resources outside of the Watershed could be adversely affected by heavy equipment accessing habitat protection and restoration sites and during construction for habitat protection and restoration. More areas would be selected for habitat restoration and protection than in the Proposed HCP Alternative because more funds would be available. Alternative AFM-3 has the potential to adversely affect a larger number of cultural resources than the Proposed HCP Alternative, because more areas downstream from the Watershed would receive construction impacts. The same procedures outlined for the Proposed HCP Alternative would be implemented to mitigate potential effects.

Deferred Hatchery Construction Alternative Contingent on Evaluation of More Information (AFM-4)

Potential effects would be similar to those for Alternative AFM-3. The same procedures outlined for the Proposed HCP Alternative would be implemented to mitigate potential effects.

All Downstream Habitat Restoration and Protection Alternative (AFM-5)

Potential effects would be similar to those for Alternative AFM-3. The same procedures outlined for the Proposed HCP Alternative would be implemented to mitigate impacts.

4.6.4 Instream Flow Alternatives

No Action Alternative (IF-1)

No archaeological resources would be adversely affected by the Applicant as part of the No Action Alternative for Instream Flows. Additionally, no traditional cultural properties associated with anadromous fish runs could be adversely affected because this would be a continuation of the existing conditions.

Proposed HCP Alternative (IF-2)

Supplemental water would be released for steelhead incubation. Water could then be recovered either by reducing instream flows or by using the existing temporary pumps. Reservoir levels under IF-2 would be reduced by an average of 0.41 feet during the fall. Unknown cultural resources currently inundated by Chester Morse Lake could be adversely affected by slight reductions in the elevation of Chester Morse Lake below normal operating elevation if water is pumped over the overflow dike to augment low fall flows in the Cedar River.

The Applicant has procedures in place to conduct archaeological investigations on the shoreline of Chester Morse Lake if temporary pumping is necessary. The CRMP would be utilized to identify and evaluate unknown cultural resources below the normal operating elevation of Chester Morse Lake and would be utilized to address potential impacts.

4.6.5 Summary

A summary of environmental consequences for cultural resources is presented in Table 4.6-1. These consequences are also summarized here for the Watershed Management, Anadromous Fish Mitigation, and Instream Flow Alternatives.

The City's CRMP is designed to avoid or mitigate any potential effect to archaeological, historical, and traditional cultural properties in the Watershed. Potential effects from Watershed Management include forestry operations such as timber harvest, thinning, and new road building. Identified resources, however, will be protected by avoidance. Additionally, operational sites will be investigated for the presence of cultural resources as indicated in the CRMP. Potential effects from the Anadromous Fish Mitigation Alternatives include construction activities related to the hatchery or instream habitat improvement projects. The CRMP would prevent or mitigate effects at these sites because surveys will be conducted as part of the EIS for construction of the Landsburg fish passage facilities and prior to implementing any downstream habitat improvements. Potential effects from the Instream Flow Alternatives will not occur.

Unknown cultural resources currently inundated by Chester Morse Lake could be adversely affected by fluctuations in the elevation of Chester Morse Lake below normal operating elevation if water is pumped to augment low fall flows in the Cedar River. Recorded sites at the or above the maximum operating elevation of Chester Morse Lake could be adversely affected by wave erosion. The CRMP has procedures in place to conduct archaeological investigations on the shoreline of Chester Morse Lake if temporary pumping is necessary.

Table 4.6-1. Summary of Environmental Consequences Evaluated for Cultural Resources

Table 4.6-1, Page 2

Table 4.6-1, Page 3

4.7 Land Use

4.7.1 Introduction

The discussion below details land use compatibility and compliance with applicable land use plans and development regulations for all of the proposed alternatives. This discussion evaluates the environmental consequences of five alternatives each for Watershed Management and Anadromous Fish Mitigation and two alternatives related to instream flows.

4.7.2 Watershed Management Alternatives

No Action Alternative for Watershed Management (WM-1)

Key land use elements of the No Action Alternative address conservation management and logging. These activities have historically occurred in the Watershed and surrounding lands and these activities are compatible with existing and adjacent land uses. Furthermore, these land uses are consistent with the King County Comprehensive Plan Land Use Plan designation as well as the King County Zoning Code designation (Forestry) of the Watershed. As such, the implementation of the No Action Alternative would not result in land use effects.

Proposed HCP Alternative for Watershed Management (WM-2)

The potential effects from the implementation of this alternative would be very similar to those described for the No Action Alternative.

Long-term Sustainable Thinning Alternative (WM-3)

The potential effects from the implementation of this alternative would be very similar to those described for the No Action Alternative.

Thinning Alternative with Phased Out Commercial Timber Harvest (WM-4)

The potential effects from the implementation of this alternative would be very similar to those described for the No Action Alternative.

No Commercial Timber Harvest Alternative (WM-5)

The potential effects from the implementation of this alternative would be similar to those described for the No Action Alternative. The exclusion of timber harvesting activities would not increase or decrease the degree that this alternative would comply with existing land use plans and zoning regulations.

4.7.3 Anadromous Fish Mitigation Alternatives

No Action Alternative (AFM-1)

Implementation of the No Action Alternative for Anadromous Fish Mitigation would not affect land use. Research studies and habitat restoration activities associated with this alternative would be compatible with existing and adjacent land uses. All of the elements of the alternative would be consistent with the King County Comprehensive Plan Land Use Plan designation of the Watershed. In addition, the proposed Anadromous Fish Mitigation measures would be consistent with the permitted land uses in the Forestry Zoning Code designation of the Watershed.

Proposed HCP Alternative for Anadromous Fish Mitigation (AFM-2)

Implementation of the Proposed HCP Alternative for Anadromous Fish Mitigation would not affect land use. Research studies and habitat restoration activities associated with this alternative would be compatible with existing and adjacent land uses. The continued operation of fish hatcheries and the construction of fish passage structures for the Landsburg Diversion also would be compatible with existing or adjacent land uses. All of the elements of the alternative would be consistent with the King County Comprehensive Plan Land Use Plan designation of the Watershed. In addition, the proposed Anadromous Fish Mitigation measures would be consistent with the permitted land uses in the Forestry Zoning Code designation of the Watershed. Specific compliance analysis of the development regulations in this land use zone, however, will be evaluated in the EIS for the alternative construction projects at Landsburg (currently under preparation).

Down-sized Sockeye Hatchery Alternative with Savings Going Towards Downstream Habitat Restoration (AFM-3)

The potential effects from the implementation of this alternative would be very similar to those described for the Proposed HCP Alternative.

Deferred Hatchery Construction Alternative Contingent on Evaluation of More Information (AFM-4)

The potential effects from the implementation of this alternative would be very similar to those described for the Proposed HCP Alternative.

All Downstream Habitat Restoration and Protection Alternative (AFM-5)

The potential effects from the implementation of this alternative would be very similar to those described for the Proposed HCP Alternative.

4.7.4 Instream Flow Alternatives

No Action Alternative (IF-1)

Implementation of the No Action Alternative for instream flows would not affect land use. None of the existing land uses within or adjacent to the Watershed would be affected by continued voluntary compliance with the non-binding WDOE 1979 instream flow guidelines. Furthermore, implementation of this alternative would continue to be consistent with the King County Comprehensive Plan Land Use Plan or Zoning Code.

Proposed HCP Alternative for Instream Flows (IF-2)

The potential effects from the implementation of the Proposed HCP Alternative for instream flows would be similar to those described in the No Action Alternative. Commitment by the Applicant to guarantee the provision of an average annual firm yield of 97 mgd does not materially differ from the No Action Alternative with regard to effects on land use.

4.7.5 Summary

A summary of environmental consequences for land use is presented in Table 4.7-1. These consequences are also summarized here for the Watershed Management, Anadromous Fish Mitigation, and Instream Flow Alternatives.

The majority of the alternatives proposed for Watershed Management, Anadromous Fish Mitigation, and Instream Flows do not constitute land uses per contemporary land use planning practices. The alternatives for Watershed Management address logging activities and land conservation. Control of minimum flows within the Cedar River is similarly resources management activities. Only alternatives for Anadromous Fish Mitigation, including the construction of a fish passage structure or new hatchery, could constitute a separate land use. In each case, however, the proposed activities or land uses are compatible with existing and adjacent land uses, comprehensive plan land use plan designations, and zoning code designations. None of the alternatives would result in land use effects.

Table 4.7-1. Summary of Environmental Consequences Evaluated for Land Use

4.8 Recreation

4.8.1 Introduction

Though limited in the Cedar River Municipal Watershed, recreational opportunities are plentiful along the Cedar River below Landsburg Diversion and around the shoreline of Lake Washington. There are water-enhancing activities such as hiking, wildlife viewing, and picnicking. In addition, there are water-dependent activities including wading, swimming, boating, and fishing. The sections below evaluate potential effects on recreational opportunities resulting from the implementation of Watershed Management, Anadromous Fish Mitigation, and Instream Flow Alternatives. Effects analyzed include those occurring in the Cedar River Municipal Watershed, the Cedar River below Landsburg Diversion, and Lake Washington and the waters that link the lake to Puget Sound. Implementation of the alternatives would generally not affect recreational opportunities.

4.8.2 Watershed Management Alternatives

In all, there are five proposed alternatives for Watershed Management in the Watershed. These alternatives encompass varying levels of logging and timberland management practices activities. As described in Section 4.2, the quality and quantity of water flowing in the Cedar River would only be minimally affected, if at all, by the implementation of the Watershed Management Alternatives. Such effects would be limited to short durations due to increased turbidity from landslides or road erosion. As a result, both water-enhancing and/or water-dependent recreational activities could be affected. The following paragraphs described these potential effects by alternative for recreation in the Watershed, the Cedar River, and Lake Washington.

No Action Alternative for Watershed Management (WM-1)

Watershed Recreation

The Seattle Public Utilities does not allow unescorted public access to the Watershed for recreational activities. Implementation of the No Action Alternative for Watershed Management, therefore, would not affect public recreation within the boundaries of the Watershed.

Public access, however, is allowed to two small recreational areas owned by the City of Seattle, but lying outside of the Watershed. Visitors to the Rattlesnake Lake Recreation Area would not be expected to view the Watershed due to a small ridge that separates the area from the Watershed. In addition, the layout of harvest units would be designed to be located outside of the viewshed of Rattlesnake Lake. As such, visitors would not likely see any changes in the landscape due to logging activities proposed under the No Action Alternative. Rattlesnake Lake also lies outside of the hydrologic boundaries of the Watershed, which means surface waters in the Watershed do not drain into the lake. Thus, water-dependent recreational activities occurring in or adjacent to Rattlesnake Lake would not be expected to affected. In sum, changes in watershed management would not alter the type or quality of recreational activities at the Rattlesnake Lake Recreational Area.

The second location where public access is allowed is at Landsburg Park. This park is located just downstream of the Landsburg Diversion. As described in Section 4.2 Water Quantity and Water Quality, changes in watershed management activities would not significantly alter the quantity or quality of water passing over Landsburg Diversion. Therefore, implementation of any of the proposed alternatives for Watershed Management would not affect either water-enhancing or water-dependent activities at Landsburg Park.

Cedar River Recreation

The implementation of the No Action Alternative for Watershed Management would not be expected to significantly change either water quantity or quality below Landsburg Diversion. In particular, riparian buffers would substantially protect water quality from sediment effects. As such, the quality of existing water-enhancing and water-dependent recreational activities would continue to be available to the public at the many formal and information recreation sites located along the shores of the river between Landsburg Diversion and the outlet of the river to Lake Washington.

Lake Washington Recreation

Under the No Action Alternative, the potential effects on recreation in and around Lake Washington and the waters that link the lake to the Puget Sound would be similar to those described above for the Cedar River below Landsburg Diversion.

Proposed HCP Alternative for Watershed Management (WM-2)

Under this alternative, the potential effects on recreation would be very similar to those described above for the No Action Alternative.

Long-term Sustainable Thinning Alternative (WM-3)

Under this alternative, the potential effects on recreation would be very similar to those described above for the No Action Alternative.

Thinning Alternative with Phased Out Commercial Timber Harvest (WM-4)

Under this alternative, the potential effects on recreation would be very similar to those described above for the No Action Alternative.

No Commercial Timber Harvest Alternative (WM-5)

Under this alternative, the potential effects on recreation would be very similar to those described above for the No Action Alternative.

4.8.3 Anadromous Fish Mitigation Alternatives

This section evaluates the environmental consequences of the five Anadromous Fish Mitigation Alternatives. These alternatives combine different levels of habitat restoration and protection programs, proposals for passage over Landsburg Dam, and artificial supplementation of the Cedar River sockeye at a hatchery. Except for the No Action Alternative, all of the alternatives provide for the same mitigation measures for coho salmon, chinook salmon, and steelhead trout.

The implementation of any of these alternatives would not be expected to alter water quality, except during short period for the instream construction related to the construction of a hatchery or fish passage (see Section 4.2 Water Quantity and Quality). Water-enhanced recreation along the shores of the Cedar River could be enriched and recreational fisheries of Lake Washington could benefit from some of the anadromous fish mitigation proposals. The paragraphs below describe the potential effects of the alternatives for Anadromous Fish Mitigation. The discussion will present potential effects within the Watershed, in the Cedar River below Landsburg Diversion, and in Lake Washington and the waters linking the lake to Puget Sound.

No Action Alternative (AFM-1)

Watershed Recreation

As mentioned in Section 3.8, the Seattle Public Utilities does not allow any public recreational activities to occur within the hydrologic boundaries of the

Watershed. As such, implementation of the No Action Alternative for Anadromous Fish Mitigation would not affect recreation in the Watershed.

The Rattlesnake Lake Recreation Area lies outside of the hydrologic boundaries of the Watershed. Thus, any potential changes to water quality and the size of fisheries in the Cedar River above the Landsburg Diversion would not effect either water-enhancing or water-dependent activities at the Rattlesnake Lake Recreation Area.

Moreover, the implementation of the No Action Alternative for Anadromous Fish Mitigation would not affect recreational opportunities at Landsburg Park. Under this alternative, negotiations for meeting mitigation goals would continue between the Applicant, state, tribal, and federal agencies. As such, the type and quality of existing recreational opportunities would continue for the foreseeable future.

Cedar River Recreation

Under the No Action Alternative, there would generally be no beneficial effects on recreational opportunities in and along the shoreline of the Cedar River. Without enhanced fish protection or habitat improvement, it would be unlikely that wildlife enthusiasts would be able to view larger populations of migrating fish. The river's recreational fisheries would be expected to continue to be closed. In fact, implementation of this alternative could result in continued declines of one or more anadromous species inhabiting the Cedar River. If so, these effects would degrade water-enhanced recreation along the river.

All other water-enhancing and water-dependent recreational opportunities currently available to the public in and along the shores of the Cedar River would not be affected by the implementation of the No Action Alternative.

Lake Washington Recreation

The potential effects on recreational opportunities in Lake Washington and waters linking the lake to the Puget Sound that would result from the implementation of the No Action Alternative would be similar to those described above for potential effects on Cedar River recreation. In addition, opportunities to harvest sockeye salmon in Lake Washington would continue to be sporadic, if at all. Considering the infrequency of sockeye recreational fishing on Lake Washington, potential effects would not markedly diminish recreational fishing for other species on the lake. Rainbow and cutthroat trout would continue to be the most prevalent species caught by anglers.

Proposed HCP Alternative for Anadromous Fish Mitigation (AFM-2)

Watershed Recreation

The implementation of the Proposed HCP Alternative, AFM-2, for Anadromous Fish Mitigation would not affect recreational opportunities in the Watershed and the Rattlesnake Lake Recreational Area. The anticipated effects would be identical to those described above for the No Action Alternative.

Water-enhanced recreational opportunities at the Landsburg Park, however, would benefit from the implementation of the anadromous fish mitigation measures proposed under this alternative. In particular, constructing a fish passage over the Landsburg Diversion for Chinook, coho, and steelhead would likely increase the number of visitors to the park to view the increased numbers of migrating fish as well as viewing fish in the fish passage. Other existing recreational opportunities at the Landsburg Park would not be affected.

Cedar River Recreation

The implementation of the Proposed HCP Alternative for Anadromous Fish Mitigation would be expected to improve fisheries habitat in the Cedar River below Landsburg Diversion, which could improve the quality of some recreational activities available to the public in and along the shores of the river. The goal of proposed activities is to improve the quality of water as well as fisheries habitat in the Cedar River. Implementation of the alternative would be expected to increase the number of fish that would migrate up the Cedar River to spawn. Opportunities to view migrating or spawning fish would be expected to increase. The carcasses of fish would likely attract other wildlife to the shores of the river. Thus, implementation of anadromous fish mitigation measures would be expected to increase opportunities for wildlife viewing from the shores of the Cedar River.

In addition, depending on the long-term success of the anadromous fish mitigation measures, recreational fishing in the Cedar River could potentially be allowed in the future. Potential fisheries could include coho, chinook, sockeye, and steelhead. The probability and timing of reopening a recreational fishery is uncertain. The implementation of the anadromous fish mitigation measures would not be expected to result in additional recreational fishing opportunities in the Cedar River within the near future. Moreover, opportunities for recreational fishing in the Cedar River may never occur.

Other water-enhanced and water-dependent recreational opportunities in and along the Cedar River that are currently available to the public would continue to be available.

Lake Washington Recreation

The key objectives of the Proposed HCP Alternative for Anadromous Fish Mitigation is to implement biological solutions that help provide for the recovery and persistence of healthy, harvestable runs of sockeye, coho, and chinook salmon and steelhead trout originating from the Cedar River. The recovery and persistence of other runs of coho, chinook, and sockeye salmon and steelhead trout must also occur to improve the likelihood of increased opportunities for recreational fishing in Lake Washington. Thus, the anadromous fish mitigation measures proposed under the Proposed HCP Alternative would contribute to the long-term recovery of these fisheries in Lake Washington.

Regarding the sockeye fishery of Lake Washington, the implementation of the Proposed HCP Alternative would likely produce the best results of all of the Anadromous Fish Mitigation Alternatives. Recreational fishing for sockeye salmon in Lake Washington would likely occur more frequently than in the last decade, and potentially the most frequent of all of the alternatives. In the near-term, opportunities for recreational fishing for sockeye salmon would more than likely remain unchanged from current conditions.

The implementation of Proposed HCP Alternative would not effect other water-enhancing or water-dependent recreational opportunities currently occurring in and along the shoreline of Lake Washington and the waters linking the lake with the Puget Sound. Rainbow and cutthroat trout would continue to be the most prevalent species caught by anglers on Lake Washington.

Down-sized Sockeye Hatchery Alternative with Savings Going Towards Downstream Habitat Restoration (AFM-3)

Watershed Recreation

Under this alternative, the potential effects on recreational opportunities within the Watershed, the Rattlesnake Lake Recreational Area, and the Landsburg Park would be nearly identical to those described above for the Proposed HCP Alternative.

Cedar River Recreation

Implementation of the Down-sized Sockeye Hatchery Alternative would be expected to affect recreational opportunities in and along the Cedar River in a very similar manner as described above for the Proposed HCP Alternative.

Lake Washington Recreation

The potential effects on recreational opportunities in and along the shoreline of Lake Washington and the waters that link the lake to the Puget Sound would be similar to those described above for the Proposed HCP Alternative.

Regarding recreational fisheries, rainbow and cutthroat trout would continue to be the most prevalent species caught by anglers.

Opportunities for recreational fishing for sockeye in Lake Washington would likely occur more frequently than in the past decade. The chances of a recreational fishery under this alternative would be less likely than the Proposed HCP Alternative and more likely than the No Action and Delayed Hatchery alternatives. In the near-term, opportunities for recreational fishing for sockeye salmon would more than likely remain unchanged from current conditions.

Deferred Hatchery Construction Alternative Contingent on Evaluation of More Information (AFM-4)

Watershed Recreation

Under this alternative, the potential effects on recreational opportunities within the Watershed, the Rattlesnake Lake Recreational Area, and the Landsburg Park would be nearly identical to those described above for the Proposed HCP Alternative.

Cedar River Recreation

Implementation of the Delayed Hatchery Construction Alternative would be expected to affect recreational opportunities in and along the Cedar River in a very similar manner as described above for the Proposed HCP Alternative.

Lake Washington Recreation

Under this alternative, the potential effects on recreational opportunities in and along the shoreline of Lake Washington and the waters that link the lake to the Puget Sound would be similar to those described above for the Proposed HCP Alternative. Regarding recreational fisheries, rainbow and cutthroat trout would continue to be the most prevalent species caught by anglers.

The effects on sockeye recreational fishing differ for the first 12 years after implementation and the years following. In the near-term, there would be some potential for enhanced fishery because of continued production of 16 million fry at the interim hatchery. The effects on recreational fishing for sockeye in Lake Washington would be the same as described under the No Action Alternative. During this near-term period, the chances that the fishery would be open would be slim.

Over the long-term, there could be several outcomes for recreational fishing for sockeye on Lake Washington. If a full hatchery were constructed, the effects would be the same as the Proposed HCP Alternative. If a smaller hatchery were constructed, the effects would be the same as described above under the Down-sized Sockeye Hatchery Alternative. And, if no hatchery

were operated on the Cedar River, then the effects on the sockeye recreational fishery in Lake Washington would be dependent upon habitat restoration efforts as described below for the All Habitat Restoration and Protection Alternative.

All Downstream Habitat Restoration and Protection Alternative (AFM-5)

Watershed Recreation

Under this alternative, the potential effects on recreational opportunities within the Watershed, the Rattlesnake Lake Recreational Area, and the Landsburg Park would be nearly identical to those described above for the Proposed HCP Alternative.

Cedar River Recreation

Implementation of the Delayed Hatchery Construction Alternative would be expected to affect recreational opportunities in and along the Cedar River in a very similar manner as described above for the Proposed HCP Alternative.

Lake Washington Recreation

Under this alternative, the potential effects on recreational opportunities in and along the shoreline of Lake Washington and the waters that link the lake to the Puget Sound would be similar to those described above for the Proposed HCP Alternative. Regarding recreational fisheries, rainbow and cutthroat trout would continue to be the most prevalent species caught by anglers.

Harvest rates for adult sockeye would be lowest due the larger numbers of spawners required to seed available spawning habitat. Opportunities for recreational fishing for sockeye in Lake Washington would likely occur more frequently than in the past decade. The chances of a recreational fishery under this alternative would be less likely than the Proposed HCP Alternative and the Down-sized Sockeye Hatchery Alternative, but more likely than the No Action Alternative. In the near-term, opportunities for recreational fishing for sockeye salmon on Lake Washington would more than likely remain unchanged from current conditions.

4.8.4 Instream Flow Alternatives

There are two alternatives pertaining to instream flows in the Cedar River below Landsburg Diversion. The primary distinction between the two alternatives is whether or not the City will continue to manage flows following the minimum instream flow guidelines promulgated by the Washington Department of Ecology in 1979 or will commit to a new legally-binding instream flow management flow regime.

The paragraphs below describe the potential effects of these alternatives on recreational opportunities in the Watershed, the Cedar River, and in Lake Washington and the waters linking the lake to the Puget Sound. Changes in instream flow, however, primarily affect water-dependent recreational opportunities. Water-enhancing recreational activities such as picnicking and hiking are not reliant upon how much water is flowing in the river. As such, implementation of either alternative would not be expected to affect water-enhancing recreational opportunities. As such, the discussion below focuses on water dependent activities and does not provide any additional analysis of potential effects on water-enhancing recreational opportunities in the Watershed, the Cedar River, or Lake Washington.

No Action Alternative (IF-1)

Watershed Recreation

Implementation of the No Action Alternative would not affect water-dependent recreation opportunities occurring within the Watershed. The City does not allow public access to the Watershed for public recreational purposes.

Water-dependent activities at the Rattlesnake Lake Recreational Area would not be affected because changes in water flow downstream of Landsburg Diversion would not affect the hydrology of Rattlesnake Lake.

In addition, implementation of the No Action Alternative for instream flow would not affect existing recreational activities enjoyed at the Landsburg Park.

Cedar River Recreation

The Cedar River below Landsburg Diversion offers a variety of water-dependent recreational activities. During warm spring and summer months, people wade and swim in the river from one of the many parks along the river. Implementation of the No Action Alternative would not change water-dependent recreation activities from existing conditions. In contrast, implementation of the Proposed HCP Alternative would commit the City to guarantee instream flows that would be similar to or greater than existing conditions. As such, implementation of either of the alternatives would not negatively affect wading and swimming activities during summer months along the Cedar River below Landsburg Diversion.

Boating on the Cedar River

Boating is also quite popular on this segment of the Cedar River. Rafts and row boats are commonly seen on the river during warm months of the year. Whitewater kayaking is popular on the river during winter and early spring months when instream flows are high. Whitewater rafting is less common on this stretch of the Cedar River. The following discussion provides a detailed analysis of potential affects on boating activities from changes in instream

flows in the Cedar River. This analysis demonstrates that the opportunities for recreational boating on the Cedar River below Landsburg Diversion are expected to remain essentially unchanged.

Wide Variation of Streamflows Exist Under Baseline Conditions

Review of past and recent streamflow measurement records made by USGS shows that there is a wide range of variation and fluctuation of daily flow values seen in the Cedar River below Landsburg Diversion Dam. To illustrate this variation in streamflows for the No Action Alternative, Figure 3.2-9, Figure 3.2-10 and Figure 3.2-11, found in Section 3.2.1, show average daily streamflow records taken from published annual USGS water resources data reports for water years 1974, 1981 and 1993, respectively. Over the past 30 years, these selected water years generally represent high, median, and low flow years for the Cedar River. These flow measurements were made at the USGS Stream Gauge No. 12119000 in the Cedar River at Renton. The magnitudes, fluctuations and variations in streamflow values can be seen by inspection of the daily data. Also, in Section 4.2.5, Figure 4.2-2 shows streamflow statistics for the Cedar River at Renton and includes the 1979 normal minimum instream flow regime and the proposed HCP instream flow regime for reference.

Boating activities are closely tied to the amount of water flowing in the river, and the Cedar River's flow characteristics provide for a variety of different types of boating experiences. During the warm months of late spring and summer, row boats, rafts, and canoes are commonly seen on the Cedar River. In the late summer, however, low instream flow typically exposes gravel bars, which become obstacles for these boaters. When water levels are high during the winter and early spring months, boaters keen on kayaking take to the river, particularly between the Landsburg Diversion and Maple Valley (Bennett, 1991). Due to the narrow river channel and overhanging vegetation upstream of Maple Valley, the Cedar River is not frequently used for whitewater rafting. Thus, there are several boating seasons that correlate to different seasonal water levels and the optimum flow level for one activity may exclude another.

The Proposed HCP Alternative Assures Minimum Streamflows

Under the Proposed HCP Alternative, boaters would continue to see the wide range of flow variations and fluctuations associated with the Cedar River after the adoption of the proposed instream flow agreement for their various boating activities and experiences. The Applicant's proposed instream flow agreement, by definition, deals with minimum instream flow values (Technical Appendix 27). By committing to the proposal, Seattle would ensure that flows measured at the USGS Stream Gage No. 12117600 below Landsburg, at river mile 20.4, would not drop below certain minimum flow levels critical to protecting the biological needs of the Cedar River fisheries. These minimum flow values are based on recent extensive scientific studies done in

collaboration with state and federal resource agencies and the Muckleshoot Indian Tribe. From a boater's perspective, the protection of minimum instream flows under the Proposed HCP Alternative should be considered a new benefit to them.

The City's Ability to Manage and Control Downstream Flows has Limitations

As described in Section 3.2.1, the City does not have the ability to trim and/or augment flows downstream of Landsburg in such a discretionary way that people might be aware of on other regulated rivers. The reservoir storage capacity behind Masonry Dam, located in the Cedar River headwaters, is small compared to the high inflows associated with the upper Cedar River Municipal Watershed. Masonry Dam was not originally built for flood control purposes and although Seattle's dam management strategies include incidental flood control operations to benefit the lives of people and their property, the City's ability to control downstream flood flows has its limitations and is a complex operational activity.

By the same token, the reservoir's small size also limits the City's ability to make additional discretionary reservoir releases at certain times of the year to supplement low flows in the river without creating undue risks of drawing down the reservoir to levels that would make it difficult to provide water supply and instream flows required for the biological needs of the fisheries.

The City's ability to manage and control flows at the Landsburg Diversion Dam is also limited. This diversion dam is too small to provide significant storage or reregulation of flows. The Landsburg Dam is operated in a run-of-river mode, passing all flows over the dam which are not diverted for water supply. During periods of high turbidity in the river, or during facility maintenance, diversion may cease altogether.

Finally, large unregulated streamflows tributary to the Cedar River between Masonry Dam and the Landsburg Diversion Dam, as well as tributary streamflows downstream of Landsburg, contribute to the total volume of water seen in the Cedar River. This aspect of the Cedar River system accentuates the limitations of the City's ability to control certain high flows and downstream flooding events with its dam facilities.

From an operational perspective, the Proposed HCP Alternative would protect instream flows during any period of low flow and would have little effect on the range of streamflow variations expected in the higher flow ranges seen in past and recent streamflow records. Boater's would expect to see river flows above the proposed state minimum instream flow values in most years.

Modeled Flow Comparison between the Proposed HCP and No Action Alternatives

To further assess the incremental effect of the Proposed HCP Alternative, a simplified water balance model of the Cedar River system was made assuming

representations of (1) the proposed minimum instream flow regime and (2) the 1979 State of Washington minimum instream flow requirements. The purpose of the model is to provide a comparison of average monthly modeled flows in the Cedar River between these two instream flow scenarios. Both modeled scenarios deal with simplifying assumptions about the Cedar River system and operational constraints. The results from the model are not intended to predict actual future monthly flows in the Cedar River. Rather, the model is used here to anticipate if there will be any significant differences in mean monthly flows of the City's proposal compared to following the state's 1979 minimum instream flow regime.

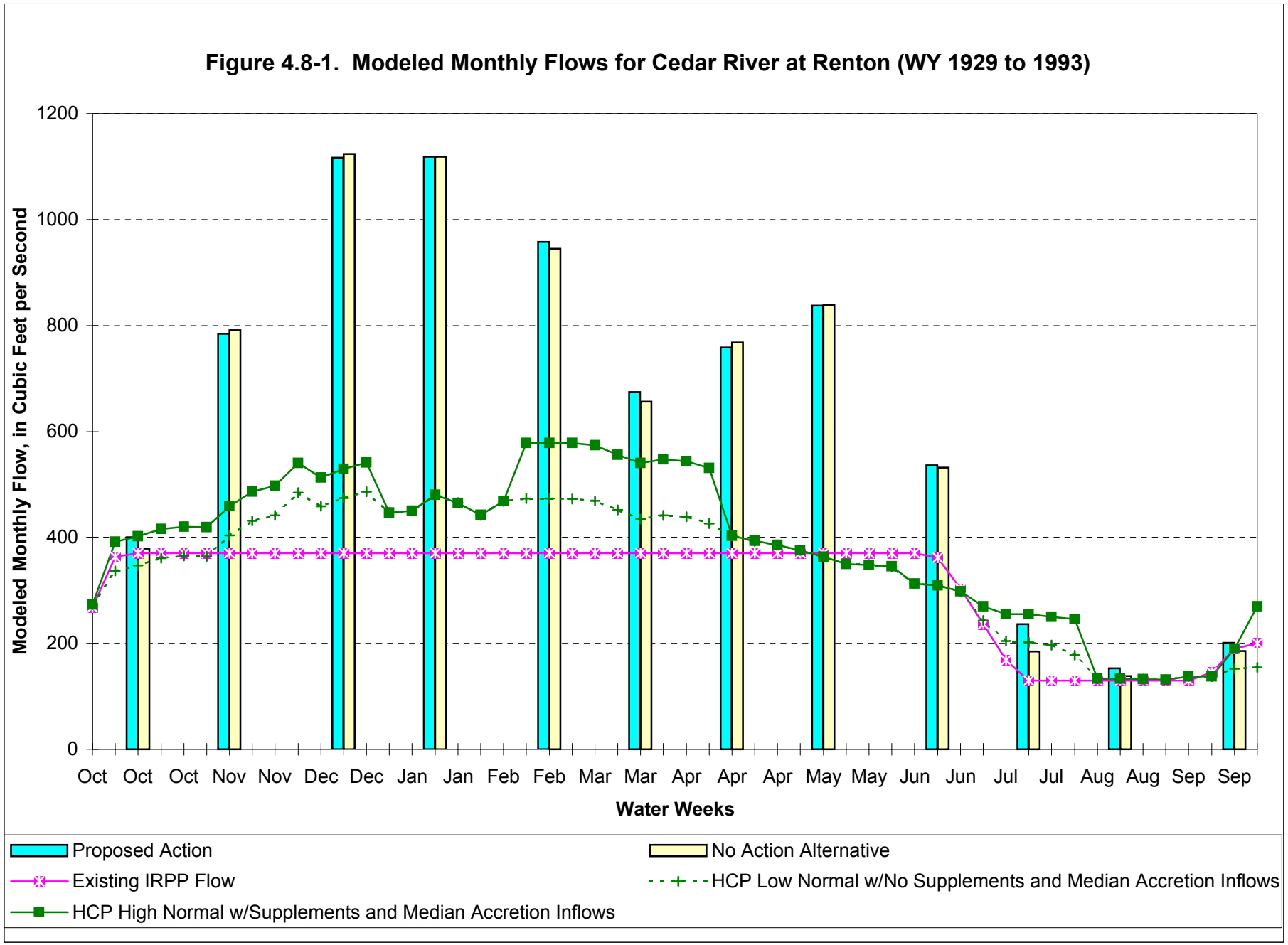
Major assumptions included in the model are (1) under the No Action Alternative, the Applicant is assumed to voluntarily follow the 1979 State of Washington minimum instream flow regime requirements; (2) under the Proposed HCP Alternative, the Applicant is assumed to follow the proposed minimum instream flow regime requirements; (3) under the Proposed HCP Alternative, the supplemental instream flow commitments from the Applicant are included in the analysis with an understanding that there are limitations associated with modeling actual real-time operational constraints and the collaborative decision-making processes that will occur between resource agencies and the Muckleshoot Indian Tribe; and (4) streamflow records used for the analysis are from the 64.5-year period 1929 to 1993.

The results of the model show that there is essentially no difference in average monthly modeled flows in the Cedar River at Renton using the City's proposed instream flow regime when compared to the scenario of the City's abiding by the 1979 state minimum instream flow regime. A comparative graph of the average monthly modeled flow results for these two scenarios is shown in Figure 4.8-1, and includes the 1979 normal minimum instream flow regime and the proposed HCP instream flow regime for reference.

Proposed HCP Alternative Offers Commitments to Provide Supplemental Flows Above Minimums

Unlike the No Action Alternative, the Proposed HCP Alternative would provide additional flows for specific fisheries needs over and above the minimum instream flow regime requirements. Specifically, between February 11 and April 14, the Applicant would set a goal to supplement minimum instream flows by 105 cfs 70 percent of the time in normal years for sockeye out-migration needs.

Between June 17 and August 4, the Applicant would provide 2,500 acre feet of water in all normal years and another 3,500 acre feet of water in 70 percent of all normal years. Known as blocks of water, the water releases would be specifically allocated over this time period as determined by the Parties, acting through the Commission as defined in the instream flow agreement. The purpose of these releases would be to protect steelhead redds.



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For sockeye and chinook spawning needs, the Applicant would, under certain conditions, supplement normal minimum instream flows by 38 cfs between September 15 and 22, and by 115 cfs between September 23 and 30. Second, the Applicant would supplement critical minimum flows by 10 cfs each day between September 1 and 15 during critical low flow periods. These critical low flows are hydrologically expected to occur one in ten years on average.

And between October 8 and December 31, the City would follow, on average, a high normal minimum flow regime in six of nine normal years, and a low normal minimum flow regime in 3 of nine normal years for sockeye and chinook spawning. The high normal flow regime is 55 cfs higher than the low normal flow regime.

What the Proposed HCP Alternative Does Not Do

By all of the above discussion points, boaters can expect to see flows above the 1979 minimum flow regimes established by the State of Washington most years. It is important for boater interest groups and individuals to recognize the Proposed HCP Alternative does not address or include new arrangements for special reservoir releases for boating activities in the Cedar River below Landsburg. On this issue, the effect of the Proposed HCP Alternative would be the same as the No Action Alternative.

To the extent that regulated flows for fisheries management coincide with specific boater interests and purposes, the City could continue to accommodate, within limitations, some flow scheduling to meet specific boater use requests. The City has coordinated with the boating community in the past and will continue to do so in the future.

Lake Washington Recreation

Implementation of the No Action Alternative for instream flows would not affect water-dependent recreational activities in Lake Washington or the waters linking the lake to the Puget Sound. The Cedar River Basin does contribute approximately 50 percent of the inflow into Lake Washington and obviously has great influence over the water level in Lake Washington. The drainage from other watersheds and the operation of the Hiram M. Chittenden Locks also influence the water level in Lake Washington. As a result, implementation of this instream flow alternative would not significantly affect water-dependent recreational opportunities in Lake Washington or the waters linking the lake to the locks. Moreover, water levels between the locks and Shilsole Bay in the Puget Sound would not be significantly affected by the alternative.

Proposed HCP Alternative for Instream Flows (IF-2)

Watershed Recreation

Implementation of the Proposed HCP Alternative for Instream Flow would not affect water-dependent recreation opportunities occurring within the Watershed or at the Rattlesnake Lake Recreational Area. Potential effects would be the same as described for the No Action Alternative. The potential effects on water-dependent recreation activities at the Landsburg Park would be similar to those described under the No Action Alternative. For purposes of assessing potential effects on water-dependent recreation activities at Landsburg Park, the effects should be considered the same as those described under the No Action Alternative.

Cedar River Recreation

The potential effects on water-dependent recreation in and along the shoreline of the Cedar River would be similar to those described for the No Action Alternative. As such, the potential effects on water-dependent recreation, including kayaking, are essentially the same as described under the No Action Alternative.

Lake Washington Recreation

Under this Proposed HCP Alternative for Instream Flows, the potential effects on recreational opportunities in and along the shores of Lake Washington and the waters linking the lake with the Puget Sound would be nearly identical to those described above for the No Action Alternative.

4.8.5 Summary

A summary of environmental consequences for recreation is presented in Table 4.8-1. These consequences are also summarized here for the Watershed Management, Anadromous Fish Mitigation, and Instream Flow Alternatives.

The opportunities for public recreation in the Watershed, the Cedar River downstream of Landsburg Diversion, and Lake Washington and the waters that link the lake to the Puget Sound would not be negatively affected by implementation of any of the proposed alternatives. Because the City cannot allow public access in the hydrologic boundaries of the Watershed, the implementation of Watershed Management, Anadromous Fish Mitigation, and Instream Flow Alternatives would not affect recreational opportunities in this area.

Habitat restoration activities associated with the Watershed Management and Anadromous Fish Mitigation Alternatives would not affect water-dependent recreational opportunities at the Rattlesnake Lake Recreation Area. These activities, however, would be expected to increase the likelihood that visitors to Landsburg Park on the Cedar River would see migrating fish. Other forms

of water-enhancing and water-dependent recreation commonly enjoyed by visitors to these park would not be negatively affected by the implementation of any of alternatives. In fact, construction of a new hatchery or fish passage over the Landsburg Dam would likely attract more visitors to Landsburg Park.

The implementation of habitat restoration activities for anadromous fish, including Watershed Management, Anadromous Fish Mitigation, and Instream Flow Alternatives, would generally increase opportunities to view fish and other wildlife from the shores of the Cedar River downstream of Landsburg Diversion. Summer-time activities such as swimming and rafting would essentially remain unchanged or would increase due to the implementation of the Proposed HCP Alternative for instream flows. Kayaking and whitewater rafting are most popular during months of high instream flows and detailed modeling demonstrated that boaters would continue to experience the same variety of peak flows during the same winter and spring months. Moreover, implementation of the proposed instream flow alternative, would be expected to improve the health and persistence of fish runs in the Cedar River and potentially could result in the reopening of the fishery.

None of the Watershed Management or Instream Flow Alternatives would result in changes to recreational opportunities in and around Lake Washington and the waters that link the lake to the Puget Sound. The Cedar River is one of several rivers that flow into Lake Washington. The aggregate inflow and lake water level is managed by the Corps of Engineers through the operation of the Hiram Chittenden Locks. Water-enhancing recreation such as picnicking, wildlife viewing, hiking, and biking would not be affected by likely improvements in the quality of water and legally-binding minimum instream flows in the Cedar River. In addition, effects resulting form the implementation of the alternatives would not affect boating and swimming.

Implementation of the proposed alternatives for Watershed Management, Anadromous Fish Mitigation, and Instream Flows, however, would be expected to benefit the fisheries of Lake Washington and the waters linking the lake to Puget Sound. Depending on the long-term success of these proposed actions and other related factors affecting the survivability of Lake Washington fish runs, opportunities for recreational fishing for coho, chinook, and sockeye salmon and steelhead trout could expand for Lake Washington.

Table 4.8-1 Summary of Environmental Consequences Evaluated for Recreation (page 1 of 3)

Potential Impact Evaluated	Environmental Consequences					Comments
	Watershed Management Alternatives					
	WM-1	**WM-2**	**WM-3**	**WM-4**	**WM-5**	
Potential effects on public access for recreational purposes in the Cedar River Municipal Watershed	No Effects	No Effects	No Effects	No Effects	No Effects	Unsupervised public access to the Cedar River Municipal Watershed is prohibited under all of the Watershed Management alternatives. As a result, access to the watershed for recreational purposes will not be affected by any of the alternatives.
Potential effects on recreational use and aesthetics of the Rattlesnake Lake area from timber harvesting in the Cedar River Municipal Watershed	No Effects	No Effects	No Effects	No Effects	No Effects	The Rattlesnake Lake Viewshed is included in the ecological reserve designs for all of the Watershed Management alternatives. As a result, recreational use of the Rattlesnake Lake area will not be affected by any of the alternatives.
Potential effects on recreational activities on the Cedar River downstream of Landsburg	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Protection of water quality from the large reserves in all of the alternatives may provide small net benefits to recreational uses on the Cedar river downstream of Landsburg but effects between the alternatives is negligible.
Potential effects on the recreational uses of Lake Washington	No Effects	No Effects	No Effects	No Effects	No Effects	Watershed Management activities for the alternatives are not anticipated to have any affect on recreational uses on Lake Washington.
	Anadromous Fish Mitigation Alternatives					
	AFM-1	**AFM-2**	**AFM-3**	**AFM-4**	**AFM-5**	
Potential effects on recreation within the Cedar River Municipal Watershed	No Effects	No Effects	No Effects	No Effects	No Effects	Unsupervised public access to the Cedar River Municipal Watershed would continue to be prohibited under all of the Anadromous Fish mitigation alternatives.
Potential effects on recreation within the Rattlesnake Lake recreational area	No Effects	No Effects	No Effects	No Effects	No Effects	The anadromous fish mitigation alternatives would not affect fisheries in Rattlesnake Lake and as a result would not affect recreation in the area.

Table 4.8-1 Summary of Environmental Consequences Evaluated for Recreation (page 2 of 3)

Potential Impact Evaluated	Environmental Consequences					Comments
	Anadromous Fish Mitigation Alternatives (cont.)					
	AFM-1	AFM-2	AFM-3	AFM-4	AFM-5	
Potential effects on recreational fishing within the Cedar River downstream of Landsburg and also Lake Washington	Positive Effects	Positive Effects	Positive Effects	Positive Effects	Positive Effects	Recreational fishing for sockeye salmon in the Cedar River and Lake Washington is dependent on the returns of adult fish which are affected by many factors, including fry survival in Lake Washington, passage through the Hiram Chittendon Locks, loss of habitat from encroaching urban development, commercial fishing pressures, etc. For these reasons it is not known exactly what effects the anadromous fish mitigation alternatives will have on recreational fishing in the region. However, most of the alternatives, including AFM-2, AFM-3, AFM-4 and AFM-5 are expected increase the production of sockeye fry above current conditions. Any measure that would increase production of sockeye or other anadromous salmonids in the basin would increase the chance for tribal, commercial or sport fishing. As a result, these alternatives are expected to have a positive effects. The potential environmental consequences are unknown for the No Action Alternative (AFM-1) because the timing of mitigation, if provided at all under this alternative, is uncertain.

Table 4.8-1 Summary of Environmental Consequences Evaluated for Recreation (page 3 of 3)

Potential Impact Evaluated	Environmental Consequences		Comments
	Instream Flow Alternatives		
	IF-1	IF-2	
Potential effects on the recreational use of the Watershed or Rattlesnake Lake Recreational area.	No Effects	No Effects	Unsupervised public access within the Cedar River municipal watershed is prohibited. As a result, the alternative flow regimes would not have an effects on recreation within the Watershed. Changes in flows would not affect recreation at Landsburg Park. Water-dependent recreational activities at Rattlesnake Lake would not be affected because the two flow alternatives would not affect the hydrology of Rattlesnake Lake.
Potential effects on recreational boating on the Cedar River between Landsburg and Lake Washington	No Effects	Negligible Effects	The instream flow regime proposed as part of the HCP alternative, IF-2, is not expected to have negligible effects compared to the No Action Alternative, 1F-1.
Potential effects on Lake Washington recreation	No Effects	Negligible Effects	The alternative flow regimes are not expected to have any effects on recreational activities on Lake Washington.

4.9 Public Services

4.9.1 Introduction

In the Cedar River Municipal Watershed, there are three key public services that could be affected by the implementation of any of the alternatives proposed for Watershed Management, Anadromous Fish Mitigation, and Instream Flow. These public services include the following: (1) the supply of potable water to SPU's customers; (2) the generation of electric energy at the Seattle City Light Cedar Falls Hydroelectric Plant; and (3) the control of flooding of the Cedar River. The following paragraphs briefly describe the potential effects on public services resulting from the implementation of the proposed alternatives. A more detailed analysis of changes in water quantity and water quality is found in Section 4.2.

4.9.2 Watershed Management Alternatives

There are five alternatives considered for management of the Cedar River Municipal Watershed. The elements of the five alternatives would not be expected to affect public services provided by the City of Seattle.

Seattle Public Utilities - Potable Water

No Action Alternative for Watershed Management (WM-1)

The Watershed is a primary source of potable water for most King County residents and businesses. The volume of water available for use is dependent upon precipitation and snowfall. The total quantity of water flowing in the river would not be altered by activities associated with watershed management activities. Thus, the implementation of this alternative would have no effect on the availability of potable water from the Watershed.

The quality of water could be affected by timber harvest activities associated with the management of the Watershed (see Section 4.2 , Water Quantity and Quality). However, these effects would only be localized and generally would not affect the quality of water downstream at the Landsburg Diversion. Activities in the urbanizing Taylor Creek drainage, however, may affect water

quality at the Landsburg Diversion in the future. Restrictions on the use of dirt roads during wet weather and closure of the intake valve at Landsburg Diversion would greatly reduce high levels of suspended sediments in the water diverted for public drinking water. Thus, implementation of the No Action Alternative would not effect the quality of public drinking water.

Proposed HCP Alternative for Watershed Management (WM-2)

The potential effects from the implementation of this alternative would be very similar to those described for the No Action Alternative.

Long-term Sustainable Thinning Alternative (WM-3)

The potential effects from the implementation of this alternative would be very similar to those described for the No Action Alternative.

Thinning Alternative with Phased Out Commercial Timber Harvest (WM-4)

The potential effects from the implementation of this alternative would be very similar to those described for the No Action Alternative.

No Commercial Timber Harvest Alternative (WM-5)

The potential effects from the implementation of this alternative would be similar to those described for the No Action Alternative. Potential impacts, however, would be even less likely under this alternative as there would be no timber harvesting activities associated with management of the Watershed.

Seattle Public Utilities - Flood Control

No Action Alternative for Watershed Management (WM-1)

Under the No Action Alternative, there likely would be no changes in the number or magnitude of potential floods in the Watershed, the Cedar River downstream of the Landsburg Diversion, or Lake Washington (see Section 4.2 Water Quantity and Quality). Watershed management activities could increase localized peak flows, but Washington forest practices, BMPs, and the lack of any alteration of the natural floodway would mitigate the potential risk of flood damage in the Watershed. The applicant's watershed management activities associated with this alternative, however, would not directly affect surface water runoff in the subbasin that drain into the Cedar River below Landsburg Diversion or the water level of Lake Washington. Consequently, there would be no effect on flood flows downstream of Cedar Falls, Landsburg Diversion, or in Lake Washington under this alternative.

Proposed HCP Alternative for Watershed Management (WM-2)
The potential effects from the implementation of this alternative would be very similar to those described for the No Action Alternative.

Long-term Sustainable Thinning Alternative (WM-3)
The potential effects from the implementation of this alternative would be very similar to those described for the No Action Alternative.

Thinning Alternative Designed to Phase Out Commercial Timber Harvest (WM-4)
The potential effects from the implementation of this alternative would be very similar to those described for the No Action Alternative.

No Commercial Timber Harvest Alternative (WM-5)
The potential effects from the implementation of the No Commercial Timber Harvest Alternative would likely result in even less potential impact on flooding than described under the No Action Alternative. This is due to the lack of timber harvesting activities in the proposed watershed management activities under this alternative.

Seattle City Light Hydroelectric Generating Plant

No Action Alternative for Watershed Management (WM-1)
Independent of proposed watershed management activities associated with the No Action Alternative, the operation of the Cedar Falls Hydroelectric Plant remains dependent on water quantity. As described above, differing levels of timber harvesting and watershed management practices would not be expected to change flows in the Cedar River. Water would continue to flow through the power plant, the bypass, or overflow Masonry Dam. The total amount of electric energy generated at the facility would still fall within the average annual generation capacity of the installed generators. The plant would continue to generate less than 1 percent of the utility's available supply of energy to meet customer demand. As such, implementation of this alternative would not affect Seattle City Light's ability to meet customer demand for electricity.

Proposed HCP Alternative for Watershed Management (WM-2)
The potential effects from the implementation of this alternative would be very similar to those described for the No Action Alternative.

Long-term Sustainable Thinning Alternative (WM-3)
The potential effects from the implementation of this alternative would be very similar to those described for the No Action Alternative.

Thinning Alternative Designed to Phase Out Commercial Timber Harvest (WM-4)
The potential effects from the implementation of this alternative would be very similar to those described for the No Action Alternative.

No Commercial Timber Harvest Alternative (WM-5)
The potential effects from the implementation of this alternative would be very similar to those described for the No Action Alternative.

4.9.3 Anadromous Fish Mitigation Alternatives

There are five alternatives considered for mitigation of anadromous fish in the Cedar River Basin. The primary difference among the alternatives is how mitigation for sockeye salmon would be provided. The sockeye salmon mitigation measures range from habitat restoration within the Watershed and downstream of Landsburg Diversion, construction of a fish passage facility over Landsburg Diversion, constructing a small or large hatchery to replace the existing interim facility. The existing interim facility is located downstream of the Landsburg Diversion and the proposed location of a new facility would be located in close proximity to the existing facility site. None of these proposed measures would be expected to affect public services supplied by the applicant from resources within the Watershed.

Seattle Public Utilities - Potable Water

No Action Alternative (AFM-1)
Implementation of anadromous fish mitigation measures proposed under the No Action Alternative would not affect the Cedar River above the Landsburg Diversion. As such, neither the quality or quantity of water diverted for public drinking water supplies would be affected by this alternative.

Proposed HCP Alternative for Anadromous Fish Mitigation (AFM-2)
Implementation of anadromous fish mitigation measures proposed under the Proposed HCP Alternative would not affect the quantity of water available for public drinking water supplies, but could potentially affect the quality of the water. Under this alternative, the applicant proposes to provide fish passage above Landsburg Dam. In particular, a fish passage would allow anadromous fish to inhabit the waters of the Cedar River above Landsburg Diversion but below the natural barrier of Cedar Falls (see Section 3.4, Fisheries Habitat and Resources). Consequently, during certain seasons of the year, there would be

an increase in the number of fish and fish carcasses in this portion of the river. These impacts, however, are not expected to result in a decrease in the quality of water available for public water supplies (see Section 4.2 Water Quantity and Quality). Consequently, the implementation of the Anadromous Fish Mitigation Alternatives would not affect the Applicant's ability to meet customer demands for high quality public water supplies.

Down-sized Sockeye Hatchery Alternative with Savings Going Towards Downstream Habitat Restoration (AFM-3)

The potential effects from the implementation of this alternative would be very similar to those described for the Proposed HCP Alternative.

Deferred Hatchery Construction Alternative Contingent on Evaluation of More Information (AFM-4)

The potential effects from the implementation of this alternative would be very similar to those described for the Proposed HCP Alternative.

All Downstream Habitat Restoration and Protection Alternative (AFM-5)

The potential effects from the implementation of this alternative would be very similar to those described for the Proposed HCP Alternative.

Seattle Public Utilities - Flood Control

No Action Alternative (AFM-1)

The implementation of the proposed anadromous fish mitigation measures of the No Action Alternative would have no effect on flows in the Cedar River, including flood flows (see Section 4.2 Water Quantity and Quality). The potential risk of flooding would continue to be primarily determined by the natural precipitation in the Watershed, urban development trends in the Taylor Creek drainage, the operation of Masonry Dam, and other factors affecting the water level in Lake Washington. The Landsburg Diversion would continue to function as a run-of-river facility. As such, implementation of this No Action Alternative for Anadromous Fish Mitigation would not affect flooding in the Cedar River below the Landsburg Diversion or in Lake Washington.

Proposed HCP Alternative for Anadromous Fish Mitigation (AFM-2)

Implementation of the Proposed HCP Alternative for Anadromous Fish Mitigation would not be expected to affect the risk of flooding of the Cedar River or Lake Washington. Though this alternative includes the construction of a fish passage at the Landsburg Diversion, the amount of water flowing in the Cedar River below the dam would not necessarily change. Combined volumes of water from flows through the fish passage or over the dam would be expected to be nearly the same as current volumes in order to ensure

sufficient quantities of water may be diverted for public drinking water. This can be accomplished through careful design of the fish passage.

Other activities proposed as part of the anadromous fish mitigation measures proposed under this alternative would occur downstream of the Landsburg Diversion and would not be expected to affect the likely number or magnitude of flood events of the Cedar River. The potential risk of flooding would continue to be primarily determined by the natural precipitation in the Watershed, urban development trends the Taylor Creek drainage, the operation of Masonry Dam, and other factors affecting the water level in Lake Washington. The Landsburg Diversion would continue to function as a run-of-river facility. As such, implementation of this alternative would not affect flooding of the Cedar River below the Landsburg Diversion.

Down-sized Sockeye Hatchery Alternative with Savings Going Towards Downstream Habitat Restoration (AFM-3)

The potential effects from the implementation of this alternative would be very similar to those described for the Proposed HCP Alternative.

Deferred Hatchery Construction Alternative Contingent on Evaluation of More Information (AFM-4)

The potential effects from the implementation of this alternative would be very similar to those described for the Proposed HCP Alternative.

All Downstream Habitat Restoration and Protection Alternative (AFM-5)

The potential effects from the implementation of this alternative would be very similar to those described for the Proposed HCP Alternative.

Seattle City Light Hydroelectric Generating Plant

No Action Alternative for Anadromous Fish Mitigation (AFM-1)

The No Action Alternative for Anadromous Fish Mitigation would not affect the amount of energy generated at the Cedar Falls Hydroelectric Plant. Proposed mitigation would occur downstream of the Cedar Falls, the river's natural fish barrier. Water would continue to flow through the turbines at the power house and excess volumes would be diverted to the hydroelectric plant's bypass pipeline. Generation of electricity at the Cedar Falls Hydroelectric Plant would continue to be limited by the capacity of the plant generators and the plant would continue to generate approximately 0.6 percent of the energy currently needed to meet customer demand.

Proposed HCP Alternative for Anadromous Fish Mitigation (AFM-2)

The potential effects from the implementation of this alternative would be very similar to those described for the No Action Alternative.

Down-sized Sockeye Hatchery Alternative with Downstream Habitat Restoration (AFM-3)

The potential effects from the implementation of this alternative would be very similar to those described for the No Action Alternative.

Deferred Hatchery Construction Alternative Contingent on Evaluation of More Information (AFM-4)

The potential effects from the implementation of this alternative would be very similar to those described for the No Action Alternative.

All Downstream Habitat Restoration and Protection Alternative (AFM-5)

The potential effects from the implementation of this alternative would be very similar to those described for the No Action Alternative.

4.9.4 Instream Flow Alternatives

There are two alternatives for instream flows, the No Action Alternative and the Proposed HCP Alternative. Under the No Action Alternative, management of flows generally would follow the minimum instream flow guidelines promulgated by the Washington Department of Ecology in 1979, but lack of an Incidental Take Permit (ITP) would create uncertainty about water supply and river operations. The Proposed HCP Alternative would commit SPU to maintain a specified minimum instream flow regime with both firm and non-firm components, and an ITP would eliminate the uncertainty of the effect of future endangered species listings on operations. The implementation of either of these alternatives could have some affect on the applicant's ability to continue to provide public services for public water, flood control, and electric energy generation.

Seattle Public Utilities - Potable Water

No Action Alternative (IF-1)

The implementation of the No Action Alternative for Instream Flows could affect the applicant's ability to continue to meet its customer demands for potable water. The No Action Alternative represents what is likely to occur as part of the management of instream flows if the applicant does not pursue an ITP and does not implement an approved HCP. The potential effects to the applicants ability to provide potable drinking water relate to the issues of *certainty* and the amount of unallocated water potentially available for water supply and fish.

Under this alternative, the applicant would follow the flow regime set in 1979 for the Cedar River by the Instream Resource Protection Program (IRPP) as general, nonbinding guidelines for managing flows. However, without an ITP, the applicant would have to address any potential future listing of threatened

and endangered fish species on a case-by-case basis. Currently, bull trout and chinook salmon have been proposed for listing. It is assumed that if these listings were to occur the applicant would have to tailor the management of instream flows to maximize benefits to listed species, possibly impacting other non-listed species constraining the applicant's water supply operations, and potentially reducing the City's water supply capability. It is not possible to quantify this potential impact, but the applicants' firm water supply yield, as well as the unallocated, or non-firm water, would be at risk. A fundamental reason for not recommending a No Action Alternative is that the future instream flow requirements would be highly uncertain, thus the water supply capability would be equally uncertain.

If listings did not affect flow commitments, on an average annual basis the IRPP instream flow regime commits approximately 40 percent of the Cedar River discharge to minimum instream flows. Another 23 percent represents the amount that has been diverted (based on the 1990s) for water supply. The remaining 37 percent is termed "unallocated" water, which historically has remained in the river, but could be allocated should future studies and developments reveal beneficial instream, downstream, or out-of-stream uses for some of this water. Modeling indicates that the firm yield of the total supply system, assuming nonbinding IRPP flows on the Cedar, is 160 mgd for the current configuration, and 171 mgd for the year 2000 configuration which includes the Tolt Treatment Facilities.

Regional water supply planning efforts must consider the yield of existing supply sources and the potential of future supply and demand management (conservation) projects. Under the No Action Alternative for instream flows, the effects on long-range water supply planning may be summarized as follows:

1. The current estimate of firm yield would remain unchanged, therefore no change in the timing or magnitude of new supply or demand management projects to meet future demand would be warranted,
2. The future firm yield of the Seattle supply system would be uncertain, subject to potential ESA listings as well as potential disagreements between the City and Corps of Engineers over appropriate Cedar River flows into Lake Washington, and
3. The commitments to instream flows would allow for future opportunities to use some of the unallocated water to meet future instream or out-of-stream uses.

Proposed HCP Alternative for Instream Flows (IF-2)

The implementation of the Proposed HCP Alternative for instream flow could affect the applicant's ability to continue to meet its customer demands for

potable water. As with the No Action Alternative, the potential effects to the applicants ability to provide potable drinking water relate to the issues of *certainty* and the amount of unallocated water potentially available for water supply and fish.

Under this alternative, the applicant would follow the flow regime proposed in the HCP, and operate under the terms of an ITP. Through the HCP, the applicant is making a 50-year commitment to a binding set of minimum instream flow requirements, to replace the current nonbinding flow targets, in order to ensure greater certainty in river flows. In addition, the applicant will provide non-firm water to supplement minimum instream flows under specified conditions. Greater certainty in instream flows produces greater certainty in water supply capability. The goals for both firm and non-firm flows will be incorporated into the applicants estimates and actions regarding the water supply capacity of the Cedar River system, which are part of the applicants water supply planning process. Neither the volume of water provided to meet the non-firm flow goals nor the frequency of the applicants achievement of those flows will be decreased throughout the 50-year term of the HCP.

Under the Proposed HCP Alternative, on an average annual basis the instream flow regime commits approximately 50 percent of the Cedar River discharge to minimum instream flows. Another 23 percent represents the amount that has been diverted (based on the 1990s) for water supply. The remaining 28 percent is unallocated water. The HCP allows the flexibility for future decisions regarding uses for this unallocated water. The HCP provides for a Commission which will serve as a forum for sharing of information and discussion concerning potential use of this unallocated water.

Modeling indicates that the firm yield of the total supply system, assuming HCP flow regime on the Cedar, is 160 mgd for the current configuration, and 171 mgd for the year 2000 configuration which includes the Tolt Treatment Facilities. This reflects no difference from the No Action Alternative.

Regional water supply planning efforts must consider the yield of existing supply sources and the potential of future supply and demand management (conservation) projects. Under the HCP Alternative for instream flows, the effects on long-range water supply planning may be summarized as follows:

1. The current estimate of firm yield would remain unchanged, therefore no change in the timing or magnitude of new supply or demand management projects to meet future demand would be warranted,
2. The future firm yield of the Seattle supply system would be certain, and
3. The commitments to instream flows would allow for future opportunities to use some of the unallocated water to meet future instream or out-of-stream uses.

Seattle Public Utilities - Flood Control

No Action Alternative (IF-1)

The implementation of the No Action Alternative for minimum instream flows would not alter the risk of flooding in the Cedar River or Lake Washington (see Section 4.2 Water Quantity and Quality). The applicant would continue to observe Washington State Department of Ecology instream flow guidelines. Because the proposed instream flows are minimums, observation of the guidelines would have no effect on flood flows in the Cedar River. Precipitation in the Watershed would continue to define the peak volume of flows in the Cedar River. Flood control and suburban development in the subbasins that drain into the Cedar River downstream of Masonry Dam, as well as the flood season operations of Masonry Dam, would continue to be the key factors affecting the risk of flooding in this section of the river. A number of other factors, in addition to flows in the Cedar River, affect potential flooding along the shores of Lake Washington. In sum, the implementation of the minimum instream flows proposed under this alternative would not be expected to affect the risks from flooding.

Proposed HCP Alternative for Instream Flows (IF-2)

The potential effects from the implementation of this alternative would be very similar to those described for the No Action Alternative. The hydrologic modeling that was used to develop and analyze the HCP flow regimes considered no change to flood season operations.

Seattle City Light Hydroelectric Generating Plant

No Action Alternative for Instream Flow (IF-1)

As described above, the No Action Alternative for Instream Flows define the minimum volume of water that would flow in the Cedar River below Landsburg Diversion. The implementation of the alternative would not affect the generation capacity of the Cedar Falls Hydroelectric Plant or Seattle City Light's abilities to meet customer demand for electricity.

Proposed HCP Alternative for Instream Flows (IF-2)

Approximately 0.5 miles of potential anadromous fish habitat is present in the river between the tailrace of the Cedar Falls Hydroelectric Project and the natural migration barrier formed by Lower Cedar Falls. This 0.5 mile bypass reach is located upstream of the influence of water delivered from Masonry Pool to the Cedar River via Cedar Falls Hydroelectric Project. Under the Proposed HCP Alternative, after construction of a fish ladder at Landsburg Diversion Dam and subsequent upstream passage of selected species of anadromous fish, the applicant will provide a minimum flow of 30 cfs on a continuous basis to protect rearing habitat in the Cedar River "Canyon Reach". Provision of this water will result in a small loss of hydropower generation, estimated to be worth approximately $86,000 annually. In addition, valve modifications at Masonry Dam are estimated to cost $500,000.

4.9.5 Summary

A summary of environmental consequences for public services is presented in Table 4.9-1. These consequences are also summarized here for the Watershed Management, Anadromous Fish Mitigation, and Instream Flow Alternatives.

Potential effects on the drinking water supply includes both water quantity and quality issues. The implementation of minimum instream flow alternatives affects flows above and below the Landsburg Diversion Dam. Neither alternative would affect the applicant's water claims in the Watershed, nor the firm yield estimate for the supply system. The No Action Alternative would not eliminate uncertainty about instream flow requirements and water supply operations in the face of potential endangered species listing. The Proposed HCP Alternative for Instream Flows commits more water to instream uses; consequently, less unallocated water is available for out-of-stream uses. Proposed alternatives for Watershed Management and Anadromous Fish Mitigation are primarily designed to improve water quality and fish habitat in the Cedar River. Analysis of likely increases in fish and fish carcasses in the Cedar River above Landsburg Dam due to the construction of a fish passage determined potential increases in nutrients or chemical compounds. Such changes, however, would be very small, if not negligible, and would not likely violate health standards or require additional water treatment.

Potential risk to flooding and flood damage is related to the maximum flows within the river system. Implementation of the Watershed Management Alternatives and the Anadromous Fish Mitigation Alternatives primarily address water quality issues. Increased flows from the Proposed HCP Alternative in the lower Cedar River due to the proposed watershed management activities in the proposed HCP would be undetectable. Operation of the Hiram M. Chittenden Locks would control the water level of Lake Washington and potential risk to flood damage along the lake's shoreline. Flood damage along the Cedar River below Landsburg Diversion would continue to be dependent upon flood control measures and suburban

development patterns in the lower subbasins of the Cedar River Basin, and the flood season operations of Masonry Dam, not activities in the Watershed.

Operation of the Cedar Falls Hydroelectric Plant depends on water quantity and operations at Masonry Dam. Implementation of any of the alternatives would have negligible effect on the amount of water flowing into Masonry Pool. Precipitation in the Watershed and the capacity of the electric energy generation facility would continue to determine the minimum and maximum amount of energy produced, respectively. Provision of minimum flows released below Masonry Dam will result in a small loss of hydropower generation. Implementation of any of the alternatives would not significantly alter Seattle City Light's ability to meet customer demand for electric energy.

Table 4.9-1 Summary of Environmental Consequences Evaluated for Public Services

Potential Impact Evaluated	Environmental Consequences					Comments
	Watershed Management Alternatives					
	WM-1	**WM-2**	**WM-3**	**WM-4**	**WM-5**	
Environmental review did not identify any potential impacts to Public Services from the Watershed Management Alternatives*						
	Anadromous Fish Mitigation Alternatives					
	AFM-1	**AFM-2**	**AFM-3**	**AFM-4**	**AFM-5**	
Flood control	No Effects	No Effects	No Effects	No Effects	No Effects	
Water supply	No Effects	No Effects	No Effects	No Effects	No Effects	The Andromous Fish Mitigation Alternatives are not expected to have any effect on water supply. For information on potential consequences to water quality see Section 4.2, Water Resources.
	Instream Flow Alternatives					
	IF-1			**IF-2**		
Water supply	Mixed Effects			Mixed Effects		Neither alternative would affect the current firm yield estimate for the supply system. IF-1 would not eliminate uncertainty about instream flows and water operations in the face of potential ESA listings, whereas IF-2 would provide certainty. IF-2 commits more water to instream uses, consequently less is available for potential out-of-stream uses.
Hydroelectric power generation	No Effects			Negligible Effects		Under IF-2, there would be a very small loss of electrical energy generation at the Cedar Falls Hydroelectric Project in some years due to 30 cfs minimum flow in the bypassed "canyon" reach.

* For more information on potential water quality impacts please see Section 4.2

4.10 Socioeconomic Effects

4.10.1 Introduction

Potential socioeconomic impacts likely to be caused by the development and implementation of the proposed HCP in the Cedar River Municipal Watershed are evaluated in this section. Baseline socioeconomic conditions of the study region were discussed previously in Section 3.10.

From a socioeconomic perspective, all impacts likely under each of the various alternatives are minimal. Potential socioeconomic impacts under the proposed HCP and alternatives fall under three classes. One class of socioeconomic impacts is associated with the various forest management scenarios. There are five forest management alternatives under consideration by SPU for the Cedar River Municipal Watershed above the point of municipal water withdrawal at Landsburg Diversion. One of these forest management alternatives (or some modification of one or more) will be included within the broader HCP for the Watershed. For each of these forest management alternatives, there are financial implications. The total cost of implementing all of the commitments made in the HCP is estimated at approximately $113.3 million over 50 years. Out of this total, approximately $30 million will be paid for by commitments related to the current and ongoing operations of SPU in the Cedar River Municipal Watershed. As a result, an additional $83.3 million will be needed to pay for commitments not covered by current operations. Financing these net HCP-related costs will need to come from additional funding sources that could include timber harvesting, increases in water rates, some other yet to be determined source, or a combination thereof.

The second class of socioeconomic impacts is associated with the various anadromous fish mitigation scenarios. There are five Anadromous Fish Mitigation Alternatives under consideration by SPU for the Cedar River Municipal Watershed. Each of these Anadromous Fish Mitigation Alternatives have implications for the commercial and recreational fisheries on Lake Washington.

The third class of socioeconomic impacts is associated with two instream flow alternatives under consideration by SPU for the Cedar River Municipal

Watershed. The operation of the City's water storage and diversion facilities and hydroelectric generating plant directly effects the quantity and quality of fish habitat. As in the case of the Anadromous Fish Mitigation Alternatives, these instream flow alternatives have implications for the commercial and recreational fisheries on Lake Washington.

4.10.2 Economic Impacts of Watershed Management Alternatives

There are five Watershed Management Alternatives under consideration for the Habitat Conservation Plan:

- No Action Alternative for Watershed Management (WM-1);
- Proposed HCP Alternative for Watershed Management (WM-2);
- Long-term Sustainable Thinning Alternative (WM-3);
- Thinning Alternative Designed to Phase Out Commercial Timber Harvest (WM-4); and
- No Commercial Timber Harvest Alternative (WM-5).

Common to all five alternatives is a core Ecological Reserve. With the exception of Alternative 1 and No Commercial Timber Harvest WM-5, there is allowance for ecological thinning and restoration to accelerate watershed function for water quality, fisheries, and wildlife populations. This ecological thinning and restoration will involve cutting trees inside the Reserve, from which some revenue in excess of cost may be derived.

No Action Alternative (WM-1)

Under the No Action Alternative, a core Reserve of 51,522 acres (58 percent) and a commercial timber base of 38,806 acres (42 percent) would be established. This alternative continues the present management direction established by the City's 1989 Secondary Use Policy. Commercial timber would consist of regeneration cuts only in timber stands of greater than 60 years old on an even flow, sustained yield basis. Maximum size of regeneration cuts sections would be no greater than 120 acres. The estimated average annual board feet of timber harvested under this No Action regime would range from between 20.9 MBF to 22.0 MBF (Table 4.10-1). This volume is an approximation of the maximum amount that could be harvested under Washington FPRs. Maximum potential income generated from timber harvest under this alternative could total approximately $299 million over 50 years.

Table 4.10-1. Summary of Timber harvest-related Employment and Earnings Effects Under the No Action Alternative (WM-1)

Decade	Timber Harvest Regeneration Cut Acres/yr.	Timber Harvest Million Board Feet/yr.	Direct Employment	Direct Labor Earnings (1998 $000)
Decade 1	623	20.869	39	1,991.1
Decade 2	524	20.868	39	2,070.8
Decade 3	457	20.930	40	2,205.5
Decade 4	511	21.696	41	2,344.4
Decade 5	467	22.049	42	2,487.4
Cumulative Total	25,820	1,064.120	2,010	110,991.4

Cumulative totals are annual averages summed over the fifty year period.

Note: Direct employment estimated on the basis of thousand board feet harvested in King County per logging contractor/worker in King County.
Sources: Seattle Public Utilities (timber harvest estimates); Washington State Department of Natural Resources (timber harvest); Washington State Employment Security Department and U.S. Census Bureau (employment and labor earnings).

The direct jobs and labor earnings (i.e., proprietors' income, wages and salaries) associated with the No Action Alternative timber harvest have been estimated based on the average amount of board feet harvested by logging worker. Over the fifty year period, the annual timber harvest would directly support an average of 39 to 42 workers.

Using economic multipliers borrowed and modified from a previous regional input-output model (Chase and Pascall, 1996), the total estimated annual economic impact within the King County region associated with the Cedar River Municipal Watershed timber harvest would range between 214 to 230 workers with $6.9 to $8.7 million in labor earnings over the 50-year period (Table 4.10-2). The total employment impact is calculated by multiplying the direct logging employment by that industry's total employment multiplier, which is 5.49 (=39*5.49). Likewise, the total annual labor income effect of $6.93 million during the first decade is obtained by multiplying the direct logging labor income by that industry's total income multiplier, which is 3.48 (=$1.99*3.48).

Table 4.10-2. Total Annual Economic Impact of Cedar River Municipal Watershed Timber Harvest for WM-1

Sector	*Output ($millions)*	*Employment*	*Labor income ($millions)*
Forestry	$3.843	20	$0.761
Logging	$11.195	42	$2.127
Other manufacturing	$1.772	10	$0.325
Construction	$0.281	3	$0.095
Transportation	$1.865	26	$0.714
Utilities	$0.688	3	$0.181
Wholesale & retail trade	$2.339	42	$0.899
Services	$3.812	67	$1.799
Other	$0.081	1	$0.030
Total	$25.876	214	$6.931

Note: Total economic impacts are for a typical year during the first decade.
Source: Chase & Pascall, 1996.

The logging activity associated with the timber harvest within the Cedar River Municipal Watershed indirectly affects activity within other sectors due to direct purchases of services and supplies by the logging industry (e.g., logging trucks, road construction, sawmills, replanting) and purchases of services and goods by logging industry employees.

In the context of the broader King County economy, the direct and total economic impacts associated with timber harvest activity under the No Action Alternative within the Cedar River Municipal Watershed is insignificant given a 1997 employment base of 1.06 million jobs with 46.3 billion in labor earnings. The total job gains associated with the No Action Alternative, WM-1, are equivalent to about .02 percent of King County's current job base.

Proposed HCP Alternative (WM-2)

Under the Proposed HCP Alternative of retention cutting and commercial thinning, there will be a Reserve of 56,220 (64 percent) acres and a commercial base of 32,108 acres (36 percent). The commercial base consists of retention cuts only, in timber stands that are at least 60 years old. Timber harvest would be on an even flow, sustained yield basis and would include commercial thinning in areas where more than 5,000 board feet per acre could be removed. Final harvest areas would be limited to a maximum size of 120 acres. The estimated average annual board feet of timber harvested under this retention cut and commercial thin alternative would be about 8.8 million board feet (Table 4.10-3). This volume is approximately a 59 percent reduction from the total potential timber volume available under the No Action Alternative

Table 4.10-3. Summary of Timber harvest-related Employment and Earnings Effects Under the Proposed HCP Alternative (WM-2)

Decade	*Retention Cut Acres/yr.*	*Timber Harvest Commercial Thin Acres/yr.*	*Million board feet/yr.*	*Direct Employment*	*Direct Labor Earnings (1998 $000)*
Decade 1	110	369	8.788	17	$847.8
Decade 2	242	0	8.786	17	$881.5
Decade 3	215	0	8.788	17	$915.6
Decade 4	45	588	8.852	17	$956.4
Decade 5	199	0	8.795	17	$984.2
Cumulative Total	8,110	9,570	440.090	832	$45,855.2

Cumulative totals are annual averages summed over the fifty year period.

Note: Direct employment estimated on the basis of thousand board feet harvested in King County per logging contractor/worker in King County.

Sources: Seattle Public Utilities (timber harvest estimates); Washington State Department of Natural Resources (timber harvest); Washington State Employment Security Department and U.S. Census Bureau (employment and labor earnings).

(WM-1). Maximum potential income generated from timber harvest as part of the Proposed HCP Alternative (WM-2) could total approximately $119 million over 50 years.

The direct jobs and labor earnings (i.e., proprietors' income, wages and salaries) associated with the Proposed HCP Alternative (retention cut and commercial thin) timber harvest have been estimated based on the average amount of board feet harvested by logging worker. Over the 50-year period, the annual timber harvest would directly support an average of 17 workers.

Using economic multipliers borrowed and modified from a previous regional input-output model (Chase and Pascall, 1996), the total annual economic impact within the King County region associated with the Cedar River Municipal Watershed timber harvest is estimated at 93 workers with $3 million in labor earnings. In the context of King County—the largest economy within Washington State, with 1.06 million jobs and 46.3 billion in labor earnings—these economic effects hardly register with .009 percent of total employment.

Long-term Sustainable Thinning Alternative (WM-3)

This alternative consists of a Reserve of 56,220 acres (64 percent) and a commercial base of 32,108 acres (36 percent). Timber harvest, consisting of commercial thinning only, would be allowed outside the Reserve. Timber harvest would be on an even flow, sustained yield basis. Affected acres for commercial thinning would occur only during decades one and four (Table 4.10-4). The total board feet of timber harvested would be about 183.62 million board feet (Table 4.10-4). This volume is approximately an 82 percent reduction from the total potential timber volume available under the No Action

Table 4.10-4. Summary of Timber harvest-related Employment and Earnings Effects Under the Commercial Thin Alternative (WM-3)

	Timber Harvest			*Direct*
Decade	*Commercial Thin Acres/yr.*	*Million board feet/yr.*	*Direct Employment*	*Labor Earnings (1998 $000)*
Decade 1	348	3.367	6	$324.8
Decade 2	0	0.000	0	$0.0
Decade 3	0	0.000	0	$0.0
Decade 4	1,618	14.995	28	$1,620.2
Decade 5	0	0.000	0	$0.0
Cumulative Total	19,660	183.620	347	$19,449.8

Cumulative totals are annual averages summed over the fifty year period.

Note: Direct employment estimated on the basis of thousand board feet harvested in King County per logging contractor/worker in King County.
Sources: Seattle Public Utilities (timber harvest estimates); Washington State Department of Natural Resources (timber harvest); Washington State Employment Security Department and U.S. Census Bureau (employment and labor earnings).

Alternative (WM-1). As a result, maximum potential income generated by the long-term sustainable thinning alternative (WM-3) could be approximately $14.4 dollars.

In general, the proposed direct actions under this alternative will have minimal impacts on existing (baseline) socioeconomic conditions. Unlike WM-1 and WM-2, timber-related activity will occur in only two decades. Commercial thinning activity during the first decade will result in an estimated 38 total jobs with $1.35 million of labor earnings. During the fourth decade, commercial thinning is estimated to be nearly five times as extensive in acreage. Total economic effects will obviously be greater (153 jobs with $5.6 million in labor earnings), but in the broader context of the King County economy, the impact is insignificant.

Thinning Alternative Designed to Phase Out Commercial Timber Harvest (WM-4)

This alternative would end commercial timber harvest by the end of 50 years. The alternative consists of a Reserve of 56,220 acres plus an additional 3,590 acres (total 68 percent); and a commercial base of 28,518 acres (32 percent). The commercial base under this alternative is further divided into four zones. Neither regeneration or retention cutting would occur; only commercial thinning would occur under this alternative. Affected acres for commercial thinning would occur only during decades one and three (Table 4.10-6). The total board feet of timber harvested would be about 176.18 million board feet (Table 4.10-5). This volume is approximately a 83 percent reduction from the

Table 4.10-5. Summary of Timber harvest-related Employment and Earnings Effects Under the Thinning Alternative Designed to Phase Out Commercial Timber Harvest (WM-4)

Decade	Timber Harvest: Commercial Thin Acres/yr.	Timber Harvest: Million Board Feet/yr.	Direct Employment	Direct Labor Earnings (1998 $000)
Decade 1	1,138	9.499	18	916.4
Decade 2	0	0.000	0	0.0
Decade 3	0	0.000	0	0.0
Decade 4	959	8.119	17	865.3
Decade 5	0	0.000	0	0.0
Cumulative Total	20,970	176.180	350	17,817.0

Cumulative totals are annual averages summed over the fifty year period.

Note: Direct employment estimated on the basis of thousand board feet harvested in King County per logging contractor/worker in King County.

Sources: Seattle Public Utilities (timber harvest estimates); Washington State Department of Natural Resources (timber harvest); Washington State Employment Security Department and U.S. Census Bureau (employment and labor earnings).

total potential timber volume available under the No Action Alternative (WM-1). As a result the maximum potential income generated under Alternative WM-4 is estimated at approximately $12 million.

In general, the proposed direct actions under this alternative will have minimal impacts on existing (baseline) socioeconomic conditions. Similar to alternative WM-3, timber-related activity under the alternative WM-4 will occur in only two decades. Commercial thinning activity during the first decade will result in an estimated 99 total jobs with $3.2 million of labor earnings. During the fourth decade, commercial thinning acreage is estimated to be slightly less than the first decade. Total economic effects will be 93 jobs with $3.0 million in labor earnings. Again, in the broader context of the King County economy, the impact is insignificant.

No Commercial Timber Harvest Alternative (WM-5)

Under the no-harvest alternative, the entire Watershed would become Reserve (13,278 acres of core Reserve, plus 75,050 acres). Timber harvest (including ecological thinning and restoration) would not occur within the Cedar River Municipal Watershed, resulting in no timber volume and no related timber jobs and labor earnings. Obviously, the economic impact of not having these 39-42 related jobs and related labor earnings would be insignificant.

4.10.3 Financial Effects of Watershed Management Alternatives

The total cost of implementing all of the commitments made in the HCP is estimated at approximately $113.3 million over 50 years (in 1998 dollars).

Out of this total, approximately $30 million is allocated from commitments already budgeted as part of the SPU's current and ongoing operations in the Cedar River Municipal Watershed. As a result, an additional $83.3 million will be needed to pay for commitments not covered by current operations. Financing these net HCP-related costs will need to come from additional funding sources that could include timber harvesting, increases in water rates to SPU's wholesale and retail customers, some other yet to be determined source, or a combination thereof.

Under the Proposed HCP Alternative, the entire plan could be "rate-neutral" with respect to SPU's wholesale and retail customers, if the City Council so decides. Thus, net revenue obtained from its forest management program in the Watershed could be one option to finance the development and implementation of the proposed HCP. If the No Action Alternative is selected, net revenue from the forest management program could continue to accrue and presumably, projected wholesale and retail rate increases to finance its future capital improvements program will be reduced (Table 4.10-6).

Table 4.10-6. Estimated Revenues of Timber Management Program Under No Action Alternative for Watershed Management (WM-1)

Decade	Estimated Revenues	Estimated Costs	Estimated Net Revenues
Decade 1	$78.22	$11.86	$66.36
Decade 2	$75.15	$11.03	$64.12
Decade 3	$70.51	$10.55	$59.96
Decade 4	$66.42	$10.96	$55.46
Decade 5	$63.80	$10.63	$53.17
Cumulative Total	$354.10	$55.03	$299.07

Revenues and costs are in millions of 1998 dollars.

Source: SPU draft working paper, 1998c.

Under the Proposed HCP Alternative of retention cut and commercial thinning, implementation of the proposed HCP would be rate neutral (Table 4.10-7). Net revenue from this timber management alternative could more than sufficiently cover the projected costs of the proposed HCP on the Watershed.

Table 4.10-7. Estimated Revenues of Timber Management Program Under Proposed HCP Alternative for Watershed Management (WM-2)

Decade	Estimated Revenues	Estimated Costs	Estimated Net Revenues
Decade 1	$30.10	$9.53	$20.57
Decade 2	$34.98	$8.76	$26.22
Decade 3	$34.54	$8.97	$25.57
Decade 4	$27.37	$10.88	$16.49
Decade 5	$38.29	$8.28	$30.01
Cumulative Total	$165.28	$46.42	$118.86

Revenues and costs are in millions of 1998 dollars.

Under the other three watershed management alternatives (WM-3, WM-4, WM-5), net revenue from timber harvests would be insufficient to cover the costs of the proposed HCP. Thus, under these alternatives, the HCP could not be "rate neutral" and would have to be financed under a wholesale and/or retail customer rate increases, unless some other acceptable funding source was approved by the Seattle City Council. For the long-term sustainable thinning alternative (WM-3), total net revenue over the 50-year watershed management plan could be $14.38 million (Table 4.10-8). Under the thinning alternative designed to phase out commercial logging (WM-4), total net revenue could be even less at $11.89 million (Table 4.10-9). Obviously, under the no commercial timber harvest alternative (WM-5), no revenue from the timber management program could be available to finance the expected costs of the proposed HCP.

Table 4.10-8. Estimated Revenues of Timber Management Program Under Long-term Sustainable Thinning Alternative (WM-3)

Decade	Estimated Revenues	Estimated Costs	Estimated Net Revenues
Decade 1	$7.28	$8.76	-$1.48
Decade 2	$0.00	$0.00	$0.00
Decade 3	$0.00	$0.00	$0.00
Decade 4	$32.65	$16.79	$15.86
Decade 5	$0.00	$0.00	$0.00
Cumulative Total	$39.93	$25.55	$14.38

Revenues and costs are in millions of 1998 dollars.

Source: SPU draft working paper, 1998c.

Table 4.10-9. Estimated Revenues of Timber Management Program Under Thinning Alternative Designed to Phase Out Commercial Timber Harvest (WM-4)

Decade	Estimated Revenues	Estimated Costs	Estimated Net Revenues
Decade 1	$20.62	$13.63	$6.99
Decade 2	$0.00	$0.00	$0.00
Decade 3	$0.00	$0.00	$0.00
Decade 4	$18.03	$13.04	$4.99
Decade 5	$0.00	$0.00	$0.00
Cumulative Total	$38.65	$26.67	$11.98

Revenues and costs are in millions of 1998 dollars.

Source: SPU draft working paper, 1998c.

Estimate of Rate Impact of HCP Under Management Watershed Alternatives (WM-3, 4, 5)

The obvious implication of Watershed Management Alternatives 3 and 4 is the lack of timber-related revenue that could be available for fully financing the proposed HCP. Under these alternatives, the proposed HCP would no longer be considered rate neutral, unless another funding source becomes available. Within a present value context, financing the cost of the proposed HCP would result in a total rate increase of between 2.2 and 2.3 percent relative to the 1997 base (Tables 4.10-10 and 4.10-11), if rates were used as the financing mechanism to provide the funding that could not be generated through timber harvesting.

Table 4.10-10. Rate Impact of Financing HCP Under Long-Term Sustainable Thinning Alternative (WM-3)

	Present Value Over 50-Year Time Period		
Customer Class	Billed Consumption (1000s of ccf)	Unit Cost (Cost/ccf)	Rate Increase Relative to 1997 Base
Direct Service	1,090,293	$0.037	2.4%
Purveyor	1,141,741	$0.015	2.2%
Total	2,232,034	$0.026	2.3%

Source: Seattle Public Utilities, Finance Department

Table 4.10-11. Rate Impact of Financing HCP Under Thinning with Phased Out Commercial Timber Harvest Alternative (WM-4)

	Present Value Over 50-Year Time Period		
Customer Class	Billed Consumption (1000s of ccf)	Unit Cost (Cost/ccf)	Rate Increase Relative to 1997 Base
Direct Service	1,090,293	$0.035	2.3%
Purveyor	1,141,741	$0.014	2.1%
Total	2,232,034	$0.024	2.2%

Source: Seattle Public Utilities, Finance Department

Table 4.10-12. Rate Impact of Financing HCP Under No Commercial Timber Harvest Alternative (WM-5)

	Present Value Over 50-Year Time Period		
Customer Class	Billed Consumption (1000s of ccf)	Unit Cost (Cost/ccf)	Rate Increase Relative to 1997 Base
Direct Service	1,090,293	$0.040	2.6%
Purveyor	1,141,741	$0.016	2.4%
Total	2,232,034	$0.028	2.5%

Source: Seattle Public Utilities, Finance Department

Estimate of Rate Impact of HCP Under Alternative WM-5

The obvious implication of Alternative WM-5 is the lack of timber-related revenue for fully financing the proposed HCP. Under these alternative, the HCP would no longer be considered rate neutral, unless another acceptable funding source becomes available. Within a present value context, financing the cost of the proposed HCP would result in a total rate increase of 2.5 percent relative to the 1997 base (Tables 4.10-12).

4.10.4 Economic Impacts of Anadromous Fish Mitigation Alternatives

There are five alternative measures for mitigating the Applicant's blockage to migrating salmonids at the Landsburg Diversion and other operations. These alternatives are:

- No Action Alternative for Anadromous Fish Mitigation (AFM-1)
- Proposed HCP Alternative for Anadromous Fish Mitigation (AFM-2);
- Downsized Sockeye Hatchery Alternative with Savings Going Towards Downstream Habitat Restoration (AFM-3);
- Deferred Hatchery Construction Alternative Contingent on Evaluation of More Information (AFM-4); and

- All Downstream Habitat Restoration and Protection Alternative (AFM-5)

As discussed elsewhere (Chapter 4.2.4), the proposed alternative and other alternatives include five different types of measures that would be implemented in various combinations at different intensity levels. All of the alternatives (i.e., all alternatives except the No Action Alternative) include: (1) construction of fish ladders, downstream fish passage facilities, and juvenile fish screens at the Landsburg diversion dam and allowing passage of chinook salmon, coho salmon, and steelhead trout; (2) protection of salmonid habitat within 12.4 miles of the mainstem Cedar River and 4.6 miles of associated tributaries above Landsburg Dam as an Ecological Reserve; (3) research and monitoring; and (4) implementation of habitat acquisition, protection, restoration or enhancement projects downstream of Landsburg Dam. These alternatives all have potential socioeconomic impacts.

No Action Alternative for Anadromous Fish Mitigation (AFM-1)

Under the No Action Alternative, none of the above proposed activities would be implemented. For example, passage facilities at Landsburg Dam would not be constructed and no support would be provided to implement improvements at the Chittenden Locks. Consequently, there are no socioeconomic impacts related to construction and research and monitoring activities associated with this No Action Alternative.

Recreational and Commercial Fisheries. Under this alternative, opportunities to harvest sockeye salmon in Lake Washington would continue to be sporadic at best, if they occurred at all. This alternative, however, could lead to the continued decline of one or more of the anadromous species within the Cedar River, with deleterious effects on the recreational and commercial fisheries. No quantitative estimates, however, have been made since catch projections have proved to be unreliable for both recreational and commercial fisheries within Lake Washington.

Proposed HCP Alternative for Anadromous Fish Mitigation (AFM-2)

Under the Proposed HCP Alternative, the Applicant would construct a sockeye fry hatchery capable of producing 34 million fry. The approximate cost for the hatchery—both construction and operation & maintenance activities—over the 50 year life-span of the proposed HCP would be $22.5 million.

In general, the proposed direct actions relating to anadromous fish mitigation will have minimal impacts on existing (baseline) socioeconomic conditions. The economic impacts associated with the Proposed HCP Alternative relate to the primary activities of (1) construction of fish ladders, downstream fish passage facilities, and screen facilities at Landsburg Dam; (2) construction of

the fish hatchery; (3) operation and maintenance of the hatchery; and (4) research studies and monitoring.

The direct and total economic impacts associated with the various anadromous fish mitigation activities under the Proposed HCP Alternative are shown in Table 4.10-13. The timing of these activities are variable: construction activities occur between years one and four; operation and maintenance of the hatchery begin in year five; and research and monitoring activities are annual throughout the 50-year life-span of the proposed HCP. In addition, it is assumed that not all expenditures for construction activities will occur within King County; some of these designated construction monies (approximately 2.5 percent) will be spend outside the county.

The direct impacts associated with construction of anadromous fish mitigation facilities amounts to $11.3 million in spending, 118 jobs, and $3.8 million of labor income (wages, salaries and proprietor income). Total economic impacts of construction are estimated by multiplying the direct impact by the appropriate economic multipliers. In sum, total economic impacts are minimal within the context of King County. The annual direct impacts of operation and maintenance and research and development amount to $0.5 million, 10 jobs and $0.3 million in labor income. Again, in the context of King County, the total economic impacts of these annual activities are minimal. With the largest economy in Washington State (1.06 million jobs and 46.3 billion in labor earnings in 1997), these economic effects hardly register—less than 0.001 percent of total employment.

Table 4.10-13. Direct and Total Economic Impacts Related to Construction, Operations & Maintenance, and Research Mitigation Activities for Proposed HCP Alternative AFM-2

	Direct Economic Impact			Total Economic Impact		
	Output ($mil)	*Employment*	*Labor Income ($mil)*	*Output ($mil)*	*Employment*	*Labor Income ($mil)*
Construction						
Hatchery	$6.943	73	$2.328	$12.835	155	$4.522
Passage at Landsburg	$4.329	45	$1.452	$7.997	96	$2.818
Total, Construction	$11.273	118	$3.780	$20.832	251	$7.340
Operation & Maintenance						
Hatchery	$0.300	7	$0.161	$0.589	12	$0.282
Passage	$0.045	1	$0.024	$0.088	2	$0.042
Research & Development						
Research & Monitoring	$0.108	2	$0.069	$0.239	4	$0.117
Total, Operations & Research	$0.453	10	$0.254	$0.917	18	$0.441

Sources: Montgomery Watson, 1998; Chase & Pascall, 1996.

Note: Specific cost information for mitigation activities related to habitat protection and restoration downstream of Landsburg is unavailable.

Recreational and Commercial Fisheries. The Proposed HCP Alternative would likely produce the best results of all of the Anadromous Fish Mitigation Alternatives. These efforts would likely increase the recreational and commercial opportunities to harvest sockeye salmon in Lake Washington. Considerable uncertainty, however, remains and would make catch projections for Lake Washington unreliable.

Downsized Sockeye Hatchery Alternative with Savings Going Towards Downstream Habitat Restoration (AFM-3)

Under this alternative, the Applicant would commit to building a sockeye fry hatchery capable of producing 17 million fry. Economies of scale related to constructing this hatchery results in costs totaling more than half of the proposed full size hatchery. The estimated cost for the hatchery over the 50 year life-span under this alternative would be $18.9 million.

The direct and total economic impacts associated with the various anadromous fish mitigation activities under this alternative are shown in Table 4.10-14. The timing of these activities are variable: construction activities occur between years one and four; operation and maintenance of the hatchery begin in year five; and research and monitoring activities are annual throughout the 50-year life-span of the program under this alternative.

The direct impacts associated with construction are essentially equivalent to AFM-2 and amount to $11.3 million in spending, 118 jobs, and $3.8 million of labor income (wages, salaries and proprietor income). The annual direct impacts of a operation and maintenance and research and development amount to $0.5 million, 10 jobs, and $0.3 million in labor income. As in the Proposed HCP Alternative, the total economic impacts are insignificant under this alternative.

Recreational and Commercial Fisheries. The habitat enhancement projects under the proposed action alternative would presumably increase the recreational and commercial opportunities to harvest sockeye salmon in Lake Washington. Increased opportunities for sockeye harvest would be less than under the Proposed HCP Alternative, but more likely than the No Action Alternative, AFM-1. Considerable uncertainty remains, however, and would make catch projections on Lake Washington unreliable. Thus, the economic implications for recreational and commercial fisheries are indeterminate.

Deferred Hatchery Construction Alternative Contingent on Evaluation of More Information (AFM-4)

Under this alternative, the decision to build a permanent sockeye fry hatchery is deferred until year 10 of implementation. Instead, the Applicant would commit $4.9 million to upgrade and operate the interim sockeye hatchery during the first 12 years.

Table 4.10-14. Direct and Total Economic Impacts Related to Construction, Operations & Maintenance, and Research Mitigation Activities for Alternative AFM-3

	Direct Economic Impact			Total Economic Impact		
	Output ($mil)	*Employment*	*Labor Income ($mil)*	*Output ($mil)*	*Employment*	*Labor Income ($mil)*
Construction						
Hatchery	$6.943	73	$2.328	$12.842	156	$4.538
Passage at Landsburg	$4.329	45	$1.452	$7.997	96	$2.818
Total, Construction	$11.273	118	$3.779	$20.839	253	$7.357
Operation & Maintenance						
Hatchery	$0.300	7	$0.164	$0.589	12	$0.282
Passage	$0.045	1	$0.025	$0.088	2	$0.042
Research & Development						
Research & Monitoring	$0.108	2	$0.069	$0.239	4	$0.117
Total, Operations & Research	$0.453	11	$0.258	$0.917	18	$0.441

Sources: Montgomery Watson, 1998; Chase & Pascall, 1996.
Note: Specific cost information for mitigation activities related to habitat protection and restoration downstream of Landsburg is unavailable.

In general, this alternative will have minimal impacts on existing (baseline) socioeconomic conditions. The economic impacts associated with this alternative relate to the primary activities of (1) construction of the fish ladders, downstream fish passage facilities, and screen facilities at Landsburg Dam; (2) construction upgrade of the interim fish hatchery; (3) operation and maintenance of the interim hatchery; and (4) research studies and monitoring. For this alternative, no direct cost estimates are made on constructing a permanent hatchery which would not occur until at least year 10 of HCP implementation (Table 4.10-15).

The direct impacts of construction associated with anadromous fish mitigation facilities amounts to $9.2 million in spending, 94 jobs, and $3 million of labor income (wages, salaries and proprietor income). As in the Proposed HCP Alternative, AFM-2, the total economic impacts are insignificant under this alternative.

Recreational and Commercial Fisheries. The habitat enhancement projects under the Alternative AFM-4 would result in different outcomes. In the near term, there would be some potential for enhanced fishery due to the continued production of the 16 million fry at the interim hatchery. Overall effects would be similar to the No Action Alternative.

Over the long term, the results would depend on whether or not either a large or small hatchery would be constructed. The effects would be similar to the Proposed HCP Alternative if a large hatchery were constructed following the 12-year deferral of the construction project. If a smaller hatchery were constructed,

Table 4.10-15. Direct and Total Economic Impacts Related to Construction, Operations & Maintenance, and Research Mitigation Activities for Alternative AFM-4

	Direct Economic Impact			Total Economic Impact		
	Output ($mil)	*Employment*	*Labor Income ($mil)*	*Output ($mil)*	*Employment*	*Labor Income ($mil)*
Construction						
Hatchery	$4.829	48	$1.533	$8.807	104	$3.080
Passage at Landsburg	$4.329	45	$1.452	$7.997	96	$2.818
Total, Construction	$9.158	94	$2.985	$16.805	200	$5.899
Operation & Maintenance						
Hatchery	$0.352	9	$0.214	$0.692	14	$0.331
Passage	$0.045	1	$0.027	$0.089	2	$0.042
Research & Development						
Research & Monitoring	$0.190	4	$0.122	$0.421	7	$0.206
Total, Operations & Research	$0.587	15	$0.363	$1.202	23	$0.579

Sources: Montgomery Watson, 1998; Chase & Pascall, 1996.

Note: Specific cost information for mitigation activities related to habitat protection and restoration downstream of Landsburg is unavailable.

the effects on recreational and commercial fishing would be similar to those described under Alternative AFM-5. If no hatchery were operated in the Cedar River, the long-term effects would be similar to Alternative AFM-5. Considerable uncertainty, however, remains and would make catch projections on Lake Washington unreliable. Thus, the economic implications for recreational and commercial fisheries are indeterminate.

All Downstream Habitat Restoration and Protection Alternative (AFM-5)

Under this alternative, the sockeye fry hatchery would not be constructed and $24.1 million would be expended instead on habitat enhancement, restoration, and acquisition downstream of Landsburg. The economic impacts associated with this alternative relate to the primary activities of (1) construction of the fish ladders, downstream fish passage facilities, and screen facilities at Landsburg Dam; (2) construction and maintenance of downstream habitat enhancement, restoration, and acquisition projects downstream of Landsburg; and (3) research studies and monitoring. Given the lack of specific cost information on specific downstream habitat restoration projects, economic impacts were not estimated (Table 4.10-16).

Table 4.10-16. Direct and Total Economic Impacts Related to Construction, Operations & Maintenance, and Research Mitigation Activities for Alternative AFM-5

	Direct Economic Impact			Total Economic Impact		
	Output ($mil)	*Employment*	*Labor Income ($mil)*	*Output ($mil)*	*Employment*	*Labor Income ($mil)*
Construction						
Passage at Landsburg	$4.329	45	$1.452	$7.997	96	$2.818
Total, Construction	$4.329	45	$1.452	$7.997	96	$2.818
Operation & Maintenance						
Passage	$0.045	1	$0.027	$0.089	2	$0.042
Research & Development						
Research & Monitoring	$0.190	4	$0.122	$0.421	7	$0.206
Total, Operations & Research	$0.235	5	$0.150	$0.509	9	$0.248

Note: Special cost information for mitigation activities related to habitat projection and restoration downstream of Landsburg is unavailable.

The direct impacts of construction associated with anadromous fish mitigation facilities amounts to $4.3 million in spending, 45 jobs, and $1.5 million of labor income (wages, salaries and proprietor income). Annual activities related to operation and maintenance and research and development amount to $0.7 million in spending, 18 jobs, and $0.4 million in labor income. As in the Proposed HCP Alternative, the total economic impacts are insignificant under this alternative.

Recreational and Commercial Fisheries. Harvest rates of adult sockeye would be lower because this alternative requires larger numbers of spawners to maintain the size of the fishery in comparison to hatchery alternatives. Harvest opportunities would be expected to increase in comparison to the No Action Alternative, but would be lower than the Proposed HCP Alternative and Alternative AFM-3. Considerable uncertainty, however, remains and would make catch projections on Lake Washington unreliable. Thus, the economic implications for recreational and commercial fisheries are indeterminate.

4.10.5 Instream Flows

There are two instream flow alternatives (Proposed HCP Alternative and No Action Alternative) under consideration. Each of these alternatives provides for a normal flow schedule and a critical flow schedule implemented during periods of severe drought. The Proposed HCP Alternative provides for increased stream flows that will improve the habitat. However, no quantitative estimates have been made; thus, no economic impacts are estimated with the instream flow alternatives. In addition, the estimates surrounding the impacts on the recreational and commercial fisheries on Lake Washington are indeterminate.

4.10.6 Summary and Conclusion

A summary of environmental consequences for socioeconomics is presented in Table 4.10-17. These consequences are also summarized here for the Watershed Management, Anadromous Fish Mitigation, and Instream Flow Alternatives.

The socioeconomic impacts associated with implementing the proposed HCP are expected to be minimal. In the context of the King County economy, these economic impacts simply become insignificant.

With regards to the financial effects of the proposed HCP, the forest management program becomes important with respect to rate neutrality. The Proposed HCP Alternative, WM-2, generates sufficient income to cover the costs of implementing the proposed HCP. Alternative WM-3 would require rate increases totaling $55.62 million over the life of the proposed HCP. Alternative WM-4 would require rate increases totaling $58 million over the life of the proposed HCP. Alternative WM-5, because it generates no timber income, and would require rate increases totaling more than $77 million (1998 dollars) over the life of the proposed HCP. The expected impact would be about a 2.5 percent increase on existing rates.

The increased activities associated with the Anadromous Fish Mitigation Alternatives would also have minimal socioeconomic impacts. The job and labor income effects of construction, operation and maintenance, and research and monitoring activities are insignificant.

Likewise, the increased activities associated with the instream flow alternatives would have minimal socioeconomic impacts. Any job and labor income effects due to construction, operation and maintenance, and research and monitoring activities are insignificant.

Table 4.10-17 Summary of Environmental Consequences Evaluated for Socioeconomics (page 1 of 2)

Potential Impact Evaluated	Environmental Consequences					Comments
	Watershed Management Alternatives					
	WM-1	WM-2	WM-3	WM-4	WM-5	
Potential effects on direct jobs and labor earnings in King County	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	The Watershed Management alternatives will have a negligible effect on direct jobs and labor earnings in King County. Total job gains under the No Action Alternative (WM-1) where the largest amount of timber harvesting would take place, are equivalent to about two one-thousandths of one percent of King County's current job base.
Potential effects on water rates	No Effects	No Effects	Negligible Effects	Negligible Effects	Negligible Effects	At this time, the City of Seattle is investigating alternative ways to pay for the HCP besides raising water rates or generating revenue from timber harvesting. For a more detailed discussion of water rate implications please see the text in Section 4.10.3, which identifies a maximum total rate increase of 2.5% under WM-5 where no commercial logging would take place.
	Anadromous Fish Mitigation Alternatives					
	AFM-1	AFM-2	AFM-3	AFM-4	AFM-5	
Potential effects on the King County economy from recreational fishing within the Cedar River downstream of Landsburg and also Lake Washington	Unknown	Positive Effects	Positive Effects	Positive Effects	Positive Effects	Recreational fishing for sockeye salmon in the Cedar River and Lake Washington is dependent on the returns of adult fish which are affected by many factors, including fry survival in Lake Washington, passage through the Hiram Chittendon Locks, loss of habitat from encroaching urban development, commercial fishing pressures, etc. For these reasons it is not known exactly what effects the anadromous fish mitigation alternatives will have on recreational fishing in the region. However, most of the alternatives, including AFM-2, AFM-3, AFM-4 and AFM-5 are expected to increase production of sockeye fry above current conditions. As a result, these alternatives are expected to have a positive effect. The potential environmental consequences are unknown for the No Action Alternative (AFM-1) because the timing of mitigation, if provided at all under this alternative, is uncertain.

Table 4.10-17 Summary of Environmental Consequences Evaluated for Socioeconomics (page 2 of 2)

Potential Impact Evaluated	Environmental Consequences					Comments
	Anadromous Fish Mitigation Alternatives (cont.)					
	AFM-1	AFM-2	AFM-3	AFM-4	AFM-5	
Potential effects on direct jobs and labor earnings from the construction activities associated with fish passage facilities, fish screening facilities, hatchery facilities and downstream habitat restoration projects	Unknown	Negligible Effects	Negligible Effects	Negligible Effects	Negligible Effects	Although dollars would be spent on the construction of the various fisheries enhancement projects proposed for alternatives AFM-2, AFM-3, AFM-4 and AFM-5, the total contribution to direct jobs and labor earnings is very small relative to the entire King County region. The potential environmental consequences are unknown for the No Action Alternative (AFM-1) because the timing of mitigation, if provided at all under this alternative, is uncertain.
	Instream Flow Alternatives					
	IF-1			**IF-2**		
Environmental review did not identify any potential impacts to Socioeconomics from the Instream Flow Alternatives						

4.11 Overall Summary of Environmental Consequences

Table 4.11-1 summarizes and compares the main environmental consequences of the Watershed Management Alternatives. Table 4.11-2 highlights and compares environmental consequences of the Anadromous Fish Mitigation Alternatives. Table 4.11-3 summarizes and compares the environmental consequences of the Instream Flow Alternatives on the life history stages of salmon and steelhead in the Cedar River downstream of Landsburg Diversion and summarizes the additional instream flow management provisions under each alternative. Please note that these tables emphasize the main environmental consequences for each component of the plan in order to highlight differences between the alternatives. Consequences for each component of the plan are organized by categories derived to reflect the main issues raised by the public during the scoping process. For the Watershed Management Alternatives these categories include: impacts to old growth and mature forest habitats; effects on water quality and fish; consequences for threatened and endangered wildlife; impacts on cultural resources; and the amount of timber revenue that could potentially be generated from timber harvesting and the implications for water rates. For the Anadromous Fish Mitigation Alternatives these categories include: effects on Chittenden Locks; effects on chinook and coho salmon and steelhead trout; effects on water quality above Landsburg; the likelihood of the alternative meeting the sockeye mitigation goal; the likelihood of each alternative contributing towards tribal and sports fisheries; the effects of increased fish production on existing fish stocks; and the effects of the proposed hatchery operation, including domestication and disease control issues. For the Instream Flow Alternatives, categories include: the effects on all life history stages of each anadromous species including chinook salmon, coho salmon, sockeye salmon, and steelhead trout; effects on recreation; effects on public services; and a comparison of certain management provisions.

Cumulative effects are discussed throughout Chapter 4 for each element of the affected environment. For example, Section 4.3 discusses the overall effects at the landscape level of different timber harvesting alternatives on species

composition over time. Section 4.5 provides information on habitat fragmentation and connectivity over time at the landscape level and within a regional context. Another example is Section 4.9 which discusses the relationship of the proposal to regional water supply planning. For more specific information on cumulative effects, see the writeups and summary tables for each element of the affected environment.

Overall, the environmental consequences of the City's Proposed HCP and the alternatives have been evaluated according to the Watershed Management, Anadromous Fish Mitigation, and Instream Flow components of the HCP. Although these breakdowns are needed from a programmatic standpoint, it is important to keep in mind that each component of the plan is interrelated. For example, under the Proposed HCP Alternative for Anadromous Fish Mitigation (AFM-2), chinook salmon, coho salmon, and steelhead trout would be provided passage upstream of the Landsburg Diversion Dam into the Cedar River Municipal Watershed. Fisheries habitat within the Watershed would be protected by the proposed ecological reserve and constraints on timber harvest (WM-2). Additional protection would be provided through the management of instream flows between Landsburg and Lower Cedar Falls, the natural barrier to upstream fish passage.

Another example of how the components of the Proposed HCP interrelate would be demonstrated by the measures proposed for sockeye salmon. Although sockeye would not be allowed above Landsburg because of drinking water quality concerns, the proposed sockeye hatchery would produce an equivalent number of fry that could be potentially produced by spawning habitat upstream of the Landsburg Diversion Dam. Sockeye salmon utilizing the Lower Cedar River would receive the downstream water quality benefits provided by the proposed ecological reserve and constraints on timber harvest. The proposed provisions for managing instream flows (IF-2) would make use of potential cumulative spawning habitat, minimize risks for dewatering redds, and provide flows to protect during incubation and provide benefits for outmigration.

Table 4.11-1. Watershed management alternatives (WM-1 to WM-5) overall environmental consequences summary

Alternative/Factor	Old Growth and Mature Forest	Water Quality and Fish	Threatened and Endangered Wildlife	Cultural Resources	Timber Volume Available and Income Generated for HCP Mitigation Costs
No Action Alternative for Watershed Management (WM-1)	All 13,889 acres of existing old growth forest completely protected in Reserve. Forest Service land exchange deed restrictions met with no harvest of old growth. Within the 51,657 acre Reserve approximately 20,322 acres of forest will grow to the mature seral stage and 6,362 acres will grow to late successional seral stage. Outside the Reserve acres of forest will remain in early to mid seral stages and be harvested on a 40-80 year rotation with regeneration cuts up to 120 acres in size. (See Section 4.3 Forest Resources)	Extensive riparian buffers would substantially protect water quality from sediment and temperature effects. Similarly, riparian buffers would fully protect aquatic functions such as LWD influx and would allow substantial natural restoration of riparian functions over a 50 year time frame. There would be some minor risk of occasional landslides affecting stream channels because no specific prescriptions are identified to eliminate these affects. There would be some localized water quality effects on turbidity from road related sediment influx. This latter effect would be especially possible in the Taylor Creek drainage which has logging traffic from the Green River watershed. There is some possibility that there would be short term shut downs at Landsburg Diversion to prevent turbid water being diverted to Lake Youngs and the drinking water supply.	All current habitat for threatened and endangered wildlife would be protected under this alternative because none of this habitat would be harvested. It would all be protected as an ecological reserve as directed by Ordinance #114632. Only minor potential for take would occur due to forestry operations primarily from noise disturbance. Substantial benefit would occur to T&E species because 20,322 acres would grow into mature and 6,362 acres would grow into late successional forest thereby providing additional habitat for these species compared to existing conditions. (See Section 4.5 Wildlife)	No effect to cultural resources is likely to occur because of extensive surveys have already been conducted and because of the requirements of the Cultural Resources Management Plan to survey areas and to avoid or mitigate any potential effects prior to any activities. (See Section 4.6 Cultural Resources)	Approximately 1,064 MMBF would be available over a 50 year timeframe. This represents the maximum expected timber yield under Washington Forest Practice Rules. This volume would be generated from approximately 25,820 acres of regeneration cuts and 0 acres of commercial thinning over a 50 year period. (See Section 4.3 Forest Resources) Potential income generated from timber harvest could total $299 million dollars over 50 years. None of this money would be designated for mitigation because there would be no HCP and it would be used to offset SPU operating costs. (See Section 4.10 Socioeconomics)
HCP Alternative for Watershed Management (WM-2)	All 13,889 acres of existing old growth forest completely protected in Reserve. Within the 56,223 acre Reserve approximately 22,800 acres of forest will grow to the mature seral stage and 7,227 acres will grow to late successional seral stage. Outside Reserve 17,914 acres of forest will remain in early to mid seral stage, 895 acres will be mature and these acreages will be available for harvest with a transition to 120 year to 140 year rotation. Timber harvest will be a mixture of regeneration cuts with a maximum unit size of 120 acres.	Extensive riparian buffers would substantially protect water quality from sediment and temperature effects. Similarly, riparian buffers would fully protect aquatic functions such as LWD influx and would allow substantial natural restoration of riparian functions over the 50 year life of the HCP. There could be extremely minor risk of an occasional landslide affecting stream channels because prescriptions are identified to eliminate these affects. There could be some localized water quality effects on turbidity from road related sediment influx despite the road management improvements. There is a minor possibility that there would be short term shut downs at Landsburg Diversion to prevent turbid water being diverted to Lake Youngs and the drinking water supply. (See Sections 4.1 Geology and Soils, 4.2 Water Resources, and 4.4 Fisheries Resources)	All current habitat for threatened and endangered wildlife would be protected under this alternative because none of that habitat would be harvested. Only minor potential for take would occur due to forestry operations primarily from noise disturbance. Substantial benefit would occur to T&E species because 22,800 acres would grow into mature and 7,227 acres would grow into late successional forest thereby providing additional habitat for these species compared to existing conditions over the life of the HCP. Restoration planting along with ecological and restoration thinning would improve the quality and speed of habitat development for these and other species compared to No Action alternative. (See Section 4.5 Wildlife)	No effect to cultural resources is likely to occur because of extensive surveys have already been conducted and because of the requirements of the Cultural Resources Management Plan to survey areas and to avoid or mitigate any potential effects prior to any activities. (See Section 4.6 Cultural Resources)	Approximately 440 MMBF would be available over a 50 year timeframe. This represents a 59% reduction from the maximum expected timber yield under Washington Forest Practice Rules (Alternative WM-1). This volume would be generated from approximately 8,100 acres of regeneration cuts and 9,500 acres of commercial thinning over a 50 year period. (See Section 4.3 Forest Resources) Potential income generated from timber harvest could total $119 million over the 50-year period of the HCP. This amount would be more than sufficient to cover the net $83.3 million (1998 dollars) in commitments to cover costs not already addressed by current operations and ongoing activities (see Section 4.10 Socioeconomics)

Table 4.11-1. Watershed management alternatives (WM-1 to WM-5) overall environmental consequences summary (continued)

Alternative/Factor	Old Growth and Mature Forest	Water Quality and Fish	Threatened and Endangered Wildlife	Cultural Resources	Timber Volume Available and Income Generated for HCP Mitigation Costs
Long-term Sustainable Thinning Alternative (WM-3)	All 13,889 acres of existing old growth forest completely protected in Reserve. Forest Service land exchange deed restrictions met with no harvest of old growth. Within the 56,223 acre Reserve approximately 22,800 acres of forest will grow to the mature seral stage and 7,227 acres will grow to late successional seral stage. Outside Reserve 4,428 acres of forest will grow to mid seral and 21,415 acres will grow to mature stage. Rotation age and unit size are not applicable because of commercial thinning harvest only.	Extensive riparian buffers would substantially protect water quality from sediment and temperature effects. Similarly, riparian buffers would fully protect aquatic functions such as LWD influx and would allow substantial natural restoration of riparian functions over the 50 year life of the HCP. No additional protection of the aquatic system is realized under this alternative compared to Alternative WM-2. It is unlikely that landslides would affect stream channels because only commercial thinning would occur. There would be some localized water quality effects on turbidity from road related sediment influx. This latter effect would be especially possible in the Taylor Creek drainage which has logging traffic from the Green River watershed. There is a minor possibility that there would be short term shut downs at Landsburg Diversion to prevent turbid water being diverted to Lake Youngs and the drinking water supply. (See Sections 4.1 Geology and Soils, 4.2 Water Resources, and 4.4 Fisheries Resources)	All current habitat for threatened and endangered wildlife would be protected under this alternative because none of that habitat would be harvested. Only minor potential for take would occur due to forestry operations primarily from noise disturbance. Substantial benefit would occur to T&E species because 22,800 acres would grow into mature and 7,227 acres would grow into late successional forest thereby providing additional habitat for these species compared to existing conditions over the life of the HCP. This alternative would have additional potential habitat compared to Alternatives 1 and 2 primarily related to the exclusion of regeneration harvest and resulting early to mid successional forests. Restoration planting along with pre-commercial, ecological and restoration thinning would improve the quality and speed of habitat development for these and other species compared to No Action alternative. (See Section 4.5 Wildlife)	No effect to cultural resources is likely to occur because of extensive surveys have already been conducted and because of the requirements of the Cultural Resources Management Plan to survey areas and to avoid or mitigate any potential effects prior to any activities. (See Section 4.6 Cultural Resources)	Approximately 183 MMBF would be available over a 50 year timeframe. This represents an 82% reduction from the maximum expected timber yield under Washington Forest Practice Rules. This volume would be generated from approximately 0 acres of regeneration cuts and 19,660 acres of commercial thinning over a 50 year period. (See Section 4.3 Forest Resources) Potential income generated from timber harvest could total $14 million over the 50-year period of the HCP. This amount would be about $69.3 million less than would be needed to cover the net $83.3 million in commitments not already covered by current operations and ongoing activities. This alternative could result in an increase in water rates unless another source is identified. (See Section 4.10 Socioeconomics)
Thinning with Phased Out Commercial Timber Harvest Alternative (WM-4)	All 13,889 acres of existing old growth forest completely protected in Reserve. Forest Service land exchange deed restrictions met with no harvest of old growth. Within the ultimately 90,400 acre Reserve approximately 44,326 acres of forest will grow to the mature seral stage and 13,231 acres will grow to late successional seral stage. Outside Reserve 0 acres of forest will grow to mid seral and 0 acres will grow to mature stage. Rotation age and unit size are not applicable because of commercial thinning harvest only.	Extensive riparian buffers would substantially protect water quality from sediment and temperature effects. Similarly, riparian buffers would fully protect aquatic functions such as LWD influx and would allow substantial natural restoration of riparian functions over the 50 year life of the HCP. No additional protection of the aquatic system is realized under this alternative compared to Alternative WM-2. It is unlikely that landslides would affect stream channels because only commercial thinning would occur. There would be some localized water quality effects on turbidity from road related sediment influx. This latter effect would be especially possible in the Taylor Creek drainage which has logging traffic from the Green River watershed. There is a minor possibility that there would be short term shut downs at Landsburg Diversion to prevent turbid water being diverted to Lake Youngs and the drinking water supply. (See Sections 4.1 Geology and Soils, 4.2 Water Resources, and 4.4 Fisheries Resources)	All current habitat for threatened and endangered wildlife would be protected under this alternative because none of that habitat would be harvested. Only minor potential for take would occur due to forestry operations primarily from noise disturbance. Substantial benefit would occur to T&E species because 30,027 acres would grow into mature and late successional forest thereby providing additional habitat for these species compared to existing conditions over the life of the HCP. This alternative would have additional potential habitat compared to Alternatives 1 and 2 primarily related to the exclusion of regeneration harvest and resulting early to mid successional forests. Because this alternative has less thinning than alternative WM-3, there would be more older habitat that is placed into the Reserve over time. Restoration planting along with pre-commercial ecological and restoration thinning would improve the quality and speed of habitat development for these and other species compared to No Action alternative. (See Section 4.5 Wildlife)	No effect to cultural resources is likely to occur because of extensive surveys have already been conducted and because of the requirements of the Cultural Resources Management Plan to survey areas and to avoid or mitigate any potential effects prior to any activities. (See Section 4.6 Cultural Resources)	Approximately 108 MMBF would be available over a 50 year timeframe. This represents an 90% reduction from the maximum expected timber yield under Washington Forest Practice Rules. This volume would be generated from approximately 0 acres of regeneration cuts and 13,350 acres of commercial thinning over a 50 year period. (See Section 4.3 Forest Resources) Potential income generated from timber harvest would total $12 million dollars over the 50-year period of the HCP. This amount would be about $71.3 million less than would be needed to cover the net $83.3 million in HCP commitment not already covered by current operations and ongoing activities. This alternative could result in an increase in water rates unless another funding option is identified.

Table 4.11-1. Watershed management alternatives (WM-1 to WM-5) overall environmental consequences summary (continued)

Alternative/Factor	Old Growth and Mature Forest	Water Quality and Fish	Threatened and Endangered Wildlife	Cultural Resources	Timber Volume Available and Income Generated for HCP Mitigation Costs
No Commercial Timber Harvest Alternative (WM-5)	All 13,889 acres of existing old growth forest completely protected in Reserve. Forest Service land exchange deed restrictions met with no harvest of old growth. The Reserve will encompass the entire 90,400 acre Watershed and there will be not timber harvest. Within the 90,400 acre Reserve approximately 44,326 acres of forest will grow to the mature seral stage and 13,231 acres will grow to late successional seral stage. There would also be 13,624 acres of mid-seral (closed canopy) forest in the Reserve.	Extensive riparian buffers would substantially protect water quality from sediment and temperature effects. Similarly, riparian buffers would fully protect aquatic functions such as LWD influx and would allow substantial natural restoration of riparian functions over the 50 year life of the HCP. No additional protection of the aquatic system is realized under this alternative compared to Alternative WM-2. No management induced landslides that could affect stream channels would occur because there would be no timber harvest. There would be some localized water quality effects on turbidity from road related sediment influx in the Taylor Creek drainage which has logging traffic from the Green River watershed. There is a minor possibility that there would be short term shut downs at Landsburg Diversion to prevent turbid water being diverted to Lake Youngs and the drinking water supply. (See Sections 4.1 Geology and Soils, 4.2 Water Resources, and 4.6 Fisheries Resources)	All current habitat for threatened and endangered wildlife would be protected under this alternative because none of that habitat would be harvested. There would be no potential for take because noise related to forestry operations would not occur. There would be some very minor potential for take due to noise disturbance from ecological and restoration thinning operations. Substantial benefit would occur to T&E species because 44,326 acres would grow into mature and 13,231 acres would grow into late successional forest thereby providing additional habitat for these species compared to existing conditions over the life of the HCP. This alternative would have additional potential habitat compared to Alternatives 1, 2, 3, and 4 primarily related to the exclusion of regeneration harvest and resulting early to mid successional forests. Restoration planting along with ecological and restoration thinning would improve the quality and speed of habitat development for these and other species compared to No Action Alternative. (See Section 4.5 Wildlife)	No effect to cultural resources is likely to occur because of extensive surveys have already been conducted and because of the requirements of the Cultural Resources Management Plan to survey areas and to avoid or mitigate any potential effects prior to any activities. (See Section 4.6 Cultural Resources)	No timber volume would be generated under this alternative. (See Section 4.3 Forest Resources) No potential income could be generated from timber harvest under this alternative. As a result, the additional net $83.3 million needed for HCP commitments would need to come from increases in water rates unless another financing option is identified. If increases in water rates were used as the sole funding source, direct service rate increases would be 2.6% and Purveyor Rate increases could be 2.4%. (see Section 4.10 Socioeconomics)

Table 4.11-2. Anadromous fish mitigation alternatives (AFM-1 to AFM-5) overall environmental consequences summary

Alternative/ Factors	Effects on Chittenden Locks	Effects on Coho & Chinook Salmon & Steelhead Trout	Water Quality above Landsburg	Likelihood of Meeting Sockeye Mitigation Goal	Likelihood of Having More Frequent Tribal and Sport Fishery	Effects of Increased Fish Production on Existing Fish Stocks	Hatchery Effects (Domestication, Disease Control)
No Action Alternative (AFM-1)	No effects. (See Section 4.4 Fisheries)	Could lead to continued decline of one or more of the anadromous species within the Cedar River and possibly the extinction of some stocks within the drainage. If chinook salmon are listed as threatened under the ESA, the NMFS would be required to develop and implement a recovery plan that may or may not be supported by the City. The benefits to potentially listed ESA fish species from measures contained in the HCP would not be realized in the near future. (See Section 4.4 Fisheries)	No effect because no anadromous fish would be allowed above the Landsburg Diversion (See Section 4.2 Water Resources)	No mitigation for Landsburg Diversion would occur in reasonably foreseeable future. Negotiations for meeting mitigation goals would continue between the City, state, and federal agencies. Litigation could be implemented against City to meets its legal requirements. (See Section 4.4 Fisheries)	Because funding for the interim hatchery is uncertain, there would be no improvement in the likelihood of tribal and sport fishery openings. Opportunities to harvest sockeye salmon in Lake Washington would continue to be sporadic, if they occurred at all. (See Section 4.4 Fisheries)	No enhanced fish production (hatchery or habitat improvement) consequently no potential effects. (See Section 4.4 Fisheries)	Short-term effects similar to AFM-2 from interim hatchery. (See Section 4.4 Fisheries)
HCP Alternative for Anadromous Fish Mitigation (AFM-2)	Monetary support for improvements of fish passage and water use efficiency at Chittenden Locks that could be used to improve instream flows. (See Section 4.4 Fisheries)	Allowing passage over the Landsburg Diversion of chinook salmon, coho salmon, and steelhead will provide additional stability and improvement to the populations of these fish in the Cedar River. Protection of salmon habitat above Landsburg as an ecological reserve (12.4 miles mainstem Cedar & 4.6 miles of tributaries). Additional benefit to the species will occur from $1.6 million dollars of habitat improvement in the Cedar River downstream of Landsburg. (See Section 4.4 Fisheries)	No anticipated effect. The number of chinook and coho salmon and steelhead trout allowed above the Landsburg Diversion are not considered sufficient to cause water quality effects. Monitoring will be conducted to ensure water quality. (See Section 4.2 Water Resources)	High likelihood of meeting the City's mitigation goal because the 34 million fry could be produced by the hatchery even under the unlikely event that habitat improvement projects were a complete failure. Additional sockeye fry would be produced by implementing $1.6 million worth of habitat improvement projects in the lower Cedar River. (See Section 4.4 Fisheries)	Harvest rates could be higher than other alternatives because fewer adults would be needed as brood stock for the hatchery and could therefore be harvested. Opportunities to harvest sockeye salmon in Lake Washington would likely occur more frequently than in the last decade and have the highest likelihood among all alternatives. (See Section 4.4 Fisheries)	Low risk of potential genetic introgression resulting from strays from the Cedar River to other Lake Washington sockeye stocks because straying rates can be monitored and hatchery production reduced if necessary to minimize potential for effects. Effects of harvest to native stocks will be minimized as a result of harvest management policies by WDFW and Muckleshoot Indian Tribe (e.g., area and timing restrictions). (See Section 4.4 Fisheries)	To manage risks to the reproductive fitness of Lake Washington sockeye populations associated with potential domestication and straying, the City will develop and implement operational guidelines, monitoring programs, and adaptive management by agreement of the parties to the Landsburg Mitigation Agreement in consultation with the CRAFC. Low risk of infectious hematopoeietic necrosis (IHN) because control measures considered effective. However, natural sockeye population benefits from release of IHN free fry. (See Section 4.4 Fisheries)

Table 4.11-2. Anadromous fish mitigation alternatives (AFM-1 to AFM-5) overall environmental consequences summary (continued)

Alternative/ Factors	Effects on Chittenden Locks	Effects on Coho & Chinook Salmon & Steelhead Trout	Water Quality above Landsburg	Likelihood of Meeting Sockeye Mitigation Goal	Likelihood of Having More Frequent Tribal and Sport Fishery	Effects of Increased Fish Production on Existing Fish Stocks	Hatchery Effects (Domestication, Disease Control)
Down-sized Sockeye Hatchery Alternative with Savings Going Towards Downstream Habitat Restoration (AFM-3)	Same as HCP Alternative (AFM-2)	Allowing passage over the Landsburg Diversion of chinook salmon, coho salmon, and steelhead will provide additional stability and improvement to the populations of these fish in the Cedar River. Protection of salmon habitat above Landsburg as an ecological reserve (12.4 miles mainstem Cedar & 4.6 miles of tributaries). Additional benefit to the species will occur from $5.2 million dollars of habitat improvement in the Cedar River downstream of Landsburg. (See Section 4.4 Fisheries)	Same as Proposed HCP (AFM-2) (See Section 4.2 Water Resources)	Low likelihood of meeting City's mitigation goal with low or moderate spawner densities in enhanced habitats. Downsized hatchery would produce up to 17 million fry. Unlikely to meet overall goal without favorable outcomes on assumptions for spawning density, fry survival, and habitat improvement project implementation (i.e., landowner cooperation, project costs, project longevity, etc.)	Harvest rates could be between AFM-2 and AFM-5 because of the mix of hatchery and naturally reproducing fish. The higher egg-to-fry survival possible from the hatchery component of the stock means fewer spawners are needed as broodstock; therefore it is possible to harvest a higher proportion of fish. Opportunities to harvest sockeye salmon in Lake Washington would likely occur more frequently than in the last decade and the likelihood of such harvest is between AFM-2 and AFM-4. (See Section 4.4 Fisheries)	Low risk of potential genetic introgression resulting from strays from the Cedar River to other Lake Washington sockeye stocks. Straying rates (from marked hatchery fish) will be monitored and hatchery releases reduced if necessary to minimize potential for effects. Effects of harvest to native stocks will be minimized as a result of harvest management policies by WDFW and Muckleshoot Indian Tribe (e.g., area and timing restrictions). (See Section 4.4 Fisheries)	Risks of domestication to lower than the HCP Alternative (AFM-2) because production levels are lower. However, low potential for straying of hatchery or naturally produced Cedar River sockeye affecting the genetic integrity of other Lake Washington sockeye stocks. Straying rates will be monitored. IHN risks and benefits at hatchery similar to the HCP Alternative (AFM-2). However, no disease control is available for sockeye produced from habitat enhancement projects (See Section 4.4 Fisheries)
Deferred Hatchery Construction Alternative Contingent on Evaluation of More Information (AFM-4)	Same as HCP Alternative (AFM-2) (See Section 4.4 Fisheries)	Allowing passage over the Landsburg Diversion of chinook salmon, coho salmon, and steelhead will provide additional stability and improvement to the populations of these fish in the Cedar River. Protection of salmon habitat above Landsburg as an ecological reserve (12.4 miles mainstem Cedar & 4.6 miles of tributaries). Additional benefit to the species will occur from between $1.6 million and $19.3 million dollars of habitat improvement and land acquisition and protection in the Cedar River downstream of Landsburg. (See Section 4.4 Fisheries)	Same as the HCP Alternative (AFM-2) (See Section 4.2 Water Resources)	Interim 12 year period: Production of up to 16 million fry from the interim hatchery plus additional fry from habitat enhancement projects would not meet City's goal. In subsequent years (12 to 50): Selection of the option of a full size hatchery, a down-sized hatchery with habitat improvement, or only habitat improvement would be made based, in part, on the ability to meet City's requirement as indicated by monitoring and additional studies. Consequently, there is a moderate likelihood of meeting City's requirements in years 12 to 50. (See Section 4.4 Fisheries)	Some potential for enhanced fishery during first 12 years because of continued production of 16 million fry from interim hatchery. After year 12, the fishery would likely increase because additional long-term mitigation projects (either hatchery and/or habitat improvement) would be implemented. However, potential harvest would depend upon the proportions of hatchery and naturally producing fish and the actual spawning densities and fry survival realized from habitat improvement projects. (See Section 4.4 Fisheries)	Level of risk of potential genetic introgression resulting from strays from the Cedar River to other Lake Washington sockeye stocks dependent upon decision in HCP year 10, and realized production and straying rates. Monitoring of straying rates will not be possible and fine-tuning of production rates will be difficult with habitat improvement projects.. Effects of harvest to native stocks will be minimized as a result of harvest management policies by WDFW and Muckleshoot Indian Tribe (e.g., area and timing restrictions). (See Section 4.4 Fisheries)	Effects the same as AFM-2 or AFM-3 depending on if full or half hatchery constructed, respectively. If hatchery constructed, IHN risks and benefits similar to the HCP Alternative (AFM-2). (See Section 4.4 Fisheries)

Table 4.11-2. Anadromous fish mitigation alternatives (AFM-1 to AFM-5) overall environmental consequences summary (continued)

Alternative/ Factors	Effects on Chittenden Locks	Effects on Coho & Chinook Salmon & Steelhead Trout	Water Quality above Landsburg	Likelihood of Meeting Sockeye Mitigation Goal	Likelihood of Having More Frequent Tribal and Sport Fishery	Effects of Increased Fish Production on Existing Fish Stocks	Hatchery Effects (Domestication, Disease Control)
All Downstream Habitat Restoration and Protection Alternative (AFM-5)	Same as the HCP Alternative (AFM-2) (See Section 4.4 Fisheries)	Allowing passage over the Landsburg Diversion of chinook salmon, coho salmon, and steelhead will provide additional stability and improvement to the populations of these fish in the Cedar River. Protection of salmon habitat above Landsburg as an ecological reserve (12.4 mi mainstem Cedar & 4.6 mi of tributaries). Additional benefit to the species will occur from $24.1 million dollars of habitat improvement and land acquisition and protection in the Cedar River downstream of Landsburg. (See Section 4.4 Fisheries)	Same as the HCP Alternative (AFM-2) (See Section 4.2 Water Resources)	Low chance of meeting City's mitigation goal. Only favorable outcomes for assumptions on spawning density, fry survival, and habitat improvement project implementation (i.e., landowner cooperation, project costs, project longevity, etc.) would allow attainment of mitigation goal. (See Section 4.4 Fisheries)	The higher egg-to-fry survival expected from habitat improvement projects compared to current in-river levels mean a higher proportion of returning adult fish may be available for harvest. However, this rate would be lower than a hatchery because more fish would be required to seed the habitat improvement projects. Opportunities to harvest sockeye salmon in Lake Washington would likely occur more frequently than in the last decade and the likelihood of such harvest is lower than AFM-2 and AFM-3. (See Section 4.4 Fisheries)	Monitoring straying rates will not be possible and fine-tuning production levels will be difficult for habitat improvement projects. High uncertainty is present for detecting or controlling any potential genetic introgression resulting from strays from the Cedar River to other Lake Washington sockeye stocks. Effects of harvest to native stocks will be minimized as a result of harvest management policies by WDFW and Muckleshoot Indian Tribe (e.g., area and timing restrictions). (See Section 4.4 Fisheries)	No risk of hatchery fish domestication because no hatchery. No control of disease possible at habitat improvement projects.

Table 4.11-3. Summary comparison of the environmental consequences of the instream flow alternatives (IF-1 and IF-2). Comparisons are made on the normal flow regimes only, as the critical flow regimes both under alternatives are generally similar unless otherwise noted.

Factor	No Action Alternative (IF-1)	HCP Alternative for Instream Flows (IF-2)
Species/Life History Stage		
All Species		
Upstream passage	no low flow passage barriers created for upstream adult migration for any species	no low flow passage barriers created for upstream adult migration for any species
Sockeye		
Spawning	With 10% of the run in the river, sockeye spawning habitat is 99% of maximum WUA in mid-September. Flows continue to increase until October 10 in attempt to increase cumulative spawning habitat and recruit edge habitat. Flows requirements at Renton remain constant after October 10, but due to the increasing inflows to the lower river from mid-October through the remainder of the sockeye spawning period, releases from Landsburg can actually be decreased and still meet the flow target at Renton Because of the flow commitments based on the Renton gage, increases in cumulative spawning habitat can be negligible from after October 10 through the remainder of the spawning period. Nearly 50% of the sockeye run occurs after mid-October.	By September 16, with 11% of the sockeye run in the river, IF-2 flows increase to a level that is slightly above the level required to provide maximum WUA for sockeye. Normal minimum flow requirement continue to increase through October 8. Although flow releases remain constant after October 8, minimum flows continue to increase along either a low normal or high normal regime due to increasing inflow to the river downstream of Landsburg. IF-2 flow releases from Landsburg remain elevated at levels equal to or greater than the flows required to provide maximum WUA for sockeye spawning habitat throughout the duration of the run. As high normal stream flows increase, as much as 49% of the WUA of sockeye spawning habitat can become unavailable. Although significant amounts of sockeye spawning habitat are lost at these higher flows, the losses in static habitat are partially offset by increases in potential cumulative sockeye spawning habitat. Assuming that significant numbers of sockeye have spawned during September, then flow increases in October through December will tend to encourage newly entering fish to spawn in new, previously unsuitable habitat away from areas that are already seeded. This step approach to flow regulation also accommodates the theory that edge spawning habitat is less vulnerable to damaging scours during flood events.
Incubation	The spawn timing of sockeye salmon make their redds especially vulnerable to the fluctuating stream flows associated with late fall and early winter. Although minimum flows remain elevated throughout the incubation period to reduce the risk of stranding, the measurement point 20 miles downstream at Renton allows substantial reduction in releases from the Landsburg Dam during periods of normal to high inflows. Subsequently, redds established near the margins of the stream in the upper portions of the river near Landsburg are subject to a significant risk of dewatering and eventual egg desiccation. The timing and location of sockeye spawning make their redds vulnerable to scour during floods associated with large winter storm events. It is believed that redd scour during flood events is a dominant factor controlling the survival of sockeye and there appears to be a slight reduction of redd scour as you move towards the edge of the channel. At least for the early part of the sockeye run, some opportunity for margin spawning habitat is accommodated as described above. However, releases from Landsburg can actually be decreased and still meet the flow target at Renton after mid October. This can results in available spawning habitat being situated in mid-channel areas believed to be more prone to scour, especially in river portions nearer to Landsburg.	To reduce the risk of redd dewatering and mortality of salmon eggs and alevins, IF-2 minimum flows remain elevated to ensure that nearly all of the available spawning habitat would remain inundated. The Landsburg measurement point further reduces the risk of redd dewatering in the river near Landsburg. Unlike the IF-1 regime, flow releases at Landsburg must remain elevated throughout the incubation period. This is especially valuable to sockeye salmon incubation, as the "step" approach to flow regulation may encourage spawning activity along channel margins that are more vulnerable to dewatering. The sockeye spawning habitat nearer the stream margins is believed to be somewhat less vulnerable to scour during flood events. The IF-2 flow regime accommodates the theory that, provided the opportunity, sockeye will spawn in zones of less risk to scour.
Outmigration	Sampling suggests that flow can be an important factor affecting survival during the outmigration to Lake Washington. Elevated flows for incubation protection during the winter and spring also provide benefit for outmigrating sockeye. However, during periods of normal to high inflows below Landsburg, there is no assurance that flows will remain elevated in much of the river, as the downstream measurement point allows for dramatic reductions as previously described. In addition there are no provisions for elevated minimum flows during favorable hydrologic conditions.	Elevated flows for incubation protection during the winter and spring also provide benefit for outmigrating sockeye. In contrast to IF-1, there is assurance that flows will remain elevated throughout the river, as Landsburg compliance point requires sustained flow releases throughout the outmigration period. Although the exact quantitative relationship between stream flow and the survival of outmigrating wild sockeye fry is not presently known, IF-2 contains provisions for 40% higher minimum flows at least 70% of the time during the peak of sockeye outmigration from early February through mid-April.
Chinook		
Spawning	By September 15 with an average of 6% of the chinook run in the river, the IF-1 normal flows are below levels needed to create maximum WUA, and provide approximately 77% of the possible maximum WUA for chinook spawning. Flows continue to increase through October 10 and slightly exceed the level required to provide maximum chinook spawning habitat. This flow increase corresponds to the peak of the chinook spawning. Minimum flows remain at this level for the duration of the chinook spawning and provide over 99% of the maximum WUA during normal flow years.	In mid-September, IF-2 normal flows are nearly identical to the IF-1 flow guidelines and below levels needed to create maximum WUA for chinook spawning habitat (77% of WUA provided). By September 23, IF-2 normal flows provide 95% of the maximum WUA. By October 8, with an average of 50% of the run in the river, low normal flows are slightly below IF-1 levels but provide 100% of maximum WUA. In an effort to recruit additional edge habitat for spawning sockeye, high normal flows slightly exceed IF-1 and flows required to provide maximum WUA. High normal flows remain at this level for the duration of chinook spawning and provide between 89 and 98% of maximum WUA. The decrease in WUA for chinook spawning due to high flows occurs during the latter portion of the run after the majority of the chinook have spawned.
Incubation	The risk of dewatering is similar to sockeye salmon as described above, but to a lesser degree, as chinook spawning preferences encourage spawning in areas less likely to be dewatered.	Similar effects as sockeye salmon incubation described above, but to a lesser degree as chinook spawning preferences encourage spawning in areas less likely to be dewatered.
Rearing and Outmigration	Chinook fry begin emerging from the gravel in February. Depending on their life history variation, fry may begin outmigration from their natal stream immediately upon emergence, or remain in the river for up to 3 months and outmigrate as late as mid June. Flows during this period are well above the level required to provide maximum WUA for chinook rearing and result in a reduction in available rearing habitat. Although the flows during this period result in an overall reduction in available chinook rearing habitat, elevated flows may benefit outmigrating juvenile chinook. Flows during this period also address the needs of outmigrating sockeye fry; spawning steelhead; and incubating sockeye, chinook, and steelhead.	From February through mid-May normal flows are held at higher levels than IF-1 flows in an effort to provide additional benefits to incubating chinook and sockeye, and outmigrating sockeye fry. Higher flows result in a reduction in juvenile chinook rearing habitat, but may benefit outmigrating juvenile chinook. From mid-May through mid-June, normal flows are slightly lower than IF-1 flows in order to provide additional benefits for spawning and incubating steelhead. Lower flows result in an increase in juvenile chinook rearing habitat, but may provide less benefit for outmigrating juvenile chinook.

Table 4.11-3. Summary comparison of the environmental consequences of the instream flow alternatives (IF-1 and IF-2). Comparisons are made on the normal flow regimes only, as the critical flow regimes both under alternatives are generally similar unless otherwise noted.

Factor	No Action Alternative (IF-1)	HCP Alternative for Instream Flows (IF-2)
Coho		
Spawning	Critical and normal flows are greater than the amount required to provide maximum WUA for coho spawning and subsequently result in a loss in habitat. Normal flows provide 81 to 88% of maximum WUA, critical flows provide 95 to nearly 100% of maximum WUA.	As with the IF-1 regime, IF-2 minimum normal flows throughout the entire coho spawning remain well above flows required to maximize available spawning habitat. Flows as measured at Landsburg are more than double than those required to maximize WUA during the peak of the coho spawning activity during the month of January. The IFIM study suggested that nearly 30% of the potentially available spawning habitat would be lost with IF-2 normal minimum flows in January. During the early spawning period of October through December, low normal flows provide 68 to 92% of maximum WUA; high normal flows provide 60 to 92% of maximum WUA. By the end of the spawning period in mid February, normal minimum flows provide only 52% of the maximum WUA. The CRIFC considered the benefits for enhanced sockeye and chinook spawning, incubation, and outmigration flows outweighed the potential risk to the coho spawning habitat.
Incubation	Coho salmon spawn principally in smaller tributaries to the Cedar River, so mainstem redd scour and dewatering was not regarded as a significant influence in coho production by the Cedar River Instream Flow Committee.	Coho salmon spawn principally in smaller tributaries to the Cedar River, so mainstem redd scour and dewatering was not regarded as a significant influence in coho production by the Cedar River Instream Flow Committee.
Rearing	See effects to steelhead rearing below.	See effects to steelhead rearing below.
Outmigration	Coho smolts outmigrate as one year old fish and as such are more fit to avoid predation and other mortality factors during their downriver migration as compared to sockeye.	See IF-1 effects.
Steelhead		
Spawning	Discharge under the normal flow regime exceeds the flows that produce maximum WUA for steelhead spawning during the entire steelhead spawning period. Available steelhead spawning habitat ranges from 96 to 99 % of maximum WUA. Under the IF-1 critical flow regime, flow guidelines remain below optimum levels, yet they still provide 98 to 99% of the maximum WUA.	IF-2 normal flows during the late winter and spring are well above the levels that provide maximum WUA for spawning steelhead. From March 4 through April 14, normal minimum flows are supplemented by as much as 40% to enhance sockeye outmigration in 7 out of 10 years. This flow increase corresponds to a 22% decrease of available steelhead spawning habitat. After April 15, flows remain above the level required to provide maximum WUA but still provide 96 to 98% of maximum WUA.
Incubation	Steelhead spawn at a period when river flows can fluctuate naturally and commonly exceed the IF-1 minimum requirements. Periods of higher flows associated with storm events in the spring may force steelhead to spawn in areas that may later be dewatered as flows drop. Significant numbers of incubating steelhead can be placed at risk of being dewatered between late June and the first week of August. The level of risk is variable from year to year and the IF-1 regime does not provide mechanisms to address this potential risk to incubating steelhead.	In some years, high flows resulting from both natural spikes due to tributary and upriver inflows can force steelhead to spawn in areas that may be subsequently exposed to significant risk of dewatering when flows are reduced in the early summer. To address this issue, and provide the flexibility required to meet the changing needs of incubating steelhead, IF-2 provides an additional block of water to be allocated as directed by the Commission in normal years when the need exists for increased steelhead incubation protection and if specific hydrologic conditions and risk sharing mechanisms provide the flexibility to do so. Between June 17 and August 4, in addition to the normal minimum flows, and the 2500 acre foot block of water delivered in all normal years, the Applicant will expect to further supplement normal minimum flows by 3500 acre feet of water in 63% of all years. In order to support decision making regarding the use and temporal distribution of this water and to minimize dewatering of steelhead redds, the Applicant will sponsor annual real time monitoring of steelhead redds for up to eight spawning seasons beginning in HCP Year One.
Rearing	Rearing juvenile coho and steelhead are present year round in the Cedar River. The flows that create maximum WUA for juvenile steelhead rearing are greater than analogous flows for juvenile coho. Therefore, the CRIFC selected juvenile steelhead as the primary target for rearing flow considerations. Minimum flows drop below the level required to maintain maximum available rearing habitat from mid-July through mid-September. During this period, the flows provide between 98 and 99% of maximum WUA. From mid-September through mid-July, flows remain well above the levels required to provide maximum WUA and provides between 79 and 88% of maximum WUA.	For most of the year, from mid-September through early August, the HCP normal flow prescriptions are well above levels required to provide maximum WUA for juvenile steelhead rearing. Although flows at times are two to three times greater than the levels that provide maximum WUA, the loss in rearing habitat is relatively small. During August and the first two weeks in September, HCP normal flows drop to levels that approach the IF-1 minimum flow levels.
Outmigration	Steelhead smolts outmigrate as one or two year old fish more fit to avoid predation and other mortality factors associated with downriver migration as compared to sockeye.	See IF-1 effects.
Recreation	The Cedar River below Landsburg Diversion offers a variety of water-dependent recreational activities including wading, swimming, rafting, and boat rowing during warm months, and whitewater kayaking during winter and early spring months when stream flows are high. Whitewater rafting is less common. There is a wide range of variation and fluctuation of daily streamflow values seen in the Cedar River below Landsburg Diversion. IF-1 would not affect these recreational opportunities.	Potential effects on water-dependent recreational activities in the Cedar River below Landsburg Diversion from IF-2 would be essentially the same as described for IF-1. Boaters will continue to see the wide range of flow variations and fluctuations associated with the Cedar River under IF-2 for their various boating activities. IF-2 protects minimum instream flows for the biological needs of aquatic resources. Minimum flows are typically greater than under IF-1 and may be considered a new benefit to boaters.
Public Service	This alternative would not eliminate uncertainty about instream flows and water operations in the face of potential ESA listings. Current firm yield of Seattle water supply system would be maintained unless listings occur and require change from current management.	This alternative eliminates significant uncertainty about effects on water operations of potential ESA listings, allowing Seattle to maintain firm yield of supply system. IF-2 commits more water to instream uses than IF-1, consequently less is available for out-of-stream uses. A small loss of electrical energy would result for bypass reach flow provision.

Table 4.11-3. Summary comparison of the environmental consequences of the instream flow alternatives (IF-1 and IF-2). Comparisons are made on the normal flow regimes only, as the critical flow regimes both under alternatives are generally similar unless otherwise noted.

Factor	No Action Alternative (IF-1)	HCP Alternative for Instream Flows (IF-2)
Additional Instream Flow Management Provisions: Effects on Multiple Species and other Factors		
Oversight of instream flow management	Although discussions regarding instream flow management strategies pertinent to current hydrological conditions and fish runs are conducted informally, the Agencies and Tribe have no formal role in instream flow management decision making.	The IF-2 will provide a forum for parties to the Instream Flow Agreement (IFA) to be formally involved in instream flow management decision making. A Cedar River Instream Flow Oversight Commission will be established consisting of one member representing each of the signatories to the IFA.
Conditions upstream of Landsburg	The IF-1 flow regime contains no provisions for the Cedar River upstream of the Landsburg Diversion to lower Cedar Falls.	Restoring access for chinook, coho and steelhead into the habitat upstream of the Landsburg Diversion Dam is a central component of the HCP's conservation strategy for anadromous fish. The provision of beneficial flows under IF-2 in this reach is key to the success of this strategy. Flow levels in the river upstream of the Landsburg Dam and below the Cedar Falls Powerhouse will be near or above the levels required to provide maximum WUA for chinook, coho, and steelhead spawning and rearing at all times.
	Emergency shutdown of flows through the Hydroelectric Facility have the potential to cause short-term but significant reductions in flow and stage in downstream reaches of the river, posing significant risk of juvenile fish stranding and dewatering redds throughout the Cedar River downstream of Cedar Falls. Under the existing conditions, conversion of water delivery from Cedar Falls Hydroelectric Facility to the Masonry Dam takes at a minimum of several hours to as much as a day, during which time a significant reduction in flow can occur.	New equipment would be installed to provide bypass flows around hydroelectric turbines during most emergency plant shut downs to prevent rapid downramping and dewatering downstream of the powerhouse.
Reservoir level changes caused by supplemental steelhead flows and the recovery of water (if necessary) by using the temporary pumps or reducing instream flows	Reservoir operations may influence bull trout reproduction in two ways. Studies suggest that low reservoir levels during the fall can influence the upstream spawning migrations of bull trout under rare conditions. High reservoir levels of the winter and spring may also reduce bull trout egg survival in redds situated within the Rex River and Cedar River inundation zones. Given that the bull trout population has survived similar reservoir operations for over 80 years, it is assumed that IF-1 will not result in long-term reduction of bull trout numbers.	Changes in the high and low reservoir levels are expected to be minimal under the IF-2 and vary by less than a foot in most instances. While existing information suggests that small changes in existing reservoir operations would not result in a decline of bull trout population levels, no studies have been conducted to determine if reservoir operations currently limit bull trout abundance. Under the IF-2, a monitoring and research program would be funded to track the relative status of the bull trout population and investigate the influence of reservoir operations on bull trout.
Risk of fish stranding	No formal downramping criteria or specific guidelines are used to guide flow control operations at any of the three control points on the river, thus increasing the risk of fish stranding and associated mortality.	Defined rates for down ramping river flows would be established in order to avoid the stranding of juvenile fish in the river as measured by 3 flow control points.
Effects of accretion flows on habitat	Flows in the Cedar River downstream of Landsburg are significantly influenced by natural inflows. The Applicant can reduce flows in the upper river significantly during much of the year while still meeting the IF-1 stream flow targets at Renton. Although the effects of inflows and downstream compliance points rarely result in discharge below those required to maximize WUA for most species and life history stages under normal flow years, short term reductions between early September and the end of July can pose a significant risk to incubating salmon and steelhead.	To more closely align the applicant's accountability with its actual operations, improve operating precision and ensure better protection for fish habitat, the applicant will replace the existing measurement point with several new instream flow measurement points. The upper reaches of the river will be better protected and flows downstream of the Diversion Dam will vary in a much more natural manner according to changes in natural inflows to the lower river.
Response to drought conditions	The decision to switch to critical instream flows is guided by SPU's Water Shortage Contingency Plan, which does not provide defined hydrologic criteria that govern the decision to switch between normal and critical flow regimes nor does it provide a forum for the Agencies and the Tribe to assist in decisions to switch based on up to date monitoring data.	During conditions of severe drought, the Applicant will be allowed to reduce stream flows to levels described by the critical flow regime. Unlike the IF-1 flow regime, specific hydrologic criteria and conditions must be met in order to reduce to the critical minimum flow regime under the IF-2.
Response to favorable hydrologic conditions	IF-1 normal minimum flows are typically well above the levels required to provide maximum WUA. Although it is recognized that the Cedar River system exceeds the volumes needed to meet IF-1 minimum flow requirements and water supply needs in some years, the IF-1 regime does not contain provisions to supplement the minimum flow requirements under favorable hydrologic conditions for habitat requirements in addition to WUA.	In addition to the IF-2 minimum flow requirements, the applicant will provide additional supplemental flows to meet biological objectives under specific conditions that reflect actual and forecasted water availability conditions.
Waters conservation program	Water conservation programs are currently guided by the *1996 Long Range Regional Conservation Plan*. Conservation programs are currently underway or under development for domestic use, landscape use, and commercial/industrial use and other non-revenue uses of waters. Conservation efforts so far have resulted in a decrease in overall consumption; the number of SPU customers has grown 20 percent in the last 10 years, while consumption has remained the same (Seattle Public Utilities, Water Supply Plan).	Water conservation programs under IF-2 will be similar to those of IF-1 and the plan will be supplemented by an additional $30,000 annually to pursue water conservation to protect habitat in the Cedar River.
Use of Cedar dead storage on a permanent basis	Under the IF-1, the applicant can access and use the dead storage of Chester Morse Lake under a permit from the Department of Ecology only in the case of an emergency caused by an extremely severe drought. Under this emergency scenario, the expected frequency of dead storage use is estimated to be only 1 year in 50. A temporary pumping plant was constructed on Chester Morse Lake in 1987 for this emergency purpose. Under IF-1, no provisions are made to develop a permanent non-emergency access to use water stored below the natural outlet of the lake.	Potential benefits exist for augmentation of both stream flows and water supply through the development of permanent non-emergency access to water stored below the natural gravity outlet of Chester Morse Lake. The Applicant will analyze the feasibility of reliable options for utilizing water on a permanent basis stored below the natural gravity outlet of Chester Morse Lake (Cedar Permanent Dead Storage Project). The outcome of this future separate analysis may result in a proposed amendment to the IFA and HCP and would be subject to public review in compliance with NEPA and SEPA.
Passage conditions at the Chittenden Locks	The Hiram L. Chittenden Locks in Ballard form the outlet of Lake Washington and have been identified as a significant source of mortality to out-migrating anadromous salmonids. Recent investigations suggest that a number of opportunities may exist to improve the efficiency with which freshwater is used at the locks and provide better conditions for downstream migrating anadromous fish Under IF-1, no provisions are made to contribute to feasibility studies for designing and implementing long term water efficiency improvements at the Locks.	The Applicant proposes to provide up to $625,000, or about 18% of the estimated total construction costs, to support implementation of passage improvement measures currently under consideration by the Army Corps of Engineers (ACOE). The ACOE estimates that full implementation of these measures would substantially increase passage survival (Army Corps of Engineers, 1997).

Table 4.11-4. Summary comparison of the additional instream flow management provisions under IF-1 and IF-2.

Additional Instream Flow Management Provisions	No Action Alternative (IF-1)	HCP Alternative for Instream Flows (IF-2)
Oversight of instream flow management	Although informal discussions regarding instream flow management strategies pertinent to current hydrological conditions and fish runs are conducted monthly, the Agencies and Tribe have no formal role in instream flow management decision making.	The IF-2 will provide a forum for parties to the Instream Flow Agreement (IFA) to be formally involved in instream flow management decision making. A Cedar River Instream Flow Oversight Commission will be established consisting of one member representing each of the signatories to the IFA
Instream flows upstream of Landsburg Dam	The IF-1 flow regime contains no provisions for the Cedar River upstream of the Landsburg Diversion to lower Cedar Falls.	Restoring access for chinook, coho and steelhead into the habitat upstream of the Landsburg Diversion Dam is a central component of the HCP's conservation strategy for anadromous fish. The provision of beneficial flows under IF-2 in this reach is key to the success of this strategy. Flow levels in the river upstream of the Landsburg Dam and below the Cedar Falls Powerhouse will be near or above the levels required to provide maximum WUA for chinook, coho, and steelhead spawning and rearing at all times.
Influence of reservoir fluctuations	Reservoir operations may influence bull trout reproduction in two ways. Studies suggest that low reservoir levels during the fall can influence the upstream spawning migrations of bull trout under rare conditions. High reservoir levels of the winter and spring may also reduce bull trout egg survival in redds situated within the Rex River and Cedar River inundation zones. Given that the bull trout population has survived similar reservoir operations for over 80 years, it is assumed that IF-1 will not result in long-term reduction of bull trout numbers.	Changes in the high and low reservoir levels are expected to be minimal under the IF-2 and vary by less than a foot in most instances. While existing information suggests that small changes in existing reservoir operations would not result in a decline of bull trout population levels, no studies have been conducted to determine if reservoir operations currently limit bull trout abundance. Under the IF-2, a monitoring and research program would be funded to track the relative status of the bull trout population and investigate the influence of reservoir operations on bull trout.
Ramping rates	No formal downramping criteria or specific guidelines are used to guide flow control operations at any of the three control points on the river, thus increasing the risk of fish stranding and associated mortality.	Defined rates for down ramping river flows would be established in order to avoid the stranding of juvenile fish in the river as measured by 3 flow control points
Measurement point and effects of accretion flows	Flows in the Cedar River downstream of Landsburg are significantly influenced by natural inflows. The Applicant can reduce flows in the upper river significantly during much of the year while still meeting the IF-1 stream flow targets at Renton. Although the effects of inflows and downstream compliance points rarely result in discharge below those required to maximize WUA for most species and life history stages under normal flow years, short term reductions between early September and the end of July can pose a significant risk to incubating salmon and steelhead.	To more closely align the applicant's accountability with its actual operations, improve operating precision and ensure better protection for fish habitat, the applicant will replace the existing measurement point with several new instream flow measurement points. The upper reaches of the river will be better protected and flows downstream of the Diversion Dam will vary in a much more natural manner according to changes in natural inflows to the lower river.
Criteria for switching from normal to critical instream flow regime	The decision to switch to critical instream flows is guided by SPU's Water Shortage Contingency Plan, which does not provide defined hydrologic criteria that govern the decision to switch between normal and critical flow regimes nor does it provide a forum for the Agencies and the Tribe to assist in decisions to switch based on up to date monitoring data.	During conditions of severe drought, the Applicant will be allowed to reduce stream flows to levels described by the critical flow regime. Unlike the IF-1 flow regime, specific hydrologic criteria and conditions must be met in order to reduce to the critical minimum flow regime under the IF-2.
Flow management during favorable hydrologic conditions	IF-1 normal minimum flows are typically well above the levels required to provide maximum WUA. Although it is recognized that the Cedar River system exceeds the volumes needed to meet IF-1 minimum flow requirements and water supply needs in some years, the IF-1 regime does not contain provisions to supplement the minimum flow requirements under favorable hydrologic conditions.	In addition to the IF-2 minimum flow requirements, the applicant will provide additional supplemental flows to meet biological objectives under specific conditions that reflect actual and forecasted water availability conditions
Emergency flow continuation at Cedar Falls powerhouse	Emergency shutdown of flows through the Hydroelectric Facility have the potential to cause short-term but significant reductions in flow and stage in downstream reaches of the river, posing significant risk of juvenile fish stranding and dewatering redds throughout the Cedar River downstream of Cedar Falls. Under the existing conditions, conversion of water delivery from Cedar Falls Hydroelectric Facility to the Masonry Dam takes at a minimum of several hours to as much as a day, during which time a significant reduction in flow can occur.	New equipment would be installed to provide bypass flows around hydroelectric turbines during most emergency plant shut downs to prevent rapid downramping and dewatering downstream of the powerhouse
Waters conservation program	Water conservation programs are currently guided by the *1996 Long Range Regional Conservation Plan*. Conservation programs are currently underway or under development for domestic use, landscape use, and commercial/industrial use and other non-revenue uses of waters. Conservation efforts so far have resulted in a decrease in overall consumption; the number of SPU customers has grown 20 percent in the last 10 years, while consumption has remained the same (Seattle Public Utilities, unpublished data).	Water conservation programs under IF-2 will be similar to those of IF-1 and the plan will be supplemented by an additional $30,000 annually to pursue water conservation due to critical fish habitat provided in the Cedar River.
Use of dead storage for instream flows and water supply	Under the IF-1, the applicant can access and use the dead storage of Chester Morse Lake under a permit from the Department of Ecology only in the case of an emergency caused by an extremely severe drought. Under this emergency scenario, the expected frequency of dead storage use is estimated to be only 1 year in 50. A temporary pumping plant was constructed on Chester Morse Lake in 1987 for this emergency purpose. Under IF-1, no provisions are made to develop a permanent non-emergency access to use water stored below the natural outlet of the lake.	Potential benefits exist for augmentation of both stream flows and water supply through the development of permanent non-emergency access to water stored below the natural gravity outlet of Chester Morse Lake. The Applicant will analyze the feasibility of reliable options for utilizing water stored below the natural gravity outlet of Chester Morse Lake.
Passage and water efficiency at the Chittenden Locks	The Hiram L. Chittenden Locks in Ballard form the outlet of Lake Washington and have been identified as a significant source of mortality to out-migrating anadromous salmonids. Recent investigations suggest that a number of opportunities may exist to improve the efficiency with which freshwater is used at the locks and provide better conditions for downstream migrating anadromous fish Under IF-1, no provisions are made to contribute to feasibility studies for designing and implementing long term water efficiency improvements at the Locks.	The Applicant proposes to provide up to $625,000, or about 18% of the estimated total construction costs, to support implementation of passage improvement measures currently under consideration by the Army Corps of Engineers (ACOE). The ACOE estimates that full implementation of these measures would substantially increase passage survival (Army Corps of Engineers, 1997).