Tacoma Water
Habitat Conservation Plan

Green River Water Supply Operations
and Watershed Protection

Technical Appendices and Implementing Agreement

VOLUME 2 of 2

Final - July 2001

TACOMA WATER
TACOMA PUBLIC UTILITIES

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Habitat Conservation Plan
Green River Water Supply Operations and Watershed Protection

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INTRODUCTION

There are up to nine species of anadromous salmonids present in the Green River today. The Green River currently supports populations of sockeye (*Oncorhynchus nerka*), coho (O. *kisutch*), chinook (*O. tshawytscha*), and chum (*O. keta*) salmon, cutthroat (*O. clarki*) and steelhead (*O. mykiss*) trout. Pink (O. *gorbuscha*) salmon are believed to be present in the system, however, not in large numbers. Historically, bull trout (*Salvelinus confluentus*) and/or Dolly Varden (*S. malma*) have been reported to occur in the Green River (Grette and Salo 1986); however, the presence of a reproducing population has not been documented to date (WDFW 1998). Pacific (*Lampetra tridentatus*) and river (*L. ayresi*) lamprey are also present in the Green River, but little information is available on their present status.

The general life history of Pacific salmon involves constructing nests (redds) in gravel beds for spawning, followed by migration to the ocean for feeding and maturation, and returning to natal sites for spawning and completion of their life cycle. There are many variations on the timing and duration of these life cycles both between species, and from year to year for the same species. Figure A-1 provides a summary of the timing of the freshwater life phases of several salmonid species in the Green-Duwamish Basin. Each salmonid species present in the Green River has a different length and timing of freshwater residence. The freshwater periodicity of an individual species may impart differential responses by salmonids to Green River water management strategies.

The salmon and trout species listed above are proposed to be covered under the Incidental Take Permit (ITP). In order to determine the benefit of protection measures and the effect of activities proposed for coverage under the ESA, an understanding of the life history traits and habitat requirements was needed. This appendix provides a description of life history traits, habitat requirements, range and abundance of all species proposed for coverage under the ITP.

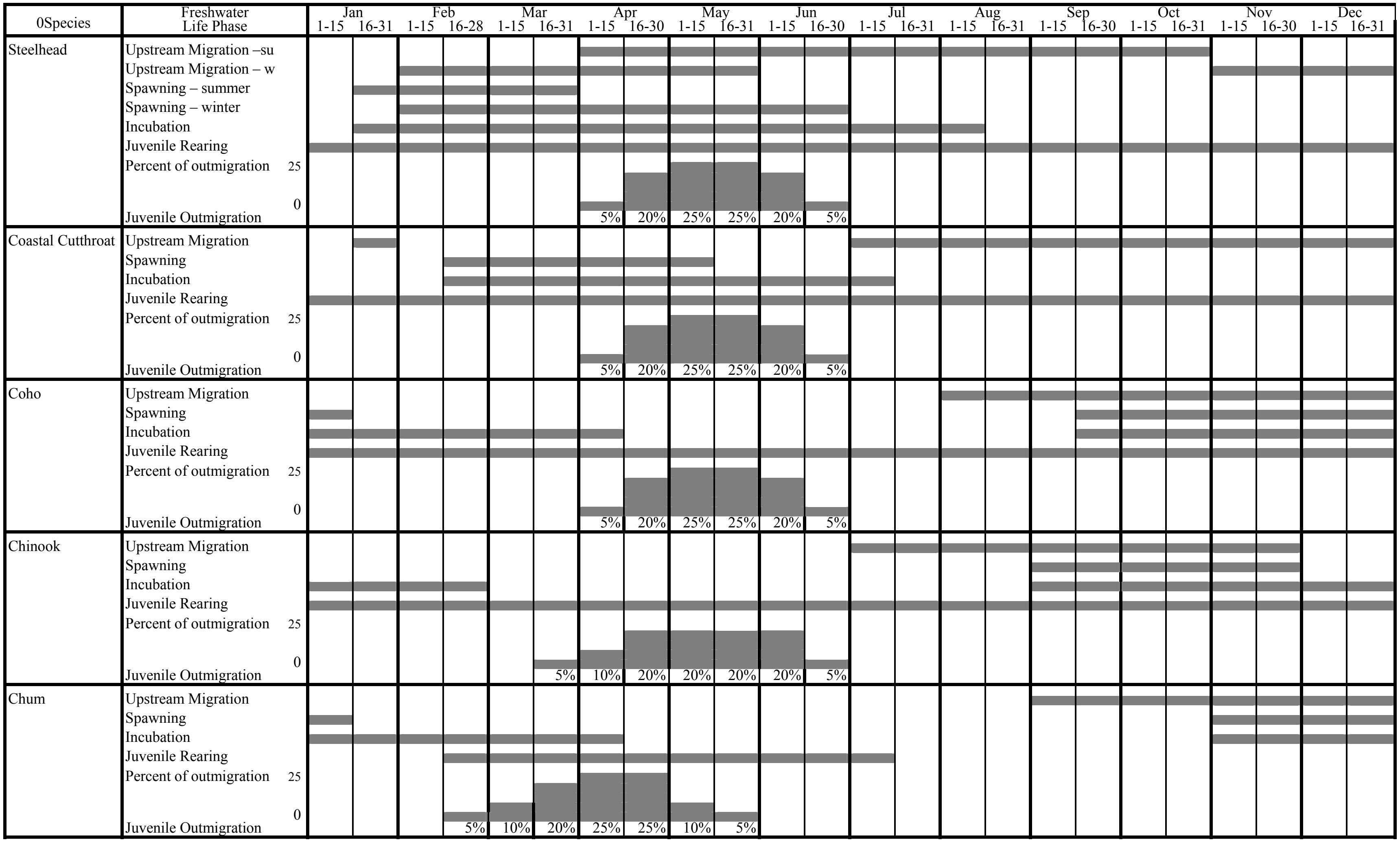

Figure A-1. Timing of selected salmonid species freshwater life phases in the Green-Duwamish Basin (Source: periodicity of adult lifestages adapted from Grette and Salo 1986).

CHINOOK SALMON *(Oncorhynchus tshawytscha)*

Life History and Habitat Requirements

Chinook salmon are the largest of all Pacific salmon and can weigh over 100 pounds; however, the average weight is closer to 22 pounds. Chinook salmon, the least abundant of the five Pacific salmon species, were historically found from the Ventura River, California to Point Hope, Alaska (Myers et al. 1998). Currently, spawning populations of chinook exist from the San Joaquin River to the Kotzebue Sound, Alaska (Healey 1991). Green River chinook salmon, along with 28 other stocks, have been placed into the Puget Sound Evolutionarily Significant Unit (ESU) by the National Marine Fisheries Service (NMFS) (Myers et al. 1998). The Puget Sound ESU encompasses all chinook populations from the Elwha River on the Olympic Peninsula to the Nooksack River in North Puget Sound and south to the Nisqually River. The 5-year mean natural escapement (1992-1996) for the Puget Sound ESU is approximately 27,000 spawners; recent total escapement (natural and hatchery fish) has averaged 71,000 chinook (Myers et al. 1998).

Based on timing of adult returns, most of the chinook salmon inhabiting the Green River are of the summer/fall origin (WDFW et al. 1994). Adult summer/fall chinook migrate upstream in the Green River from late June through November (Grette and Salo 1986). Owing to their body size, the presence of deep holding water and sufficient discharge are vital to permit upstream migration. Actual adult run and spawning timing is in response to local water temperature and flow regimes (Healey 1991). Caldwell and Associates (1994) indicate that the potential for delay of upstream migration exists in August, when Green River water temperatures can exceed 21ºC (70ºF) (criteria presented in Armour 1991). Elevated water temperatures can also lead to low dissolved oxygen (DO) levels, which could also delay migration (Armour 1991).

Chinook spawning in the Green River takes place from early September through mid-November (Grette and Salo 1986). Preferred spawning areas include the main channel from Kent (RM 24) to the Tacoma Water Supply Intake at RM 61.0 (Headworks). Spawning chinook also utilize the lower portions of Newaukum and Big Soos creeks (King County Planning Division 1978). Larger body size also allows for use of larger spawning gravel and cobble substrates (Raleigh et al. 1986). Caldwell and Hirschey (1989) report Green River chinook spawn over cobble with some large gravel and boulders at depths of greater than 1.0 feet to almost 3 feet in water velocities ranging from about 2.0 to 3.0 feet per second (fps).

Chinook eggs require 882 to 991 temperature units on average before hatching (1 temperature unit = 1 degree C above freezing for 24 hours) (Beauchamp et al. 1983). The length of incubation in the Green River varies depending on location of redds, but is generally completed by the end of February (see Figure A-1). The young remain in the gravels for 2 to 3 weeks after hatching (Wydoski and Whitney 1979).

Many variations in juvenile life history are possible within fall/summer chinook (Healey 1991), often the result of variability in the juvenile freshwater residence period (Reimers 1973). Five different juvenile chinook salmon life history strategies are suggested by Reimers (1973):

- emergent fry move directly downstream and into the ocean within a few weeks;
- juveniles rear in the main river or remain in tributaries until early summer, emigrating into the estuary for a short rearing period before entering the ocean;
- juveniles rear in the main river or tributaries until early summer, then emigrate into the estuary for an extended rearing period before entering the ocean in autumn;
- juveniles rear in the tributary streams or in the main river until autumn rainfall begins before they emigrate to the ocean; and
- juveniles remain in tributary streams, or in the main river, through the summer, rear in the river until the following spring, and enter the ocean as yearlings.

The proportion of chinook present in the Green River corresponding to the above variations in freshwater residence could be dictated by genetic and environmental factors. Environmental cues such as streamflow reductions, food supply, changes in photo-period, and temperature increases are all factors that lead to the evolution and expression of particular juvenile outmigration timing (Myers et al. 1998). Specific examples of documented life history strategies in the Green River can be found in the following studies.

The U.S. Fish and Wildlife Service (USFWS) used fyke traps to gauge trends in downstream movement of subyearling chinook planted above Howard Hanson Dam (HHD). During 1991, 979,446 subyearling chinook were planted on 21-25 February and 960,084 were planted 6-7 March. Fyke trapping above HHD was conducted 18 April through 21 November and the peak movement of subyearling chinook into the reservoir was observed during late May and early June (Dilley and Wunderlich 1992). During

1992 they expanded their trapping activities to extend from mid-February through the end of November. A large downstream movement into the reservoir was noted during late March and April, which was assumed to be displacement coincident with outplanting of hatchery juveniles. They observed a peak downstream movement out of the reservoir in early June, which coincided with peak adenosine triphosphate levels (Dilley and Wunderlich 1993). Based on available data, peak timing of outmigration of chinook smolts from the upper watershed was assumed to occur between late April and early June in the upper Green River.

Dunstan (1955) used fyke nets to sample the middle Green River between 18 February and 20 May 1955 and captured newly emerged fry in late February through April. They identified the peak outmigration occurring between 7 April and 17 April. Recent juvenile salmonid surveys found that relative chinook abundance in the middle Green River peaked in early April, while juvenile chinook salmon (age-0) were present from 25 February through 25 June (Jeanes and Hilgert 1999). Age-1+ chinook were also captured during juvenile salmonid surveys in the middle Green River (Jeanes and Hilgert 1999). The origin of age-1+ chinook is unknown, but they may represent fish over-wintering in the Green River, or fish originating upstream from HHD.

Studies performed in the Duwamish Estuary indicate that peak chinook fry abundance in the Duwamish Estuary occurs during late May (Bostick 1955; Weitkamp and Campbell 1979). Meyer et al. (1980) found the greatest abundance of juvenile chinook during early May, even though chinook persisted in beach and purse seine catches through July, indicating that juvenile chinook display an extended period of residency in the Duwamish Estuary. Due to their plastic life history structure, juvenile chinook are thought to migrate into and utilize estuarine habitats longer than other Pacific salmon species (Simenstad et al. 1982; Emmett et al. 1991). Extended estuarine residency period may provide for the highest growth rates that chinook witness in their lives (SRWA 1998). Salo (1969) indicates a growth rate of approximately 1.0 inch per week in the Duwamish Estuary that could impart higher marine survival rates for the juvenile fish (Simenstad et al. 1982).

The majority of Puget Sound chinook mature as 3- and 4-year-olds, although they may return as early as 2 years, or even later than 6 years (Myers et al. 1998). Healey (1991) found that temperature, DO, and weather may influence chinook salmon to hold in the estuary until conditions are correct to continue upstream to spawn.

Despite being the least abundant of the five species of Pacific salmon, chinook are important economically (Wydoski and Whitney 1979). Peak recorded harvest of chinook salmon in the Puget Sound corresponded to a run-size of 690,000 in 1908 (Myers et al. 1998). Coded wire tag recoveries from Puget Sound chinook, including Green River, indicate that approximately one-third of the total catch of South Puget Sound chinook occurs in Canadian fisheries, slightly less than two-thirds in Puget Sound, and a small proportion in Washington coastal fisheries (WDFW et al. 1994).

Known Occurrences in the Project Vicinity

Summer/fall chinook of the Duwamish/Green River basin are distinguished from other Puget Sound stocks by geographic isolation. The stock is mixed origin, whereby production is supplemented from hatchery releases from the Green River Hatchery located on Soos Creek. Genetic analysis is currently underway to determine if the chinook spawning in Newaukum Creek are a separate stock from those spawning in the Green River (WDFW et al. 1994). Coded-wire tag recoveries indicate that some hatchery strays are spawning naturally in the Green River and Newaukum Creek (WDFW et al. 1994). Total escapement in the mainstem Green River averaged 7,600 from 1987 through 1992 (WDFW et al. 1994), exceeding the escapement goal for all naturally spawned chinook in the Green/Duwamish River (including Newaukum Creek) of 5,800 (WDFW et al. 1994). Newaukum Creek escapement averaged 1,600 chinook from 1987-1991 with an alarming decrease in both 1990 and 1991. In meeting the natural escapement goal, Green River chinook represent approximately 21 percent of the natural escapement occurring in the Puget Sound ESU. An unknown level of natural escapement in the Green River has been attributed to hatchery strays from Soos Creek (WDFW et al. 1994).

At present, it is unknown whether a spring chinook population is present in the Green River (Grette and Salo 1986). A small run may have been present prior to the separation of the Green and White rivers in 1906; however, little information is available (Grette and Salo 1986). There is currently no hatchery production of spring chinook in the Green River.

Population Status and Status under the ESA

Overall, abundance of chinook salmon in the Puget Sound ESU has declined substantially, and both long- and short-term abundance trends are predominantly downward. These factors have led to the listing of the Puget Sound ESU as threatened under the ESA on 26 February 1998 (63 FR 11482). Sedimentation and high water temperatures are major habitat problems faced by chinook in the Green River (Myers et al. 1998), even though the Green River and Newaukum Creek stocks are listed as healthy by the Washington Department of Fish and Wildlife (WDFW) (WDFW et al. 1994). The Green River and Newaukum Creek stocks were two of the six mixed-origin stocks (out of 28 stocks located in the Puget Sound ESU) that were listed as healthy by the WDFW (Myers et al. 1998).

A Genetic Stock Inventory (GSI) sample of various parts of the river was conducted in the fall of 1997, and this sample will be analyzed to determine what parts of the Green River population may still contain segments of wild Green River chinook salmon. This analysis could be important in establishing the final assessment of the stock as wild, wild and hatchery, or hatchery, and could affect chinook protection and recovery if listed as a threatened species (Myers et al. 1998).

BULL TROUT *(Salvelinus confluentus)* and DOLLY VARDEN *(Salvelinus malma)*

Life History and Habitat Requirements

Two native char species are potentially present in the Green/Duwamish River drainage: bull trout and Dolly Varden. Bull trout are primarily an inland resident species, and widely distributed in isolated populations throughout the Columbia River drainage (63 FR 31693). Bull trout populations are also present in the Klamath River Basin of Oregon, and in the Jarbidge drainage of Nevada (63 FR 31693). The bull trout is now considered to be extinct in northern California, and is shrinking in distribution throughout its former range. Populations of bull trout are also found in western Washington, including coastal drainages of the Puget Sound, Straight of Juan de Fuca, Hood Canal, and Olympic Peninsula (64 FR 58910). In contrast to bull trout, Dolly Varden primarily inhabit coastal drainages extending from western Washington to Alaska. These two native char species occur sympatrically in a number of drainages in western Washington, including the Snohomish and Skagit rivers (WDFW 1998). The species composition of native char in most Puget Sound rivers, including the Green River, will remain uncertain until a comprehensive genetic analysis of native char populations in this region is completed (WDFW 1998).

Bull trout and Dolly Varden were previously considered to be the same species, but were recognized as separate species by the American Fisheries Society in 1980 based upon differences in morphometrics, osteological features, and embryological development (Cavender 1978). These two native char species are difficult to differentiate based upon overall physical appearance, but can be identified to species using morphological-meristic (measurements of physical features) and genetic analyses (64 FR 58910). Both species of native char have similar life history traits and habitat requirements (WDFW 1998; 64 FR 58910). Because bull trout and Dolly Varden are difficult to distinguish based upon physical appearance, and have very similar biological characteristics, WDFW manages and regulates these as the same species (WDFW 1998). WDFW refers to these bull trout and Dolly Varden as “native char” in managing and protecting these species. Both species are proposed for coverage under the ITP. Following WDFW’s convention, both species are described and analyzed together throughout the Habitat Conservation Plan (HCP), and are jointly referred to as “native char” or “bull trout” in this document.

Native char in Puget Sound and coastal streams may express both resident and migratory life history forms (USFWS 1998). Resident bull trout complete their life cycles in tributaries, while some migratory bull trout adopt an anadromous life cycle. Anadromous forms migrate to sea in the spring and return in late summer and early fall (Wydoski and Whitney 1979). Native char can spend 2 or even 3 years in fresh water before migrating to sea. Little is known about their habits or distribution while in the marine environment.

Spawning in most native char populations occurs in September and October, though it may occur in August at elevations above 4,000 feet in the Cascades and as late as November in coastal streams (Goetz 1989; Craig 1997). Most anadromous populations spawn only every second year, while resident char may spawn every year (Armstrong and Morrow 1980; USFWS 1998). Spawning sites are characterized by low gradient, uniform flow, and a gravel substrate between 0.25 to 2.0 inches in diameter (Wydoski and Whitney 1979; Fraley and Shepard 1989). Groundwater influence and proximity to cover also are reported as important factors in spawning site selection (Fraley and Shepard 1989). Studies conducted throughout the species range indicate that spawning occurs in water from 0.75 to 2.0 feet deep (Wydoski and Whitney 1979; Fraley and Shepard 1989) and often occurs in reaches fed by streams, or near other sources of cold groundwater (Pratt 1992).

Bull trout require a long period of time from egg deposition until emergence. Embryos incubate for approximately 100 to 145 days, and hatch in late winter or early spring (Weaver and White 1985). Rieman and McIntyre (1993) indicate that optimum incubation temperatures are between 2 and 4ºC. The alevins remain in the streambed, absorbing the yolk sac, for an additional 65 to 90 days (Pratt 1992). Emergence from the streambed occurs in late winter/early spring (Pratt 1992). High fine sediment levels in spawning substrates reduce embryo survival, but the extent to which they affect bull trout populations is not entirely known (Rieman and McIntyre 1993).

Fry are usually found in shallow, slow backwater side channels and eddies, in close proximity to instream cover (Pratt 1984). Young-of-the-year bull trout are found primarily in lateral stream habitats such as side-channel areas and along stream margins, similar to that reported for other species of salmonids (Fraley and Shepard 1989). Juveniles are primarily bottom dwellers and are found among interstitial spaces in the substrate (Fraley and Shepard 1989; Pratt 1992). Sub-adults are often found in deeper stream pools or in lakes in deep water with temperatures less than 15EC (Pratt 1992).

Long overwinter incubation periods for native char embryos and alevins make them particularly susceptible to increases in fine sediments (USFWS 1998). The WDFW lists the following as the limiting factors for the species: stream temperatures that exceed the normal spawning and incubation temperature range; lack of spawning and rearing habitat; and a high percentage of fine sediment in spawning gravels (WDFW 1998). Because of their close association with the bottom, native char are sensitive to changes in the streambed (Fraley and Shepard 1989; USFWS 1998). Bull trout readily interbreed with non-native brook trout *(Salvelinus fontinalis)*. Brook trout may also exclude bull trout from native habitats (USFWS 1998). Finally, native char are easily caught and are highly susceptible to fishing pressure; therefore, any increase in the accessibility of a population to fishing pressure may negatively impact a population (Fraley and Shepard 1989; USFWS 1998).

Known Occurrences in the Project Vicinity

Numerous studies have attempted to ascertain the extent to which bull trout are present in the Green/Duwamish River. The U.S. Forest Service (USFS) conducted general fisheries surveys in the upper Green River drainage and Sunday Creek basin over a series of years and found no evidence of native char (F. Goetz, USACE 1998). The USFS (1998) determined that no records exist that suggest bull trout have ever occupied habitat upstream of HHD. In support of their ITP application for lands in the upper Green River watershed, Plum Creek Timber Company biologists conducted presence/absence surveys for bull trout; however, no bull trout were detected (Watson and Hillman 1997). Streams included in this survey were: upper Green River, Twin Camp Creek, Intake Creek, Sawmill Creek, Pioneer Creek, and Tacoma Creek. Three reaches were sampled on each stream (6.2 mile/reach and 12 transects/reach). The surveys consisted of snorkeling and electrofishing during daylight hours and only during one field season (Watson and Hillman 1997).

Potential bull trout habitat in the upper Green River is considered somewhat degraded due to past timber harvests. Stream temperatures in this survey area may be warmer than temperatures required by bull trout in the late summer. Bull trout thrive in waters that are too cold for other salmonid species (USFWS 1998). The Green River is a low elevation system, and may not provide the coldwater habitat necessary for bull trout success.

However, there is evidence that native char may have historically occurred in the lower Green River/Duwamish River basin (Grette and Salo 1986). Historical records report thousands of native char in the Green River system (RM 35) in the 1800s. This report was prior to separation of the Green and White river systems. The White River was diverted from the Green River into the Puyallup River in 1906 and the White River continues to support a large population of native char.

No bull trout were observed during fisheries surveys conducted in the reach between HHD and the Tacoma Headworks intake in 1985 and 1994 (Solonsky 1985; Dillon 1994). These surveys were one-day, daylight only, snorkeling efforts by trained field crews. Trapping studies conducted between the HHD and the Headworks did not report catches of native char (Hatfield 1986). Anglers in the Headworks area have not reported catching native char. Cropp (1989) set vertical and horizontal gill nets in Howard Hanson Reservoir in August 1989, and collected only chinook, coho, steelhead, native cutthroat and whitefish; no native char were collected. Electrofishing and fyke net surveys conducted in the middle Green River (RM 34-45) did not capture bull trout (Jeanes and Hilgert 1999).

The documented presence of native char in the Green River system is limited to the capture of solitary adult specimens in the lower river. A single bull trout sighting was reported in Soos Creek in 1956. No supporting information regarding this sighting is available (Beak 1996). The capture of a solitary bull trout in the Duwamish River system (lower Green River) by E. Warner of the Muckleshoot Indian Tribe (MIT) in 1994, referenced in the USFWS proposed listing of bull trout under the Endangered Species Act (ESA) (63 FR 31693), is more likely indicative of movement between river systems than the presence of a "depressed" population in the Green River (63 FR 31693).

The observations of adult native char in themselves do not indicate that a reproducing population is present in the Green River. Bond (1992) maintained that movement between river systems during feeding forays to salt water is a potential mechanism of bull trout distribution. Anadromous Dolly Varden are known to temporarily inhabit lower portions of non-natal rivers before returning to their natal stream to spawn (Bernard et al. 1995). Native char in southeast Alaska have been observed migrating through salt water as much as 140 miles between river systems before entering their natal streams (Armstrong and Morrow 1980). One adult bull trout radio-tagged in the Sauk River, a tributary to the Skagit River, was recovered 6 months later in the lower Snohomish River (WDFW 1998). Native char have the opportunity to move in and out of the Green River, and infrequent solitary sightings of adults in the lower reaches further suggest such movement between river systems may be occurring in the Puget Sound area.

Population Status and Status under the ESA

The Green River is considered part of the Puget Sound bull trout distinct population segment (DPS) by the USFWS. This DPS is a geographically isolated segment, encompassing all Pacific Coast drainages north of the Columbia River in Washington (63 FR 31695). The Green River possesses one of 15 “native char” populations identified by the USFWS in the Puget Sound area (64 FR 58910). A total of 34 subpopulations of native char were identified in the Coastal-Puget Sound DPS. Due to several detrimental factors (including disease, predation, increased stream temperatures and loss of habitat) bull trout in the conterminous United States (including the Coastal-Puget Sound DPS) were listed as threatened by the USFWS on 1 November 1999 (64 FR 58910). There is little information available specifically on the status of the Green River stock (WDFW 1998). The WDFW (1998) has no confirmation of reproduction or juvenile rearing of native char in the Green River basin today. As a precaution, retention of native char caught in the Green/Duwamish River has been illegal since 1994 (WDFW 1998). Dolly Varden were not listed as a threatened species in the DPS when the USFWS listed bull trout in November 1999 (64 FR 58910). However, the USFWS indicated in January 2001 that Dolly Varden are being considered for listing as threatened due to their similarity of appearance to bull trout (66 FR 1628).

COHO SALMON *(Oncorhynchus kisutch)*

Life History and Habitat Requirements

Coho salmon are one of the most popular and widespread sport fishes found in Pacific Northwest waters. Coho populations exist as far south as the San Lorenzo River, California, and north as Norton Sound, Alaska (Sandercock 1991). The average size of Puget Sound coho has steadily declined from 1972 (8.8 pounds) through 1993 (4.4 pounds) (Bledsoe et al. 1989). Numerous parameters, including harvest practices, are thought to be associated with this decline. Coho originating in the Green River have been placed into the Puget Sound/Strait of Georgia ESU by the NMFS (Weitkamp et al. 1995). This ESU encompasses coho populations from South Puget and Hood Canal to eastern Olympic Peninsula up to the Powell River Basin, British Columbia. Total average run size (from 1965 through 1993) for 17 stocks located in the Puget Sound ESU is 240,795 (Weitkamp et al. 1995).

Green River coho migrate upstream from early August through mid-January (Grette and Salo 1986). As with chinook salmon, coho require both deep holding cover for resting and sufficient instream flow (water depths of 0.6 feet) to permit upstream movement (Laufle et al. 1986).

Coho spawning takes place in the Green River from late September through mid-January (Grette and Salo 1986). Coho spawn in all available tributaries and the mainstem Green River. Mainstem spawning is heaviest in the braided channel reaches near Burns Creek, in the Green River Gorge, and below the Tacoma Headworks. Major spawning tributaries include Newaukum, Big Soos, Crisp, Burns, Springbrook, and Hill creeks (Grette and Salo 1986).

Incubation periods for coho salmon last from 35 to 101 days (Laufle et al. 1986; Sandercock 1991). After hatching, larvae typically spend 3 to 4 weeks (depending on depth of burial, percentage of fine sediments, and water temperatures) absorbing the yolk sac in gravels before they emerge in early March to mid-May (McMahon 1983; Laufle et al. 1986; Sandercock 1991). Newly emerged coho (e.g., yolk sac fry) were found in the middle Green River on 25 February (Jeanes and Hilgert 1999). Coho fry continued to be present through May, with peak relative abundance occurring in mid-April (Jeanes and Hilgert 1999).

Juvenile coho salmon rear in fresh water for approximately 15 months prior to migrating downstream to the ocean, but may extend their rearing time for up to 2 years (Sandercock 1991). Newly emerged fry usually congregate in schools in pools of their natal stream. As juveniles grow, they move into more riffle habitat and aggressively defend their territory, resulting in displacement of excess juveniles downstream to less favorable habitats (Lister and Genoe 1970). Aggressive behavior may be an important factor maintaining the numbers of juveniles within the carrying capacity of the stream, and distributing juveniles more widely downstream (Chapman 1962; Sabo 1995). Once territories are established, individuals may rear in selected areas of the stream feeding on drifting benthic organisms and terrestrial insects until the following spring (Hart 1973; Cederholm and Scarlett 1981). Complex woody debris structures and side channels are important habitat elements for young-of-the-year coho salmon, particularly during the summer low flow period on the Green River (Grette and Salo 1986; Jeanes and Hilgert 1999), suggesting that the abundance of juvenile coho is often determined by the combination of space, food, and water temperature (Chapman 1966; Sandercock 1991).

The peak outmigration of coho smolts in the Green River occurs between late April and early June (Figure A-1). Bostick (1955) sampled outmigrating smolts in the Duwamish Estuary in 1953 and observed the peak outmigration of coho smolts in late May. Dunstan (1955) observed a peak outmigration of coho smolts during late April. Dunstan (1955) also captured newly emerged fry late February through April but characterized these early movements as being instream redistribution rather than an active seaward migration. Weitkamp and Campbell (1979) and Meyer et al. (1980) observed the greatest abundance of coho smolts in the Duwamish Estuary during late May. Meyer et al. (1980) noted that by early June coho smolts appeared to move quickly through the estuary and that few coho were present in the estuary after 4 June. Observations of peak coho smolt movement in the Duwamish Estuary may occur up to several weeks following peak movement through the lower Green River.

During 1983, coho fry were outplanted in the upper watershed and a scoop trap was operated below HHD to monitor the outmigration of coho smolts (Seiler and Neuhauser 1985). The trap was operated at regular intervals between 5 April through 18 June and observed the peak outmigration of coho smolts between early May and early June. Over 90 percent of smolts captured were taken during the hours of darkness. Low catches during the initial days of trapping suggested the migration began during early April, but data on the end of migration were obscured by closure of the main discharge gates at HHD on 6 June. Based on the number of coho yearlings captured during gill net sampling in the reservoir, Seiler and Neuhauser (1985) suggested downstream migration from the upper watershed continues into June.

Peak downstream movement of coho yearlings into the reservoir occurred during May and early June (Dilley and Wunderlich 1992). During 1992 they expanded their trapping activities to extend from mid-February through the end of November. Unusually warm, wet weather during February 1992 and a high early runoff coincided with downstream movement of coho yearlings into the reservoir beginning in late February and extending through May. Even though downstream migration began in February, downstream movement into the reservoir peaked during late April and early May (Dilley and Wunderlich 1993).

Outmigrating yearling coho tend to move quickly through the estuary compared to other salmonid species (Emmett et al. 1991). Adult coho generally return to their natal streams to spawn at age 3, after spending 18 to 24 months (up to 3 years) in the marine environment. Coho salmon are an important commercial and recreational species in the Puget Sound; Grette and Salo (1986) report over 150,000 fish from the Green River were reported in the commercial and recreational coho catch during 1981.

Known Occurrences in the Project Vicinity

The coho salmon is considered to be the most numerous anadromous fish in the Green/Duwamish basin (King County Planning Division 1978). Two coho stocks have been identified in the Green River Basin, the Green River/Soos Creek, and Newaukum Creek (WDFW et al. 1994). The Green River/Soos Creek stock is of mixed origin. Releases of both native and non-native hatchery-origin coho in this system dates back to the early 1950s. Currently, approximately 3 million yearling coho are released annually from hatchery facilities located on Soos and Crisp creeks. Natural reproduction in Soos Creek is derived from hatchery-origin adults passed above the rack. Production upstream of HHD is derived from off-station fry and fingerling releases. Escapement data for the Green River/Soos Creek coho stock are limited; however, run reconstruction data indicates stable escapement and the stock is considered healthy (WDFW et al. 1994). Green River coho run size from 1965 through 1993 averaged 11,979 based on run reconstruction, which equates to 5 percent of the total average run size for the Puget Sound ESU (Weitkamp et al. 1995).

Coho returning to Newaukum Creek have been identified as a separate stock within the Green River basin, based on geographic separation and differences in spawning timing (WDFW et al. 1994). Multiple peaks within spawning curves and an extended spawning season suggest that there may be a unique genetic component in the Newaukum Creek stock. This stock is believed to be a mixture of native and introduced stocks. Production occurs through both natural spawning and a comprehensive fingerling release program. Since 1987, this stock has experienced a severe short-term decline and is considered depressed.

Population Status and Status under the ESA

Green River/Soos Creek coho population data indicates stable escapement and production levels; however, the last year of data analyzed (1991) is the lowest in database history, and similar values in the future would quickly bring this stock into the "depressed" category (WDFW et al. 1994).

The Newaukum Creek coho stock has experienced short-term severe decline in population that has been limited by summer low flows (WDFW et al. 1994). This stock is currently designated as depressed by WDFW et al. (1994).

Green River coho stocks were placed in the Puget Sound/Strait of Georgia ESU. Continued loss of habitat, extremely high harvest rates, and a severe recent decline in average spawner size are substantial threats to remaining native coho populations in this ESU. Currently, this ESU is not listed as threatened or endangered. However, because of limited information on many coho stocks in this ESU and risks to naturally producing populations, the Puget Sound/Strait of Georgia ESU was added to the list of candidates for threatened and endangered species. If present trends continue, this ESU is likely to become endangered in the foreseeable future (Weitkamp et al. 1995).

SOCKEYE SALMON *(Oncorhynchus nerka)*

Life History and Habitat Requirements

Sockeye salmon are the third most abundant of the seven Pacific salmon species (Burgner 1991). As such, commercial catches of sockeye comprised 17 percent by weight and 14 percent by number of the total salmon catch in the Pacific Ocean from 1952-1976 (Burgner 1991). Historically, accounts of sockeye catches exist for California as far south as the Sacramento River; however, today there are no recognized runs existing in that state (Gustafson et al. 1997). Currently, sockeye range from the Deschutes and Willamette rivers in Oregon to Kotzebue Sound, Alaska. Green River sockeye, along with sockeye from 15 other rivers and streams in Washington, were listed as riverine spawning sockeye salmon in Washington by NMFS and were not included in one of the six ESUs established in 1997 (Gustafson et al. 1997). Other than anecdotal accounts, little information is available on the abundance and/or trends of riverine-spawning sockeye in Washington.

Sockeye salmon exhibit the greatest variety of life history patterns of all the Pacific salmon, and characteristically make more use of lacustrine habitat than other salmon species. Life history patterns of sockeye include: nonanadromous land-locked sockeye, lake type sockeye, and river or sea type sockeye. The landlocked type, called kokanee, mature, spawn and die in fresh water without a period of marine residency (Gustafson et al. 1997). Lake-rearing sockeye juveniles typically spend 1 to 3 years in lacustrine habitats, before migrating to sea (Burgner 1991). Lake-rearing stocks represent the most common and typical life history. Sockeye that rear in rivers for 1 to 2 years (river-type sockeye) are less common than the lake-type sockeye, and hence little is known about them. River type sockeye migrating as fry to salt water, or lower river estuaries in the same year as emergence, are termed "sea-type" sockeye (Gustafson et al. 1997). The distribution of sockeye in Puget Sound known to use rivers for spawning and rearing include the North and South Fork Nooksack, Skagit, Sauk, North Fork Stillaguamish, Samish, and Green river populations (Gustafson et al. 1997).

River-spawning sockeye exhibit great diversity in selection of spawning habitat and river entry timing (Gustafson et al. 1997). Puget Sound stocks, in general, enter fresh water in June, July, and August (Gustafson et al. 1997). Areas containing upwelling of oxygenated water through sand and gravel are important for spawning (Burgner 1991). For a given fish size, sockeye salmon have the highest fecundity (number of eggs), and the smallest egg size of the Pacific salmon (Gustafson et al. 1997).

Length of sockeye egg incubation is temperature dependent, but is generally longer than the other salmon species (Burgner 1991). This seems to be due to the choice of spawning environment (Burgner 1991). In general, spawning occurs during periods of declining temperatures, incubation occurs at the lowest winter temperatures, and hatching is associated with rising water temperatures in late winter or early spring (Burgner 1991).

After emergence, juvenile sockeye will migrate to nursery lakes for rearing, or in the case of river-type sockeye, utilize river and estuarine habitat for rearing, or migrate directly to the sea (Burgner 1991). Initially, upon emergence, juvenile sockeye exhibit photonegative response, moving primarily at night, which is believed to be an anti-predator adaptation (Burgner 1991). Smolt outmigration to the ocean also occurs during darkness, beginning in late April and extending through early July (Gustafson et al. 1997). After leaving the Puget Sound, sockeye move north to the Gulf of Alaska.

Maturity in sockeye salmon ranges from 3 to 8 years (Gustafson et al. 1997). Wydoski and Whitney (1979) report adult sockeye as reaching a length of 33 inches and a weight averaging between 3.5 and 8 pounds. Sockeye will spend 1 to 4 years in the ocean before returning to fresh water to spawn. Many adult sockeye make long migrations, requiring higher stored energy reserves and any delay in migration, such as those caused by dams or low water levels, can be very damaging to spawning success (Hart 1988).

Known Occurrences in the Project Vicinity

Small numbers (less than 200) of sockeye adults have been observed spawning in the Green River below the Headworks (E. Warner 1998). It is unknown whether these are strays from Lake Washington habitat or river-type sockeye. Historically there has been no lake access in the Green River, so any lake-type sockeye were probably strays from other drainages. Although the origin of the Green River stock is unknown, between 1925 and 1931 at least 392,050 sockeye salmon fry derived from the Green River, Quinault Lake, and unspecified Alaska stocks were released into the Green River from the Green River State Hatchery (Gustafson et al. 1997). Peak counts of sockeye spawners in the Green River ranged from 1 to 16 fish during 14 years of surveys that occurred between

1954 and 1990. These fish were observed from mid-September to mid-November (Gustafson et al. 1997). Several juvenile sockeye salmon were captured during juvenile salmonid surveys on the middle Green River during 1999 (Jeanes and Hilgert 1999).

Population Status and Status under the ESA

Green River sockeye are classified as a riverine-spawning sockeye salmon under “Other Population Units” by NMFS. Gustafson et al. (1997) stated "there was insufficient information (regarding riverine-spawning sockeye populations) to reach any conclusions regarding the status of this unit."

CHUM SALMON *(Oncorhynchus keta)*

Life History and Habitat Requirements

Chum salmon, known for the large teeth and calico-patterned body color of spawning males, have the widest geographic distribution of any Pacific salmonid (Johnson et al. 1997). In North America, chum range from the Sacramento River in California, to Arctic coast streams (Salo 1991). Green River chum salmon, along with chum stocks from the Puget Sound and as far west as the Elwha River, were placed into the Puget Sound/Strait of Georgia ESU by NMFS (Johnson et al. 1997). The average chum harvest from 1988-1992 for this ESU was an estimated 1.185 million fish, equating to a total abundance of 1.5 million fish (Johnson et al. 1997).

Chum salmon migration into the Green River begins in early September and continues through December (Figure A-1). Upstream migration can be very fast, with rates of 30 miles per day recorded (Salo 1991). Spawning in the Green River takes place from early November through mid-January. Preferred spawning areas are in groundwater-fed streams or at the head of riffles (Grette and Salo 1986). The major spawning areas in the Green River are the braided section of the mainstem below the Gorge and most major tributaries (Grette and Salo 1986). In general, chum salmon are reported to spawn in shallower, low-velocity streams and side channels more frequently than other salmon species (Johnson et al. 1997). Dunstan (1955) reported that most chum seemed to be produced in Burns and Newaukum creeks rather than the mainstem river. While their capture process could not differentiate between fry produced in side channels, tributaries, and mainstem habitats, spawning surveys during the 1950s identified large numbers of chum spawning in Burns Creek. Muckleshoot Indian Tribe biologists surveyed the Green

River from 1996-1998 and reported significant numbers of chum spawning in side channels in the middle and lower Green River reaches (E. Warner 1998).

The length of incubation of chum eggs is influenced by water temperature, stream discharge, DO, gravel composition, and spawning time (Salo 1991). Eggs at 15°C hatch approximately 100 days before eggs incubated at 4°C. Incubation in the Green River takes place from the beginning of November to mid-April (Figure A-1). Success and health of the emergent fry are also dependent on DO, gravel composition, spawner density, stream discharge, and genetic characteristics (Salo 1991).

Juvenile chum salmon have an ocean-type early life history, rearing in fresh water for only a few days to weeks before migrating downstream to salt water (Grette and Salo 1986; Johnson et al. 1997). Chum fry that migrate to sea within several days after emergence exhibit little growth, but fry that rear for longer periods may exhibit an increase in length up to 22 percent in less than 4 weeks (Hale et al. 1985). Hale et al. (1985) reported that chum fry grew slowly in March and April when most fry migrated to the sea, but as water temperature increased, growth of remaining fry was more rapid.

Downstream movement in the Green River occurs from mid-February through late May but varies annually. Dunstan (1955) identified an initial small surge of chum fry in late February, but believed the peak of chum fry outmigration occurred between 20 March and 3 April. Chum fry were present in juvenile surveys conducted in the middle Green River from February through June, peaking in relative abundance in mid-April (Jeanes and Hilgert 1999).

Observations of chum fry abundance in the Duwamish Estuary also indicate movement from the Green River, but peak movement in the estuary may be several days or weeks following peak movement in the river. Meyer et al. (1980) sampled juvenile salmonids in the Duwamish Estuary from early April through early July. They noted an initial peak abundance of chum fry in late April prior to any plants of hatchery chum in the system. A second, larger peak of chum abundance occurred in mid-May, several days after the MIT released 750,000 chum fry in Crisp Creek at RM 40.0. Bostick (1955) observed peak abundance of chum in the Duwamish Estuary in early May 1953, and Weitkamp and Campbell (1979) observed peak chum abundance in late April 1978. Using beach seines to collect salmonid fry in the Duwamish Estuary during the spring months of 1994, 1995 and 1996, MIT researchers observed chum fry in the estuary from February through July (E. Warner 1998). During all 3 years of study, they observed peak abundance of chum fry in the estuary in April.

Juvenile chum may remain in the brackish water habitat of the Duwamish Estuary for several days to 3 months, moving offshore as food resources decline in the summer (Meyer et al. 1980; Grette and Salo 1986). Simenstad et al. (1982) reports that eelgrass (*Zostera spp*.) habitats may be a preferred habitat of juvenile chum salmon. Juvenile chum appear to depend heavily on benthic organisms for food while residing in estuaries (Johnson et al. 1997). Like fall chinook, their dependency on estuaries as rearing habitat may limit chum production in the Green River basin (Grette and Salo 1986).

Chum salmon originating from Puget Sound streams appear to enter the ocean earlier than their northern counterparts (Johnson et al. 1997). Marine movement information is limited for chum salmon; however, commercial fishing records indicate that maturing chum begin to move coastward in May and June (Johnson et al. 1997). Chum stocks from the Green River basin are harvested in both pre-terminal and terminal commercial fisheries at a mean combined harvest rate of 8.1 percent (1988 through 1991) (WDFW et al. 1994).

Known Occurrences in the Project Vicinity

Two chum stocks are recognized in the Green River system (WDFW et al. 1994). The Crisp (Keta) Creek fall chum stock originated from releases of Quilcene and Hood Canal stocks from the Keta Creek Hatchery in the early 1980s. Currently, efforts are being made to replace this stock with south Puget Sound hatchery fish (WDFW et al. 1994). The Duwamish/Green stock is thought to be a remnant native stock; however, it is likely that hatchery plants have affected the gene pool (WDFW et al. 1994). Abundance figures are not available for the Duwamish/Green River chum stock (WDFW et al. 1994). A WDFW survey in 1947 counted 452 chum salmon in Burns Creek, prior to hatchery supplementation. Current information on this stock is sparse and it is questionable whether this population currently exists (WDFW et al. 1994). There are no WDFW escapement goals for the two stocks of chum salmon residing in the Green River.

Population Status and Status under the ESA

Green River chum salmon are included in the Puget Sound/Strait of Georgia ESU. Commercial harvest of chum salmon has been increasing since the early 1970s throughout this ESU. This increased harvest, coupled with generally increasing trends in spawning escapement, provides compelling evidence that chum salmon are abundant and have been increasing in abundance in recent years within this ESU (Johnson et al. 1997). The NMFS concluded that this ESU is not currently at risk of extinction, and is not likely to become endangered in the near future (63 FR 11778). The Crisp Creek fall chum stock is currently designated as healthy (WDFW et al. 1994), but there is some doubt whether native fish still remain. The Duwamish/Green stock, if present, may be a remnant native stock, but their status and origin presently is unknown (WDFW et al. 1994). The Crisp Creek stock originated from releases of Quilcene and Hood Canal hatchery stocks, and as such, is considered an introduced hatchery stock (WDFW et al. 1994).

PINK SALMON *(Oncorhynchus gorbuscha)*

Life History and Habitat Requirements

Pink salmon are the most abundant of the seven Pacific salmon species, totaling close to 60 percent by numbers and 40 percent by weight of all commercial catches in the north Pacific Ocean (Heard 1991). Pink salmon, the smallest of the Pacific salmon as adults, have substantial spawning populations distributed along the Pacific Coast from Puget Sound north to Norton Sound, Alaska (Heard 1991; Hard et al. 1996). Historically, small pink runs have also been reported in the Columbia River and as far south as the Sacramento River, California (Heard 1991). Pink salmon are distinguished from other Pacific salmon by their fixed 2-year life cycle and the hump that develops on maturing males. The NMFS used run-timing to identify two ESUs for pink salmon in Washington and southern British Columbia, the even-year ESU and odd-year ESU (Hard et al. 1996). Most Washington pink salmon stocks are odd-year fish, although a single even-year run exists on the Snohomish River (Hard et al. 1996). Total average escapement (1959-1993) of the 14 odd-year pink salmon stocks occurring in Washington is 888,804 fish (Hard et al. 1996).

After spending approximately 18 months at sea, inshore migration of pink salmon begins in June and continues through September. Spawning takes place from August through November and usually occurs closer to the sea than other Pacific salmon, possibly due to the fact that pink salmon are not particularly adept at leaping obstructions (Heard 1991). A large percentage of pink salmon populations spawn intertidally (Hard et al. 1996). Pink salmon spawn in riffles with clean gravel, shallower water, and moderate to fast currents (Heard 1991). Substrate preference is for coarse gravel and sand, with a few large cobbles and very little silt (Heard 1991). Pink salmon avoid spawning in quiet deep water or over heavily silted substrate (Heard 1991). Spawning activity reaches a peak at temperatures around 10ºC (50ºF).

Incubation of fertilized eggs in gravel interstices lasts between 5 and 8 months (Heard 1991). Water quality, egg desiccation, predators, and flooding are some of the major factors influencing egg survival to emergence. Pink salmon eggs hatch in late February, and the young emerge from the gravel in April and May, depending on water temperatures. Like other salmonids, the fry travel predominantly during hours of darkness during their migration downstream to the ocean (Hard et al. 1996). Pink salmon fry spend less time on average in fresh water than all other Pacific salmon species (Hard et al. 1996). Upon reaching the mouth of the stream, increased schooling takes place before pink salmon move into the estuary. Upon arrival in estuarine habitat, young pink salmon tend to remain close to nearshore nursery areas until approximately September (Emmett et al. 1991).

Pink salmon migrate at sea for 12 to 16 months before starting their inland migrations in May through July (Heard 1991). Mature adult pink salmon may grow to a length of 30 inches and weigh, on average, between 3 and 5 pounds. Pink and chum salmon often occur together in marine environments (Heard 1991). Ocean migration can generally be described to occur in a counter-clockwise circle, beginning from the Strait of Juan de Fuca, north to Prince William Sound, Alaska, and back to the Strait of Juan de Fuca (Heard 1991; Hard et al. 1996). Unlike chum and sockeye, pink salmon make only one complete cycle of the migration circle (Heard 1991).

Known Occurrences in the Project Vicinity

Prior to the 1930s, odd-year pink salmon were present in the Green River (Grette and Salo 1986). However, for the most part, they have been eliminated from the river system. They have been caught on occasion, and may stray into the Green River from the Puyallup River, which contains a substantial run of pink (WDFW et al. 1994). The highest annual number of pink salmon observed in the Green River over the last several decades is 13 (Hard et al. 1996). No juvenile pink salmon were captured during electrofishing and fyke net surveys conducted on the middle Green River, RM 34.0 to RM 45.0, in 1998 (Jeanes and Hilgert 1999).

Population Status and Status under the ESA

Washington and southern British Columbia pink salmon stocks, divided into even- and odd-year ESUs, are not considered warranted for listing at this time; however, several Pacific Northwest streams have experienced depressed pink salmon runs in recent years (Hard et al. 1996).

STEELHEAD *(Oncorhynchus mykiss)*

Life History and Habitat Requirements

Steelhead trout, displaying perhaps the most diverse life history pattern of all Pacific salmonids, reside in most Puget Sound streams. Their native distribution extends from the Alaska Peninsula to northern Mexico. Currently, spawning steelhead are found as far south as Malibu Creek, California (62 FR 43937). Two different genetic groups (coastal and inland) of steelhead are recognized in North America (Busby et al. 1996). British Columbia, Washington, and Oregon have both coastal and inland steelhead, while Idaho has only the inland form and California steelhead stocks are all of the coastal variety (Busby et al. 1996). Within these groups, steelhead trout are further divided based on the state of sexual maturity when they enter fresh water. Stream-maturing steelhead (also called summer steelhead) enter fresh water in an immature life stage, while ocean-maturing (or winter steelhead) enter fresh water with well-developed sexual organs (Busby et al. 1996). Green River steelhead (both summer and winter stocks) have been placed into the Puget Sound ESU, along with 53 other steelhead stocks, by the NMFS (Busby et al. 1996). Total run size for the major stocks of this ESU was estimated at 45,000, and natural escapement of approximately 22,000 steelhead (Busby et al. 1996).

Summer and winter races of steelhead, are present in the Green River. Steelhead entering the Green River from May through October are considered summer steelhead. Winter steelhead move into the Green River from November through May (Grette and Salo 1986; WDFW et al. 1994). Winter steelhead are native to the Green River and spawn from mid-March through June, while summer steelhead (first introduced in 1965 from the Skamania hatchery) spawning occurs from February through March (Grette and Salo 1986; WDFW et al. 1994). Hatchery-origin winter steelhead (Chamber Creek stock) generally spawn earlier in the season than do their wild counterparts, often completing spawning by mid-March; thus, they are not thought to interbreed with wild winter steelhead (WDFW et al. 1994).

The greatest number of steelhead redds counted during WDFW surveys in the Green River between 1994 and 1996 were found in late April (Table A-1). Winter steelhead spawn in the Green River from approximately RM 26.0 to RM 61.0. Summer steelhead primarily spawn in the mainstream and lower tributary areas from the Headworks (RM 61.0) downstream to the upper gorge (RM 58) (King County Planning Division 1978). An anonymous Washington Department of Game Report in 1945 (as cited in USACE 1998) states that historically at least 90 percent of steelhead spawning and rearing area were located above the City of Tacoma's Headworks at RM 61.0. Since 1982, hatchery-raised juveniles have been planted in the upper watershed; beginning in 1992, 70 to 133 adult steelhead have also been released upstream of the HHD (USACE 1998). Specific information regarding steelhead spawning temporal timing is provided in Table A-1.

Table A1. Winter steelhead redd count estimate in the mainstem Green River by timing, 1994 – 1996 (adapted from Washington Department of Fish and Wildlife).

	1994		1995		1996		Average 1994 - 1996	
Time Period	**No. Redds**	**Percent**	**No. Redds**	**Percent**	**No. Redds**	**Percent**	**No. Redds**	**Percent**
March 1 - 15	18.40	2.25%	37.00	3.40%	0.00	0.00%	18.47	1.67%
March 16 - 31	109.60	13.42%	17.02	1.57%	93.81	6.60%	73.48	6.64%
April 1 - 15	218.50	26.75%	166.43	15.31%	309.50	21.79%	231.48	20.91%
April 16 - 30	217.86	26.67%	298.00	27.41%	362.50	25.52%	292.79	26.45%
May 1 - 15	171.82	21.04%	311.05	28.61%	182.63	12.86%	220.78	19.94%
May 16 - 31	60.16	7.37%	188.53	17.34%	333.00	23.44%	193.90	17.51%
June 1 - 15	20.48	2.51%	52.05	4.79%	94.11	6.62%	55.55	5.02%
June 16 - 30	0.00	0.00%	17.00	1.56%	45.00	3.17%	20.67	1.87%
Totals	816.82	100.00%	1087.08	100.00%	1420.55	100.00%	1107.10	100.00%

In general, steelhead differ from spawning chinook and coho salmon by their use of faster, shallower, and higher gradient locations in mainstem or tributary streams (Everest and Chapman 1972). However, Caldwell and Hirschey (1989) observed steelhead spawning in the Green River in velocities ranging from approximately 2.0 to 4.0 fps, and depths ranging from 1.6 to 3.7 feet. Caldwell and Hirschey (1989) also report preferred spawning substrate composed of predominantly large gravel, with some small cobble. Pauley et al. (1986) found steelhead spawning in gravel ranging from 0.5 to 4.5 inches in diameter.

As with other salmonids, incubation rates for steelhead eggs vary with water temperature, with fry emergence occurring 40 to 80 days after spawning. Unlike other salmonids, steelhead require a relatively short incubation period; for modeling purposes, the time between fertilization and emergence on the Green River was assumed to be 50 days (see USACE 1998, Appendix FI, Section 6). Dissolved oxygen levels at or near saturation with no temporary reductions in concentration below 5 parts per million are most suitable for incubation (Stolz and Schnell 1991). Everest and Chapman (1972) found age-0 steelhead residing over cobbles in water velocities of less than 0.5 fps and depths of 0.5 to 1.0 feet. Juvenile steelhead will utilize stream margins and submerged rootwads, debris, large substrate, and logs to provide shelter and cover while rearing in freshwater habitats (Bustard and Narver 1975).

Both winter and summer juvenile steelhead rear in fresh water for 1 or more years before migrating to the ocean (Busby et al. 1996). In the Green River, most juvenile steelhead migrate after 2 years rearing in fresh water (Meigs and Pautzke 1941). In general, juvenile downstream migration for steelhead smolts occurs from April through June, with peak migration generally occurring in mid-April (Wydoski and Whitney 1979). An early study of steelhead smolt emigration by Pautzke and Meigs (1940) found that steelhead smolts emigrated from the Green River primarily during April and May. Seiler and Neuhauser (1985) planted steelhead fry in the upper watershed during the fall of 1982 and operated a scoop trap below HHD during 1984 to monitor the outmigration of smolts. They operated the trap at regular intervals between 5 April through 18 June and observed the peak outmigration of steelhead smolts were similar to coho smolts, early May through early. Steelhead trout in smolt condition were captured during juvenile surveys in the middle Green River during the month of May in 1998 (R2 Resource Consultants 1999). Based on theses studies, the peak juvenile outmigration for the Green River HCP area is assumed to be during May (Figure A-1).

Estuaries provide important nursery and schooling environments for juvenile salmonids (Shepard 1981; Simenstad et al. 1982). This transition zone allows outmigrant salmonids to physiologically adapt to the full strength saltwater conditions (SRWA 1998). However, reports that other Puget Sound steelhead smolts move quickly through estuaries, feeding in the mainstem before migrating to the ocean, indicate that they do likewise in the Green-Duwamish Estuary (Emmett et al. 1991; SRWA 1998). Meyer et al. (1980) captured more than 7,700 juvenile salmonids in surveys conducted in the Duwamish Estuary. Of these, only 50 were steelhead, representing less than 1 percent of the total number of salmonids captured from April through July 1980, furthering the idea that steelhead do not reside in estuarine habitats for extended periods of time.

Most (60-75 percent) of the steelhead originating from Washington streams remain at sea for 2-years prior to returning to fresh water; the remaining balance spend 3 years in the ocean (Grette and Salo 1986). One significant difference between steelhead and Pacific salmon life history is that not all steelhead adults die after spawning. Steelhead are capable of repeat spawning (iteroparous), although the incidence is relatively low and specific to individual streams. Steelhead rarely spawn more than twice before dying; most that do are females (61 FR 41541). Repeat spawning in Washington ranges from

4.4 to 14.0 percent of total spawning runs (Wydoski and Whitney 1979). The average 4+ wild Green River steelhead weighed 7 to 8 pounds (Meigs and Pautzke 1941).

Known Occurrences in the Project Vicinity

Two different steelhead stocks were established by WDFW in the Green River, including both summer and winter stocks (WDFW et al. 1994). The summer steelhead stock originated outside of the basin from plants beginning in 1965 from the Klickitat River (Grette and Salo1986). Winter steelhead are native to the Green River. Both winter and summer stocks currently receive hatchery supplementation; about 70,000 summer steelhead smolts are released into the Green River system annually (WDFW et al. 1994).

The natural spawning stock of winter steelhead is managed for an escapement of 2,000 fish, representing approximately 9 percent of the estimated natural escapement of all steelhead within the Puget Sound ESU. Steelhead in excess of 2,000 are available to the sport and Tribal fisheries. Natural spawner escapement has ranged from 944 to 2,778 fish and wild run size has ranged from 1,350 to 3,464 fish from 1978 through 1992 (WDFW et al. 1994). The escapement goal for the upper watershed (above HHD) is 650 while an escapement goal of 1,250 was used by USACE (1998). Returning hatchery adults support Tribal and sport fisheries with a combined exploitation rate of approximately 90 percent (WDFW et al. 1994). Both winter and summer steelhead stocks in the Green River were rated as healthy by the WDFW (WDFW et al. 1994).

Population Status and Status under the ESA

Green River steelhead have been classified as part of the Puget Sound ESU (1 of 15 West Coast steelhead ESUs). Natural fish (wild runs) are the focus of ESU determinations. In the Green River system, the wild winter steelhead population is a distinct stock based on geographic isolation of the spawning population (WDFW et al. 1994). Escapement goals have been approximately met or exceeded during five of the seasons between 1985 and 1992.

Overall, the status of Green River steelhead populations is considered healthy (WDFW et al. 1994). However, there has been a general decline in recent (within the past few years) steelhead populations throughout the Strait of Juan de Fuca, Pacific Coast, and Columbia River. The widespread decline in abundance is thought to be due to low ocean productivity, competition for food in the ocean, and high seas drift net fisheries (WDFW et al. 1994). The NMFS indicated that, in general, the entire Puget Sound ESU is not threatened at this time. However, future population declines may warrant changes in ESA status (Busby et al. 1996).

COASTAL CUTTHROAT TROUT *(Oncorhynchus clarki clarki)*

Life History and Habitat Requirements

Coastal, or anadromous, cutthroat trout are distributed on the Pacific Coast from Prince William Sound in southern Alaska to the Eel River in northern California, rarely penetrating more than 100 miles inland (Johnston 1982; Behnke 1992). Considerable information exists for Puget Sound cutthroat trout, though little of that has been collected in a standardized manner and over a sufficient time period to establish trends in populations (Leider 1997).

Coastal cutthroat trout of the Green River exhibit early life history characteristics similar to coho and steelhead, whereby juveniles spend time rearing in fresh water before outmigrating as smolts (Leider 1997). While little information exists on Green River cutthroat, Puget Sound cutthroat emigrate to estuaries at a younger age (age 2) and smaller size (6 inches total length [TL]) than cutthroat that are exposed to rough coastal waters (age 3 to 5, 8-10 inches TL) (Johnston 1982). Puget Sound cutthroat trout will feed and migrate along beaches, often in waters less than 10 feet deep (Johnston 1982). Many stocks are thought to stay within estuarine habitats for their entire marine life (Leider 1997). Most cutthroat return to fresh water the same year they migrate to sea.

Adult cutthroat trout in Washington tend to follow two run-timings (Johnston 1982). Early returning cutthroat trout typically peak in large streams in September and October. Late-returning cutthroat trout peak in December and January in small streams draining directly to salt water. Grette and Salo (1986) noted that adult upstream migration in the Green River occurs from July through early February, peaking in October and November (Grette and Salo 1986). For the purpose of this document, Green River cutthroat will be considered as early returning.

Spawning occurs from mid-March through early May, which is slightly earlier than winter steelhead. Stolz and Schnell (1991) indicate the start of spawning is prompted by 50°C water temperature. Coastal cutthroat trout spawn in low gradient reaches of small tributaries, or in the lower regions of streams (Trotter 1997). This appears to be an adaptation to isolate their nursery/rearing ground from other, more competitive, species such as steelhead (Stolz and Schnell 1991). The preferred spawning substrate is pea-towalnut-sized gravel, in 6 to 18 inches of water, with pools nearby for escape cover. Actual spawning may extend over a period of 2 to 3 days (Trotter 1997). Cutthroat eggs require approximately 300 temperature units for incubation, and an additional 150 to 200 units for emergence to occur (Stolz and Schnell 1991).

Emergence of juvenile cutthroat occurs from March to mid-July, depending on spawning date and water temperature (Trotter 1997). Newly emerged cutthroat trout are very small (<1.0 inch TL). Juvenile cutthroat move immediately to low velocity lateral habitats where they rear for 2 or more years, seeking pools and other slow water habitats with root wads and large wood for cover (Trotter 1997). Often coho fry are present in the same habitat, and the larger coho will drive the cutthroat into riffles, where they will remain until fall and winter (Sabo 1995). Seaward migration of cutthroat smolts peaks in mid-May at 2, 3, or 4 years of age (Trotter 1997). Average length at this time was found to be 6 inches TL (Johnston 1982). During the marine phase of their life cycle, juvenile and adult coastal cutthroat trout appear to utilize waters near the shore, usually in areas relatively near their natal streams (Moyle 1976; Johnston 1982; Trotter 1997). Both gravel beaches with upland vegetation and nearshore areas containing large logs and other large woody debris (LWD) are used during the marine residency phase.

Like steelhead, adult coastal cutthroat trout are repeat spawners, but unlike steelhead, coastal cutthroat trout recover quickly to pre-spawn condition (Trotter 1997). They may live to an age of 7 or 8 years, spawning three, four, or even as many as five times during their lives (Trotter 1997). By definition coastal cutthroat trout are anadromous; however, there is considerable evidence that this trait is not strongly developed in this genus. Furthermore, they generally remain inshore or in areas of reduced salinity while in salt water and will rarely, if ever, overwinter in salt water; some of the returning fish may not spawn during their first or second migrations back into fresh water (Trotter 1997). Spawning fish home precisely to specific tributaries while non-maturing fish do not always return to their home stream to feed or when seeking an overwinter habitat (Johnston 1982). Coastal cutthroat trout are usually smaller than other anadromous salmonids, and rarely exceed 20 inches TL. This size appears to be adaptive for entering small tributaries where interspecific competition for habitat with other, larger salmonids is reduced (Pearcy 1997).

Known Occurrences in the Project Vicinity

A coastal cutthroat trout population is present in the Green River; however, little information exists on their status (Grette and Salo 1986). The population inhabiting the Green River appears to be small when compared to other streams in Puget Sound (Grette and Salo 1986). Cutthroat trout fry and juveniles (age 1+) were captured in lateral habitats of the middle Green River during juvenile salmonid surveys conducted in 1998 (Jeanes and Hilgert 1999). However, their numbers and distribution relative to other juvenile salmonids appear to be limited.

Population Status and Status under the ESA

Green River coastal cutthroat trout have been classified as part of the Puget Sound ESU by the NMFS (64 FR 16397). This ESU includes populations of coastal cutthroat trout from streams in Puget Sound and the Strait of San Juan de Fuca west to and including the Elwha River. The southern boundaries extend to Nooksack River, while the northern boundaries include coastal cutthroat trout populations in Canada (64 FR 16397). The Puget Sound coastal cutthroat trout does not warrant listing under ESA, as populations have been relatively stable over the past 10 to 15 years (64 FR 16397).

PACIFIC LAMPREY *(Lampetra tridentatus)*

Life History and Habitat Requirements

One of the most primitive fishes found in the Green River, Pacific lamprey are common in the Green River downstream of the Tacoma Headworks. Pacific lamprey can be found in coastal streams from California to Alaska (Morrow 1980). Pacific lamprey are often mislabeled as pest species due to the problems associated with the exotic sea lamprey *(Petromyzon marinus)* that has invaded the Great Lakes (Close et al. 1995). The Pacific lamprey is a native fish to the Green River and has cultural, utilitarian, and ecological significance (Close et al. 1995). Pacific lamprey are well distributed in the Puget Sound region; however, little quantitative information is available for them. The widespread decline of Pacific lamprey in the Columbia River basin has led to concerns by numerous agencies and Native American tribes (Close et al. 1995; Jackson et al. 1997). The same factors that have led to the decline of Pacific salmon species (i.e., habitat alteration, water pollution, dam passage, ocean conditions) are thought to be responsible for the decline of lamprey. Recent reviews of the Jon Day, Umatilla, Walla Walla, Tucannon, and Grand Ronde subbasins revealed that Pacific lamprey populations are a fraction of past abundances in these basins (Jackson et al. 1997).

Pacific lamprey adults are parasitic in marine environments, entering fresh water to spawn (Wydoski and Whitney 1979). Adult Pacific lamprey migrate upstream in late spring and early summer in search of spawning areas, where both sexes construct a shallow nest in stream gravels (Morrow 1976). Flowing water (1.6-3.3 fps) is preferred for spawning (Close et al. 1995). The female then attaches herself to a rock with her oral sucker while the male attaches to the head of the female. The male and female, coiled together, vibrate wildly while the eggs and sperm are released. The fertilized eggs adhere to the downstream portion of the nest (Moyle 1976). The eggs are then covered by the adults and the process is repeated several times in the same nest site, with death of the adults occurring shortly thereafter (Moyle 1976).

Juvenile lamprey, termed ammocoetes, swim up from the nest and are washed downstream where they burrow into mud or sand to feed by filtering organic matter and algae (Moyle 1976). The ammocoetes generally remain in fresh water for 5 or 6 years, moving site to site (Wydoski and Whitney 1979). Such an extended freshwater residence makes them especially vulnerable to degraded stream and water quality conditions. Larval lamprey will transform to juveniles from July through October (Close et al. 1995). It is during this transition that they become ready for a parasitic lifestyle by developing teeth, tongue, eyes, and the ability to adapt to salt water. After metamorphosis, juvenile lamprey may remain in fresh water up to 10 months before passively migrating with the current downstream to the ocean.

After reaching the ocean Pacific lamprey attach themselves to and parasitically feed upon other fish (Moyle 1976). They may remain in salt water for up to 3.5 years (Close et al. 1995). Pacific lamprey return to fresh water in the fall, where they overwinter and spawn in the spring (Close et al. 1995). They do not feed during the spawning migration, and die shortly after spawning. The spawned-out carcasses provide important nutrients to the stream system, as well as dietary items for other fish, such as white sturgeon (Close et al. 1995). Pacific lamprey may reach 27 inches TL at maturity (Hart 1973).

Known Occurrences in the Project Vicinity

Little information exists regarding the status of Pacific lamprey in the Green River. Pacific lamprey ammocoetes were common during lateral habitat surveys in the Green River, conducted from late February through late June 1998 (Jeanes and Hilgert 1999). Relative abundance of Pacific lamprey ammocoetes was greater than other lamprey species encountered during all electrofishing surveys conducted on the middle Green River (RM 35-45). Pacific lamprey were captured in each habitat type surveyed (i.e., gravel bar pools, mainstem sloughs, mainstem margins, backbar channels, abandoned channels, and wallbase channels) (Jeanes and Hilgert 1999).

Population Status and Status under the ESA

Though absolute historical and current population sizes of the lamprey are not known, it is clear that these fish were once a significant source of tribal subsistence as well as ceremonial and medicinal purposes. Lamprey have shown severe population declines in the Pacific Northwest (Close et al. 1995). Lamprey have freshwater habitat requirements similar to the Pacific salmon, and therefore face the same habitat problems affecting salmonid abundance and distribution. In particular, elevated water temperatures (greater than 20ºC) and increased sediment in spawning gravels are two major habitat factors attributing to lamprey population decline (Close et al. 1995). The NMFS has not initiated a status review of Pacific lamprey in the Pacific Northwest. Plans to do so are not in the foreseeable future, unless NMFS is petitioned to list these fishes (L. Weitkamp 1998).

RIVER LAMPREY *(Lampetra ayresi)*

Life History and Habitat Requirements

River lamprey, similar to Pacific lamprey in their life history patterns, occur from northern California to southeastern Alaska, including most major rivers in Washington (Wydoski and Whitney 1979). Like Pacific lamprey, river lamprey are parasitic on fish, and migrate to fresh water to spawn. Even less is known about the abundance of river lamprey than is known concerning Pacific lamprey populations.

The larval form of river lamprey, termed ammocoetes, are similar to other lamprey in that they are blind, toothless, and feed on algae and other small organisms. River lamprey ammocoetes are morphologically similar to Pacific lamprey, making positive distinction between the two difficult (Wang 1986). River lamprey ammocoetes begin to transform into the adult stage when they are as small as 4.6 inches TL, becoming parasitic soon after this transformation (Wydoski and Whitney 1979). It is at this phase during their life history that they can become predatory on juvenile salmon. Matsuda et al. (1968) reported studies indicating that as many as 7 percent of the chinook captured in the Duwamish Estuary were wounded by river lamprey. Wetherall (1971) studied the rate of lamprey wounds on chinook fingerlings released into the Green River. He found a wound rate of 1.5 percent in 1967 and 0 percent in 1969, noting that the discrepancy may have come from increased abundance of lamprey in 1967 (Wetherall 1971). It can be concluded that lamprey predation has an impact on juvenile salmonids, but wound and mortality rates need further study to quantify such impact.

The adult river lamprey is smaller than the Pacific, with a length up to only 12 inches TL (Hart 1973). Wang (1986) reported the presence of river lamprey in collections made above dams, indicating that some river lamprey may spend their entire life in fresh water. Like Pacific lamprey, adult river lamprey die after they spawn.

Known Occurrence in the Project Vicinity

Two river lamprey were observed during juvenile salmonid surveys of lateral habitats in the middle Green River (Jeanes and Hilgert 1999). Little other information exists on the occurrence of river lamprey in the Green River. River lamprey are of no sport or commercial value (Wang 1986) and while parasitic on fish, no accurate assessment of the damage to fish populations exists (Wang 1986). Past physical damage to juvenile salmonids has been reported in the Green River; however, no juvenile salmonids (out of 4,736 total salmonids) captured during middle Green River electrofishing surveys displayed lamprey wounds (Jeanes and Hilgert 1999).

Population Status and Status under the ESA

The NMFS has not initiated a status review of river lamprey in the Pacific Northwest. Plans to do so are not in the foreseeable future, unless NMFS is petitioned to list these fishes (L. Weitkamp 1998).

Literature Cited

References cited in this chapter are provided in Chapter 10 of the HCP

WILDLIFE SPECIES

GRAY WOLF *(Canis lupus)*

Range

Historically, the gray wolf was found throughout the northern hemisphere in virtually all habitats, except tropical forests and deserts (Laufer and Jenkins 1989). Largely as a result of predator control programs, the range of the gray wolf has been reduced to less than 1 percent of its original size. The range of the species in the lower 48 states is currently limited to distinct populations in Maine, the upper Midwest, the northern Rocky Mountains, and the North Cascades of Washington.

Status

Within Washington, the gray wolf is listed as endangered at both the federal and state levels. Currently, two areas within the conterminous 48 states contain increasing wolf populations: western Montana and northern Idaho; and Minnesota, Wisconsin, and Michigan (Johnson and Cassidy 1997). In 1995, wolves were reintroduced to Yellowstone National Park and central Idaho (Johnson and Cassidy 1997). Gray wolves had apparently disappeared from Washington by 1920 (Ingles 1965). Although two reliable sightings of wolves feeding pups were recorded in the North Cascades between 1992 and 1997, the occurrence of the gray wolf in Washington remains questionable (Johnson and Cassidy 1997).

Habitat Requirements

Gray wolves are habitat generalists and may be found wherever populations of ungulates exist (Stevens and Lofts 1988). Whitaker (1980) lists gray wolf habitat in North America as open tundra and forest. Human disturbance plays a role in determining gray wolf distribution. In Alaska, Thurber et al. (1994) found that wolves avoided areas of human activity, including roads. In studying historic population changes of wolves in Wisconsin, Thiel (1985) found that wolf populations decreased when road densities exceeded 0.93 mile per square mile. Gray wolves often maintain very large home ranges, for example, 40 to 47 square miles on Vancouver Island and 93 to 248 square miles in northern British Columbia (Scott 1979).

Population in the HCP Area

Range limits of the gray wolf predicted by gap analysis modeling do not include the HCP Area (Johnson and Cassidy 1997). However, one wolf was sighted in 1992 in the USFS Green River Watershed Analysis Area (USFS 1996) and in 13 other parcels in the I-90 Land Exchange parcel groups at Snoqualmie Pass (I-90 North), Bald Mountain, and Randle (USFS 1998). Although the species is considered rare, it is possible that it inhabits the upper basin, but not the lower and mid-basin areas of the Green River.

PEREGRINE FALCON *(Falco peregrinus)*

Range

The peregrine falcon breeds throughout all western states (Platt and Enderson 1989) and Canada (Johnsgard 1990). In Washington, breeding occurs mainly along Puget Sound, in the San Juan Islands and along the northern coastline (Smith et al. 1997). Nests range from sea level to over 11,000 feet in elevation (USFWS 1982). Washington provides important migratory and wintering habitat for peregrines, where permanent residents are joined by migrants from Alaska and Canada. Important wintering areas in Washington include the Skagit River tidal flats, Grays Harbor, and Willapa Bay (USFWS 1982). Three subspecies occur in the state, including the *anatum, pealei,* and *tundrius* falcons (Allen 1991).

Status

The peregrine falcon was recently de-listed at the federal level, but remains listed as an endangered species at the state level. The population has increased over the past 25 years, following a dramatic decline due primarily to environmental contamination with DDT and other toxins (Pagel et al. 1996). The recovery goal of the Pacific Coast Recovery Plan was 30 pairs of nesting peregrines in Washington, with an average productivity of 1.5 young per active territory over a 5-year period (USFWS 1982). In 1997, there were 43 nesting attempts with an average productivity of 1.44 young per pair.

Habitat Requirements

Peregrine falcons typically nest on sheer cliffs, canyon walls, and rocky outcrops ranging in height from 75 to 2,000 feet (Hickey 1969; Ratcliffe 1980; Cade 1982). Occasionally, peregrines will nest in snags, old eagle nests, pinnacles, sand dunes, talus slopes, cutbanks, buildings, and bridges (Sharp 1992; Cade et al. 1996). In the Pacific Northwest, the smallest cliff that was used for nesting was 75 feet (Pagel 1998). For nesting, the peregrine will scratch out a shallow bowl with its feet in the soil of a ledge or hole in the cliff face, but like other falcons, it does not construct a nest (Ratcliffe 1980). Nest sites usually have a panoramic view of open country, often overlooking water, and are always associated with an abundance of waterfowl, shorebirds, or passerine prey (Johnsgard 1990). In the Pacific Northwest, nests are always close to a major water source, with a maximum distance of 3,300 feet (Pagel 1998). Nesting peregrines typically hunt over large areas, which frequently includes bodies of water, shorelines, marshes, riparian strips, and grasslands (USFWS 1982). During the breeding season, adults will hunt up to 17 miles from nest sites, although a range of 10 miles is more typical (USFWS 1982). In winter, intertidal flats, estuaries, and inland wetland habitats are important hunting areas for the peregrine (USFWS 1982).

Population in the HCP Area

Breeding sites are relatively rare within the interior of Washington (Smith et al. 1997), but several eyries have been reported in the central and southern Cascades (Stofel 1998). Two recent breeding records for King County are from downtown Seattle (Smith et al. 1997) and Mount Si (Stofel 1998), which is adjacent to the town of North Bend. At least four individual peregrines have been seen during incidental observations in the upper Green River basin (1981, 1983) (USFS 1996). There are 601 acres of suitable cliff habitat for peregrine nesting in the Green River Watershed Analysis Area, but during a helicopter survey in 1988 none of these potential habitats appeared to be occupied (USFS 1996). Although the species is considered rare, it is possible that it inhabits the upper basin. It is not likely to inhabit the lower or mid-basin areas of the Green River.

BALD EAGLE *(Haliaeetus leucocephalus)*

Range

Bald eagle nesting in Washington occurs along most major rivers entering Puget Sound, as well as the San Juan Islands, Olympic Peninsula coastline (Grubb 1976), Hood Canal, and the southwestern coastline (USFWS 1986). Bald eagles are uncommon breeders along large interior lakes and reservoirs in Washington (Smith et al. 1997). Washington also supports one of the largest populations of wintering bald eagles in the Pacific Northwest. Favored wintering areas support abundant populations of overwintering waterfowl and salmon runs with large concentrations of eagles on the Olympic Peninsula, Puget Sound and tributaries (Skagit, Nooksack, and Cowlitz rivers), and Columbia and Cowlitz rivers.

Status

The bald eagle is currently listed as a threatened species under the federal ESA in the 48 conterminous states. The state of Washington also lists it as a threatened species. In the 1950s, bald eagle populations began a precipitous nationwide decline due to eggshell thinning and other reproductive failures induced by chemical contamination of the environment with DDT, polychlorinated biphenyls, and Dieldrin (Johnsgard 1990). Since the ban of DDT in 1972, and reduction of other environmental toxins, bald eagle numbers have rebounded in Washington (Grubb et al. 1975; McAllister et al. 1986) and throughout much of the United States and Canada (Henny and Anthony 1989; Johnsgard 1990).

Habitat Requirements

Throughout the Pacific Northwest, bald eagles exhibit a close association with freshwater, estuarine, and marine ecosystems that provide abundant prey and suitable habitat for nesting and communal roosting (USFWS 1986). The nesting habitat of bald eagles is characterized by large dominant trees in stands of old-growth conifers, or old-aged second-growth coniferous stands (Anthony and Isaacs 1989). Nests are usually adjacent to large rivers and lakes with abundant populations of fish or waterfowl (Watson et al. 1991). In Oregon, the majority of 201 nests (84 percent) were within 1.0 mile of water, with a maximum of 4.5 miles (Anthony and Isaacs 1989). In western Washington, a sample of 218 bald eagle nests showed an average distance of 282 feet from water, ranging from 15 to 2,640 feet (Grubb 1980).

Bald eagle nests are most often built in conifers (Douglas-fir and Sitka spruce), but black cottonwoods (*Populus trichocarpa*) are also used along rivers and large reservoirs (Anderson et al. 1986). The nest is typically built near the top of one of the larger and more dominant trees available in the stand, rarely less than 30 inches diameter at breast height (dbh) (Anthony et al. 1982). The nest tree usually has a prominent topographic location and an unobstructed view of surrounding waters; other large trees near nest sites are often present to serve as alternate nests and perches (USFWS 1986). Bald eagles use perches during nesting, hunting, feeding, resting, preening, mating, and behavioral displays (Stalmaster 1987). Perches used for hunting are usually in tall trees or snags located close to feeding areas that give a good view of the surrounding area (USFWS 1986).

Bald eagles frequently remain in their nesting territories throughout the winter in Washington, or move relatively short distances to seasonal food supplies where they may be joined by eagles that nest in Canada and Alaska (USFWS 1986). Winter concentrations of bald eagles develop in response to temporal abundance of fish, waterfowl, snowshoe hares, or carrion from domestic sheep and deer (Frenzel 1984; Keister et al. 1987; Frenzel and Anthony 1989; DellaSala et al. 1989). Large winter communal roosts are generally located close to feeding areas on large rivers such as the Skagit (Ralph 1980), Nisqually (Stalmaster and Kaiser 1997), Nooksack (Stalmaster and Newman 1979), Columbia (Watson et al. 1991; Fielder and Starkey 1980), and Sauk, as well as along the Olympic Peninsula, Puget Trough, San Juan Islands, and the Columbia Basin (USFWS 1986).

Winter communal night roost sites are usually established in old-growth stands or mature forest with old-growth components (Anthony et al. 1982) that provide thermal cover and wind protection (USFWS 1986). In Oregon, the mean age of roost trees was 236 years, with a range of 100 to 535 years (Keister and Anthony 1983). Bald eagles will use conifers, cottonwoods, big leaf maples, and snags for perch and night roosts (Stalmaster and Kaiser 1997). Hansen et al. (1980) reported that winter roosts ranged from 0.16 to 1.5 miles from water and Keister and Anthony (1983) reported the minimum size of roost stands as 1 acre. Winter roost sites are generally close to feeding areas with low human disturbance levels, although eagles may travel up to 9 miles to feeding areas (Keister and Anthony 1983; USFWS 1986).

Population in the HCP Area

The bald eagle inhabits the upper basin and mid-basin areas of the Green River, and possibly the lower basin as well. Bald eagle nesting has been confirmed mostly in the lowlands and foothills of eastern King and Pierce counties, although possible breeding sites were identified in the Cascades of King County (Smith et al. 1997). A pair of nesting eagles was reported at Eagle Lake, which is 1 mile northeast of Howard Hanson Reservoir (USFS 1996). In the mid-Green River basin, a nest (WDW reference number 903627) has been documented in a residential area adjacent to Lake Sawyer. There are also several other lakes in this vicinity that could potentially provide foraging opportunities, but eagles have not been observed foraging there (Beak 1996a). Surveys conducted in 1981, 1982, 1989, and 1993 have detected adult bald eagles near HHD and along the Green River, Tacoma Creek, and Pioneer Creek (USFS 1996). Bald eagles are present year-round near the reservoir. Below the HHD there are seasonal runs of salmon and steelhead, and above the dam there are non-anadromous fish and abundant waterfowl. Potential habitat for winter roosts is available above the dam (USFS 1996). Approximately 3,709 acres of potential nesting habitat were identified within the Green River Watershed Analysis Area (USFS 1996) and 5,582 acres of foraging habitat are available.

MARBLED MURRELET *(Brachyramphus marmoratus)*

Range

The marbled murrelet is a seabird associated with marine waters from central California to Alaska (Marshall 1988). It forages on marine waters and nests in trees up to 39 miles inland in Washington (USFWS 1995a), although detections have been documented up to 52 miles inland (Ralph et al. 1994).

Status

The marbled murrelet was formally listed as a threatened species in Washington, Oregon and California in 1991 under the federal ESA. The state of Washington also lists it as a threatened species. A variety of factors have been implicated its decline, including over-fishing (of its prey), entanglement in fishing nets, mortality due to oil spills and loss of forest nesting habitat (Marshall 1988; Ewins et al. 1993; Ralph et al. 1995; Carter and Kuletz 1995). Recent population estimates include 5,500 murrelets in Washington; 6,000 to 20,000 in Oregon; and 6,450 in California, with a total population of about 300,000 birds in North America (Ralph et al. 1995). Beissinger (1995) has presented a model of the overall population trend for the Pacific Northwest showing an annual reduction of 2 to 12 percent in the at-sea population of marbled murrelets. Current population models indicate that a stable population would require a 15 to 22 percent ratio of juveniles to adults observed at sea (Beissinger 1995). Recent survey results from California have estimated ratios of 3 percent in 1989 through 1992 and 2.2 percent in 1993 (Ralph and Long 1995), thus indicating inadequate productivity for a stable population (Beissinger 1995).

Habitat Requirements

The marbled murrelet is a small seabird that spends most of its life cycle on marine waters, but is the only North American Alcid that nests in trees (Nelson and Hamer 1995). Suitable nesting habitat is old-growth coniferous forest or mature coniferous forest with an old-growth component (Marshall 1988; Hamer and Cummins 1990; Interagency Interim Guidelines Committee 1991; Hamer 1995; Ralph et al. 1995). Nests consist of depressions in moss or duff on large lateral branches located within the live crown of mature or old-growth trees (Marshall 1988; Interagency Interim Guidelines Committee 1991; USFWS 1995a). Murrelets typically require large coniferous trees for nest sites, usually greater than 32 inches dbh, with large-diameter moss-covered limbs (Singer et al. 1991; Ralph et al. 1994). Hamer and Nelson (1995) reported an average stand age of 522 years (range 180 to 1,824 years) for nest sites in the Pacific Northwest, although nests have been located in younger (≤ 80 years old) stands with older residual trees (Grenier and Nelson 1995).

Within stands, nests are typically located in the largest diameter trees (Hamer and Nelson 1995). Nest sites often have multi-layered canopies with high canopy cover immediately over the nest, as well as an open canopy near nest trees (Grenier and Nelson 1995; Hamer and Nelson 1995; Ralph et al. 1995; USFWS 1995a). In the Pacific Northwest, stand canopy closure averaged 49 percent from a sample of 21 nest sites, with a range of 12 to 99 percent (Hamer and Nelson 1995). Canopy closure is typically high (mean = 85 percent) over nest trees, but tends to be less dense in adjacent parts of the nest stand (Hamer and Nelson 1995; Grenier and Nelson 1995). These canopy openings are thought to facilitate murrelet flight to and from nests, but may also be due to observer bias, because nests may be more visible under such circumstances (Grenier and Nelson 1995).

Stand size is highly variable at documented marbled murrelet nest sites, and in Washington has ranged from about 12 to 2,475 acres (Hamer and Nelson 1995). Marbled murrelet detections increase with stand size, but effective size for optimal breeding success is still unknown (Interagency Interim Guidelines Committee 1991; Raphael et al. 1995). Marbled murrelet detections increase significantly when the percentage of old-growth/mature forest exceeds 30 percent of the landscape (Hamer and Cummins 1990). It is hypothesized that larger stands may be necessary to provide concealment of nests from weather and predators, as well as to avoid proximity to edge habitats, which are favored over interior forest by Corvids (i.e., ravens, crows, and jays) and other egg predators (Ralph et al. 1995).

A large proportion of nesting failures reported in Washington, Oregon, and California (43 percent) was suspected to be caused by predation from common ravens, Steller's jays, and possibly great horned owls (Nelson and Hamer 1995). Other suspected predators are common crows, Accipiter hawks, gray jays, raccoons, marten, fisher, and several species of rodents. In addition to predation, the microclimate of nest stands could be negatively affected near edges of harvested areas, where researchers have observed reduced canopy cover, increased wind speed, and increased solar radiation (Chen 1991). Decreased buffering from strong winds also increases the potential for blowdown and limb breakage

(Steinblums et al. 1984). In large areas of old-growth forest, occupied behaviors occur more frequently at lower elevations and in major drainages where wind damage and limb breakage are minimized (Miller and Ralph 1995).

Population in the HCP Area

The population of marbled murrelets in the upper Green River watershed is small. Surveys for nesting murrelets have been conducted over several years, but occupancy has been detected for only one site on USFS lands. This occupied site is adjacent to the covered lands. Marbled murrelets are not expected to occur on the covered lands, however, due to the absence of suitable habitat.

NORTHERN SPOTTED OWL *(Strix occidentalis caurina)*

Range

The northern spotted owl inhabits forested areas of the Pacific Coast from northern California to southern British Columbia (Forsman and Bull 1989). The species nests up to 3,200 feet in elevation on the Olympic Peninsula (Forsman and Giese 1997) and up to 4,000 feet in the northern part of its range (Lujan et al. 1992).

Status

The northern subspecies of the spotted owl was federally listed as threatened in Washington, Oregon, and California in 1990 under the federal ESA (U.S. Federal Register, 26 June 1990). The state of Washington lists it as an endangered species.

Habitat Requirements

Studies throughout the Pacific Northwest have found that the northern spotted owl typically selects old-growth and other late-successional coniferous forest for foraging, roosting, and nesting (see reviews by Thomas et al. 1990; Lujan et al. 1992). Suitable nesting-roosting-foraging (NRF) habitat for spotted owls on the west slope of the Cascades in Washington consists of mature or old-growth forest with moderate to high canopy closure; a multi-layered, multispecies canopy dominated by large overstory trees, a high incidence of large trees with various deformities such as cavities, broken tops, and dwarf mistletoe infections; numerous large snags; large accumulations of fallen trees and woody debris on the ground; and sufficient open space below the canopy for owls to fly

(Thomas et al. 1990). Only large diameter trees can provide cavities of sufficient size for nest sites, since spotted owls on the west slope of the Cascades do not typically use goshawk nests or other platform nests (Forsman et al. 1984; Forsman and Giese 1997). A number of researchers have found spotted owls to nest, forage and roost in young second-growth forest habitats, but these typically contain residual large trees, snags and logs from the preceding stands and high populations of prey.

On a landscape basis, spotted owls select home ranges that emphasize old-growth within the landscape (Carey et al. 1990). One study on the Olympic Peninsula reported that spotted owl pairs selected home ranges that contained an average of 44 percent old forest (Lemkuhl and Raphael 1993). Home ranges had an average of 53 percent old forest in the southern Oregon Coast range, and 53 percent old forest in southern Oregon, respectively (Carey et al. 1990, 1992). Using data throughout the Pacific Northwest, Bart and Forsman (1992) documented that reproduction declined sharply in habitats with less than 40 percent old forest; landscapes with less than 20 percent old forest rarely supported nesting owls. In southwest Oregon, Ripple et al. (1997) reported that the area of old conifer forest was significantly greater at 20 nest sites compared to 20 random sites for plots of 291, 1,163, 2,611, and 4,510 acres. In California, Rosenberg and Raphael (1986) found spotted owls significantly avoided small stand size and stand insularity (isolation).

In western Oregon, Miller (1989) determined a mean core area of 70 acres around the nest was used by post-fledgling juvenile owls just prior to dispersal. Miller et al. (1997) found that selection for mature/old-growth stands was not evident during the transient phase of dispersal (35 percent used vs. 31 percent available), but was significant for the colonization phase (61 percent used vs. 33 percent available) where owls would generally take up residency for 2 to 3 years before breeding.

Population in the HCP Area

There are currently 16 known spotted owl activity centers within 1.8 miles of the HCP Area in the upper Green River basin. These represent 15 pairs of spotted owls (10 with confirmed reproduction) and one single spotted owl of unknown status. Nine of these lie within 0.7 mile of the HCP Area, and one of the 16 is actually in the HCP Area. The entire watershed has undergone extensive surveying over the past decade, and these 16 activity centers are thought to represent all the resident spotted owls in or near the HCP Area (USFS 1996). The spotted owl is unlikely to occur in the mid- or lower Green River basins due to the absence of suitable habitat.

GRIZZLY BEAR *(Ursus arctos)*

Range

The grizzly bear historically ranged throughout western Canada and the United States, and the northern portion of central Mexico (Almack 1986). It has been extirpated from Mexico and most of the conterminous United States except for western Montana, the Selkirk Mountains of northern Idaho and northeastern Washington, and the North Cascades of Washington (Johnson and Cassidy 1997).

Status

Within Washington, the grizzly bear is federally listed as threatened and state listed as endangered. The USFWS established six recovery zones within the conterminous 48 states, of which the North Cascades Recovery Zone (north of Interstate Highway 90) is one (USFWS 1993). In order to maintain the viability of a population of grizzly bears within a zone, it is estimated to require 10,000 square miles of wilderness and a population of 500 individuals. The North Cascades ecosystem approaches the size limit; however, the population of grizzly bears is estimated to be a minimum of 10 to 20 bears and is isolated from other populations (Johnson and Cassidy 1997).

Habitat Requirements

Historically, the grizzly bear was able to utilize a wide variety of habitat conditions, from open dry prairie to wet montane forest. Whitaker (1980) describes a general habitat condition of semi-open country usually in mountainous areas. Population size and distribution have been limited by human intrusion (USFWS 1997). Grizzly bears will avoid areas of human use, including the presence of roads and timber cutting (USFWS 1997).

The grizzly bear is a free-ranging animal that requires a large home range, with males having larger home ranges (200 to 500 square miles) than females (50 to 300 square miles) (USFWS 1995b). The home range size of an individual bear is affected by a variety of factors, including the juxtaposition of seasonal habitats, population density, age and reproductive status, habitat conditions, and the social relationship of the individual to others in the population (USFWS 1997).

The grizzly bear is an opportunistic omnivore; however, 80 to 90 percent of its diet is green vegetation, wild fruits, berries, nuts, and bulbs or roots. The majority of the meat in its diet comes from carrion (USFWS 1995b). The grizzly bear begins searching for a place to den in early fall. It may travel extensively to find a suitable location, generally on a remote mountain slope where snow, which provides insulation, will last until late spring. Dens are excavated, often under the root systems of large trees (USFWS 1997).

Population in the HCP Area

Range limits of the grizzly bear predicted by gap analysis modeling do not include the HCP Area (Johnson and Cassidy 1997). However, grizzly bears have been documented to the south in the Puyallup River drainage of Pierce County (USACE 1997) and in four parcels near Snoqualmie Pass in the I-90 North Parcel group land exchange area. Although the species is considered rare, it is possible that it infrequently inhabits the upper basin, but not the lower and mid-basin areas of the Green River.

OREGON SPOTTED FROG *(Rana pretiosa)*

Range

Historically, the Oregon spotted frog ranged from southwestern British Columbia south to the northeast corner of California, including the Puget Sound lowlands, Willamette Valley, and Cascade Mountains of south-central Oregon (McAllister and Leonard 1997). It has been extirpated from much of its historic range in Washington, which was west of the Cascades in the Puget Trough (Blaustein et al. 1995). The recent gap analysis for Washington reports only three extant populations in Thurston and Klickitat counties (Dvornich et al. 1997).

Status

The Oregon spotted frog is a federal candidate for listing and a state endangered species. During recent surveys, some 60 locations in western Washington were searched, but only a single individual was found in one site (McAllister et al. 1993). The reason for their decline is not known, but degradation of wetlands (Leonard et al. 1993) and introduction of the bullfrog (*Rana catesbeiana*) are suspected (Hayes and Jennings 1986).

Habitat Requirements

The Oregon spotted frog is highly aquatic, nearly always found in marshes or on the edges of lakes, ponds, and slow streams (Blaustein et al. 1995; Corkran and Thoms 1996). In these aquatic settings, it prefers non-woody wetland plant communities including sedges, rushes, and grasses (Leonard et al. 1993). Adults feed on invertebrates, usually within 2 feet of the water's edge on dry days, but during or after rain they may travel to feed in wet vegetation and ephemeral puddles (Licht 1986). Spotted frogs do not usually occupy mature forested areas. Brown (1985) lists early-successional habitats up to the closed sapling-pole stage as primary feeding and resting habitat for the species. Adult spotted frogs are active from February through October, and hibernate in muddy bottoms of ponds near breeding sites. Egg laying is usually accomplished in February or March in the warmest shallow waters (Leonard et al. 1993) and tadpoles usually metamorphose during mid-August of their first summer at lower elevations (Nussbaum et al. 1983).

Population in the HCP Area

The lower and mid-Green River basins occur within the historical range of the Oregon spotted frog, but only a few historic records have been documented in the Puget Sound lowlands of King County (Dvornich et al. 1997). One unconfirmed adult was reported during surveys in 1995 along Upper Sunday Creek (USFS 1996) in the upper Green River basin, but this location is closer to the known range and habitat of the more abundant Columbia spotted frog (*Rana luteiventris*). Given the rarity of *R. pretiosa* in Washington and lack of historic records in eastern King County, their presence in the Green River basin is unlikely.

CANADA LYNX *(Lynx canadensis)*

Range

The range of the Canada lynx includes the boreal forests of Canada and Alaska, and the mountains adjacent to the Canadian border of the western conterminous 48 states (Ingles 1965; Koehler and Aubry 1994; Johnson and Cassidy 1997). In Washington, the Canada lynx occurs between 4,000 feet elevation and timberline east of the Cascade crest (Johnson and Cassidy 1997). There are approximately 6,500 square miles of lynx habitat within Washington (U.S. Federal Register, 27 December 1997).

Status

In Washington, where its population is estimated to be between 91 and 196 individuals, the Canada lynx is listed by the state as threatened (Washington Department of Wildlife 1993). The Canada lynx is federally listed as threatened throughout the lower 48 states (U.S. Federal Register, 24 March 2000). The original listing proposal stated that the Canada lynx is threatened by human alteration of forests, low numbers as a result of past over-exploitation, expansion of the range of competitors like the bobcat (*Felis rufus*) and coyote (*Canis latrans*), and elevated levels of human access into lynx habitat (U.S. Federal Register, 8 July 1998b).

Habitat Requirements

The Canada lynx requires a matrix of two important habitat types. For thermal and security cover and for denning it uses mature, closed-canopy, boreal forest that contains a high density of large logs and stumps and is near hunting habitat. For hunting, it uses early successional forest with high densities of snowshoe hare *(Lepus americanus)*. Additionally, lynx avoid large open spaces and tend not to cross openings greater than 330 feet (Koehler and Aubry 1994). The abundance of Canada lynx is correlated with the population cycle of the snowshoe hare, its primary prey (Ingles 1965; Koehler and Aubry 1994; Johnson and Cassidy 1997).

Population in the HCP Area

Range limits of the lynx predicted by gap analysis modeling do not include the HCP Area (Johnson and Cassidy 1997); however, one male was reportedly observed in the Green River Watershed Analysis Area in 1979 (USFS 1996). No lynx have been documented in the I-90 Land Exchange parcel groups (USFS 1998). Although the species is considered rare, it is possible that it inhabits the upper basin, but not the lower and mid-basin areas of the Green River.

CASCADES FROG *(Rana cascadae)*

Range

The range of the Cascades frog extends from northern California to Oregon and Washington, and is restricted to higher elevations of the Cascade and Olympic mountains (Leonard et al. 1993; Corkran and Thoms 1996). The Cascades frog is a montane species that rarely occurs at elevations below 2,000 feet; in Washington it has been recorded up to 6,200 feet in elevation near Mt. Rainier (Leonard et al. 1993).

Status

The Cascades frog is currently classified as a federal species of concern. In a review by Blaustein et al. (1995) it was noted that Cascades frog seems more difficult to find than historically, and the authors speculated that the species might be sensitive to habitat fragmentation, drought, disease, fish introductions, and ultraviolet radiation. Nussbaum et al. (1983) mentioned a decline of this species in Oregon. In California, Fellers and Drost (1993) concluded that Cascades frogs have exhibited precipitous declines for more than 15 years. Corn (1994) noted that so far there are no quantitative studies to document declines in northern populations.

Habitat Requirements

Cascades frogs are most commonly found at lakes, ponds, swamps, marshes, sphagnum bogs, and fens, but also inhabit pools adjacent to streams in alpine meadows and forests (Leonard et al. 1993; Beak 1994, 1995, 1996b). In shallow, lentic waters, breeding and egg laying begin shortly after snow melt, and tadpoles metamorphose by early fall or the next summer (Leonard et al. 1993). After breeding, adults are sometimes found away from water (Nussbaum et al. 1983). Brown (1985) lists primary breeding habitat in ponds and riparian habitat, and primary feeding and resting habitat in all forest ages. Dvornich et al. (1997) concluded that Cascades frogs are generally not situated within closed forest, but may inhabit open-canopy hardwood stands if residual downed conifer logs are present. In the southern Cascades of Washington, Aubry and Hall (1991) found 10 individuals in old-growth stands, two in mature stands (80-190 years old), and one in submature stands (55-75 years old), but did not sample younger stands or wetlands. Their results showed a positive correlation with well-decayed snags on the landscape, and associations with deciduous and coniferous canopy cover, although only older seral stages (>55 years old) were surveyed. On managed forest in Lewis County, Bosakowski (*in review*) found 234 adults and significant correlations were established for open wetlands, sapling conifers (0-6 years old), recent clearcuts, and mature conifers (>45 years old). In addition, Bosakowski (*in review*) reported that mature conifers were evident only at stream sites, with few around wetland breeding ponds.

Population in the HCP Area

Records of the Cascades frog exist throughout the Cascade region, including the eastern half of King County (Dvornich et al. 1997). Surveys in the Snoqualmie Pass area revealed that it is very abundant in some areas. In 1994 and 1995, presence was recorded at 19 sites, with reproduction found at 11 of the sites in the upper Green River basin (USFS 1996). Cascades frogs were found reproducing in all beaver ponds that were surveyed (USFS 1996). Habitat models predicted a total of 38,220 acres of suitable habitat in the Green River Watershed Analysis Area, which includes 380 acres of wet meadows, 102 acres of shrubby wetlands, 115 acres of lakes/ponds, and 37,623 acres of less-preferred streamside habitat (USFS 1996). The Cascades frog is locally abundant in high elevation areas (> 2,000 feet) in the upper Green River watershed above the Tacoma Headworks, but is not expected to inhabit the lower and mid-basins of the Green River.

CASCADE TORRENT SALAMANDER *(Rhyacotriton cascadae)*

Range

The range of the Cascade torrent salamander is extremely small, restricted to the west slope of the Cascades in the Mount Rainier area and southward into the northern Oregon Cascades (Leonard et al. 1993; Dvornich et al. 1997).

Status

The Cascade torrent salamander is classified a federal species of concern and a state candidate for listing, probably due to its extremely small range.

Habitat Requirements

Torrent salamanders are almost always found in or adjacent to cold, clear mountain streams with rapids, waterfalls, and splash zones, but seeps and permanently wet talus are also inhabited (Leonard et al. 1993). Adults are fully terrestrial, air-breathing salamanders, but generally live under rocks with a thin film of water present (Leonard et al. 1993). They are seldom more than 3 feet from preferred water sources (Nussbaum et al. 1983). Eggs are deposited in communal nests located between cracks of rocks with flowing water (Nussbaum et al. 1983). After hatching, the gilled larvae remain completely aquatic for 3 to 5 years before metamorphosing into terrestrial adults (Leonard et al. 1993). Larvae live under cover objects such as rocks, bark, and leaves (Stebbins 1966) and are more often located in riffle habitats than pool habitats (Bury et al. 1991a). Because of their specialization for cold water, streams inhabited by torrent salamanders are usually located in forested areas, primarily in large sawtimber and old-growth conifer or mixed forest (Brown 1985). However, no quantitative studies of forest habitat associations have been conducted for this species of torrent salamander. For the closely related southern torrent salamanders (*R. variegatus*), recent data suggest that they can persist in managed forests, but are restricted to steeper portions of streams (greater than 9 percent) where velocity is sufficient to keep cobbles and gravels free of sediment (Diller and Wallace 1996). Torrent salamanders can become rare or absent in areas where timber harvesting causes increases in water temperature, air temperature, and siltation, and decreases in DO and relative humidity (Marshall 1992; Leonard et al. 1993).

Population in the HCP Area

The HCP Area is not within the known range of the Cascade torrent salamander. There are no records of it for King and Pierce counties (Dvornich et al. 1997). The closest known sighting to the HCP Area is from the border of Thurston and Lewis counties (Dvornich et al. 1997). The species is unlikely to occur in the HCP Area because of its rarity and lack of historical range within the Green River watershed. It is even less likely in the lower and mid-basin areas of the Green River due to the lack of cold, headwater streams at lower elevations.

VAN DYKE'S SALAMANDER *(Plethodon vandykei)*

Range

The range of Van Dyke's salamander is extremely small, falling within three isolated regions of western Washington: the Willapa Hills, Olympic Peninsula, and the southwestern Cascade Range in the vicinity of Mount Rainier (Leonard et al. 1993; Dvornich et al. 1997). These salamanders are found primarily in regions of high rainfall, usually in association with rock or sometimes woody debris (Dvornich et al. 1997). This salamander species ranges from nearly sea level to about 3,600 feet in elevation near Mount Rainier (Leonard et al. 1993).

Status

The Van Dyke's salamander is a federal species of concern and a state candidate for listing in Washington because of its rarity and very limited distribution. Within its limited range, there is no evidence of a decline (Blaustein et al. 1995). Corn (1994) did not include the Van Dyke's salamander in his discussion of declining western amphibians.

Habitat Requirements

Van Dyke's salamanders are considered a small stream associate (Dvornich et al. 1997). These salamanders are frequently found in the splash zones of small streams, waterfalls, and seeps, where they hide under rocks, logs, and bark (Leonard et al. 1993). They emerge at night (Leonard et al. 1993) or during rainfall to forage on the forest floor and along streambanks (Bosakowski, unpubl. data). It is suggested that perennial non-fish streams provide the best habitat for Van Dyke's salamanders because of their permanent flow but lack of predatory fish (Rodrick and Milner 1991; Beak 1994, 1995, 1996b). However, Van Dyke's salamanders may also be locally abundant on steep talus slopes, as Herrington (1989) reported a higher abundance in talus habitats than in non-talus habitats. In Lewis County, Bosakowski (*in review*) found nearly equal proportions in forested areas adjacent to streams or on talus slopes far from water. In addition, Van Dyke's salamanders were found inhabiting the moist floor of a lava tube near Mount St. Helens (Aubry et al. 1987). Eggs are laid on land under rocks or woody debris (Leonard et al. 1993).

Very few data have been collected or reported on forest cover preferences of the Van Dyke's salamander (Blaustein et al. 1995). Jones and Atkinson (1989) reported anecdotal evidence of an association with riparian habitats in mature and old-growth coniferous forests of Long Island, Washington. Dvornich et al. (1997) assumed that young forests and large hardwood riparian stands are probably not suitable habitat for Van Dyke's salamanders since there were no published data from intensively managed timberlands. However, this speculation is not supported by recent quantitative data. On managed forest in Lewis County, Bosakowski (*in review*) found 42 adults; significant preferences were found for alder/hardwood stands, pole conifers (27-44 years old), and mature conifers (>45 years old).

Population in the HCP Area

A single published record of Van Dyke's salamanders currently exists for King County, and a limited number of occurrences have been reported less than 30 miles to the south in adjacent Pierce County (Dvornich et al. 1997). No "Survey and Manage" protocol surveys for the Van Dyke's salamander were conducted in the Green River Watershed Analysis Area, but one incidental sighting was recorded along Twin Camps Creek (USFS

1996). Habitat models predicted some 28,658 acres of suitable habitat in the Watershed Analysis Area, plus an additional 768 acres of talus and cliff habitat (USFS 1996). Although the species inhabits the upper basin, it is not very likely in the lower and mid-basin areas of the Green River due to a scarcity of forested riparian zones along lowland stream and creeks.

LARCH MOUNTAIN SALAMANDER *(Plethodon larselli)*

Range

The Larch Mountain salamander was once believed to be limited to the Columbia River Gorge (Nussbaum et al. 1983), but recent surveys have demonstrated its occurrence throughout much of the southwest Cascade Range in Washington (Dvornich et al. 1997). The species ranges from the Columbia River Gorge between Hood River and Troutdale, Oregon, north to central Lewis County in the westside forests of the Cascade Range (Aubry et al. 1987). Several new records also show the species to be present north as far as the Interstate Highway 90 corridor (WDFW et al. 1994). Leonard et al. (1993) reported that the Larch Mountain salamander ranges up to 3,400 feet in elevation, but recent surveys have found them as high as 4,100 feet near Randle in Lewis County (Bosakowski, *in review*).

Status

The Larch Mountain salamander is probably one of the rarest amphibians in Oregon and Washington (Leonard et al. 1993). It is classified as a federal species of concern and state sensitive species because of its rarity, its unique habitat associations (talus slopes), and extremely small geographic range. There is no evidence to suggest it is declining and Corn (1994) did not report any known declines. Quite the contrary, intensified survey efforts for this federal "Survey and Manage Species" (USFS 1997; Beak 1995; Plum Creek 1996) have resulted in an ever-broadening range.

Habitat Requirements

This upland salamander species is fully terrestrial and is rarely associated with streams or open water habitats (Nussbaum et al. 1983). Most populations of this salamander are located on steep talus slopes (30-50 degrees) kept moist by a covering of mosses and a dense overstory of coniferous trees (Leonard et al. 1993; WDFW et al. 1994), although it also may occur in lava tubes and caves (Aubry et al. 1987). It appears to be more common in talus slopes that are not perpetually wet throughout the year (Nussbaum et al. 1983). In Lewis

County, Bosakowski (*in review*) found five individuals on two steep talus slopes, and a habitat analysis of the survey areas (31 acres) revealed that rock was the only cover type that was significantly correlated with abundance. In that study, neither collection site had overhead canopy cover, although mature coniferous forest was adjacent to the talus slopes (within 100 to 300 feet) (Bosakowski, *in review*). Other research indicates that Larch Mountain salamanders may be more common in areas with dense overstories that help maintain higher moisture levels, but not a saturated environment. Bury and Corn (1989b) found 14 individuals, all of which were inhabiting old-growth forest, even though other seral stages were sampled in that survey. In another study, two adjacent talus slopes, separated by a creek, were searched for Larch Mountain salamanders, but only the slope that was not clearcut was found to contain them (Herrington and Larsen 1985).

Population in the HCP Area

Until recently there were no records for the Larch Mountain salamander in King County. However, five new records have emerged in the vicinity of Snoqualmie and Stampede passes (Dvornich et al. 1997; USFS 1997, 1998) with two of those records from the upper Green River watershed. Habitat models predicted some 18,792 acres of suitable habitat in the Green River Watershed Analysis Area, plus an additional 768 acres of talus and cliff habitat (USFS 1996). The Larch Mountain salamander is a resident of the upper Green River watershed, but may also occur at lower elevations in the mid-Green River basin (below Headworks) if suitable talus habitat is available. It is unlikely to occur in the lower Green River because old-growth forest and steep talus slopes are virtually absent along this stretch.

TAILED FROG *(Ascaphus truei)*

Range

Tailed frogs are distributed throughout northern California, Oregon, Idaho, British Columbia, and Washington (Nussbaum et al. 1983). In Washington, tailed frogs range throughout the Cascade Mountains, Olympic Peninsula, Willapa Hills, and Blue Mountains, where they are found from nearly sea level up to 5,250 feet in elevation near Mount Rainier (Leonard et al. 1993).

Status

The tailed frog is currently classified as a federal species of concern. Although there is no evidence of an overall decline within their range (Corn 1994), tailed frogs are locally vulnerable to timber harvesting because of associated watershed disturbances such as siltation and sedimentation, and temperature increases due to canopy removal (Bury and Corn 1988; Bury and Corn 1989a). Lemkuhl and Ruggiero (1991) considered the tailed frog to be at moderately high risk of extinction. Since recolonization after habitat loss may take a relatively long time, it is felt that some populations may not readily recover (Blaustein et al. 1995).

Habitat Requirements

The tailed frog requires cold, fast-flowing permanent streams within forested areas, and does not inhabit ponds or lakes (Nussbaum et al. 1983; Leonard et al. 1993). During breeding in June or July, the female lays 50 to 60 eggs under a rock in the stream and embryos hatch during August. The aquatic larvae (tadpoles) may take from 1 to 6 years to metamorphose while they remain in the stream (Leonard et al. 1993). The tadpoles survive in swift water by clinging to rocks with their sucker-like mouths (oral disc) which are also used to scrape-off algae, diatoms, conifer pollen, and small insects (Nussbaum et al. 1983). It may take 7 to 8 years to reach sexual maturity, and tailed frogs may live up to 18 years (Welsh 1990). During the day, adults usually remain hidden under rocks or debris, either on the streambank or underwater on the stream bottom (Beak 1994, 1995, 1996b). At night, adult tailed frogs emerge from cover (Leonard et al. 1993) and may forage up to 1,300 feet into adjacent forested areas (McComb et al. 1993).

Tailed frogs are typically restricted to small headwater streams such as WDNR Type 3 and 4 streams (Beak 1994, 1995, 1996b; Dvornich et al. 1997). Tailed frogs have a narrow water temperature tolerance (de Vlaming and Bury 1970; Welsh 1990), so forest cover along streams is essential in maintaining cool instream water temperatures. Nussbaum et al. (1983) reported that tailed frogs disappeared from streams when areas were logged, speculating that increased water temperature and siltation were the cause. Other studies have also concluded that the species is sensitive to watershed disturbances (Noble and Putnam 1931; Metter 1964, 1968; Bury 1968, 1983; Bury and Corn 1988). Riparian forest cover also provides a favorable terrestrial microclimate for adults foraging/dispersing on land (i.e., a cool, damp forest floor) and acts to alleviate stream siltation. Bull and Carter (1996) found tailed frog abundance correlated with the presence of forest buffers (>100 feet) along streams.

Streams supporting large populations of tailed frogs usually occur in mature and old coniferous forest (Aubry and Hall 1991; Corn and Bury 1991; Gilbert and Allwine 1991 Bury et al. 1991; Welsh and Lind 1991), and population densities in large clearcuts were significantly lower than forested areas (Bury and Corn 1989a, Welsh 1990). On the west slope of the Cascades in southern Washington and northern Oregon, Bury and Corn (1989b) found them to be abundant in many stands older than 30 years old, but absent or very rare in clearcut stands. Large hardwood riparian stands were not considered suitable habitat by Dvornich et al. (1997); this was verified by the multiple regression analysis of Bosakowski (*in review*). In Lewis County, Bosakowski (*in review*) found 43 adults, and significant preferences were found for pole conifers (27-44 years old) and mature conifers (>45 years old).

Population in the HCP Area

Records of the tailed frog exist mainly throughout the eastern half of King County, with a large concentration of sightings in the Stampede Pass area (Dvornich et al. 1997). Kelsey (1995) located tailed frogs in the Friday Creek drainage in the upper Green River watershed. This site is well within the range of the tailed frog and the species is very likely to occur in other suitable streams (DNR Type 4) in the area that are bordered with sufficient forest cover (USFS 1996). Approximately 7,257 acres of potential habitat were identified within the Green River Watershed Analysis Area (USFS 1996). Although the species inhabits the upper basin, it is not very likely in the lower and mid-basin areas of the Green River due to the lack of cold, headwater streams at lower elevations.

NORTHWESTERN POND TURTLE *(Clemmys marmorata)*

Range

The northwestern pond turtle ranges from Puget Sound to northwestern Baja California, principally west of the Sierra-Cascade Crest, from sea level to 6,000 feet in elevation (Blaustein et al. 1995). In Washington, confirmed populations are limited to Klickitat and Skamania counties, although sightings have recently been confirmed in Pierce and King counties in the historic range of the species (Rodrick and Milner 1991). Maximum elevation recorded in Washington is 1,000 feet; the maximum for Oregon is 3,000 feet (Brown et al. 1995).

Status

The northwestern pond turtle is listed as an endangered species by the state of Washington and a species of concern by the USFWS. Populations of the northwestern pond turtle are declining, particularly in the northern part of the range (Brown et al. 1995). Threats to this species include habitat alteration, drought, predation (on juveniles by exotic fish and bullfrogs), local disease outbreaks, and loss of connectivity between populations due to habitat fragmentation (Brown et al. 1995).

Habitat Requirements

The northwestern pond turtle inhabits marshes, ponds, sloughs, brackish waters, and slow sections of streams with gentle and unshaded banks, rocky or muddy bottoms, and emergent aquatic vegetation or submerged branches of trees or shrubs (Stebbins 1966; Holland 1991a). Adults may bask out of water for several hours each day and will use logs, rocks, open banks, or floating vegetation for basking sites (Nussbaum et al. 1983). Females leave the water to nest up to 1,640 feet from shoreline in adjacent open, grassy areas with soft soil and good sun exposure (Rathbun et al. 1992), but most nests are dug within 300 feet of water (Brown et al. 1995). Pond turtles are omnivores, feeding on aquatic vegetation and small aquatic animals and carrion, with a preference for animal tissue (Bury 1986; Holland 1991b). To hibernate, northwestern pond turtles dig burrows along undercut banks (Holland 1994), in soft bottom mud of ponds (Ernst and Barbour 1972), or in uplands up to 1,640 feet from water (Rathbun et al. 1992). Winter hibernation sites in the uplands are generally dug in soils or duff on slopes less than 35 degrees (Holland 1994). Brown (1985) lists primary habitat as early successional forest stages (grass-forb, shrub, open sapling-pole).

Population in the HCP Area

Records of the northwestern pond turtle in Washington are mainly from the southern end of the Puget Sound lowlands, with several records from western King County (Dvornich et al. 1997). The species could be present in lowland habitat of the lower and mid-Green River basins, but because of its extreme rarity and specialized wetland requirements, presence is unlikely. Lack of historical records in the Washington Cascades and limited elevation (<1,000 feet) tolerance in Washington, make this species extremely unlikely to occur in the upper Green River basin above the Headworks.

NORTHERN GOSHAWK *(Accipiter gentilis)*

Range

In North America, the northern goshawk breeds throughout most of the boreal forest region, other northern forest biomes, and high elevation montane forests of the Southwest and Mexico. Nesting in the Pacific Northwest occurs most frequently at mid- to upper elevations, although nests may occasionally occur at low elevations (Reynolds 1989; DeStefano and McCloskey 1997). Distribution in Washington is mostly restricted to mountainous regions including the Cascade, Olympic, Selkirk, and Blue mountains, and Okanogan Highlands, but occasional breeding has been recorded in southwest Washington and the western Olympic lowlands (Smith et al. 1997). Adults and juveniles are generally permanent residents or only weakly migratory (Johnsgard 1990; Iverson et al. 1996).

Status

The northern goshawk is classified as a state candidate species and federal species of concern. Although there have been several petitions to list the species at the federal level, there is little evidence available to suggest that the northern goshawk is rapidly declining in the United States. The latest petition to list the species west of the 100th meridian was denied (U.S. Federal Register, 29 June 1998).

Habitat Requirements

Breeding goshawks primarily inhabit large tracts of mature and old-growth coniferous forest in the Pacific Northwest region (Saunders 1982; Reynolds et al. 1992; Moore and Henny 1983; Bull and Hohmann 1994; USFS 1994). Goshawks are associated with large tree habitat for three major reasons: these habitats provide dense canopy cover, they provide clear flight space below the canopy, and the large trees are needed to provide support for their large stick nests (Speiser and Bosakowski 1987; Reynolds 1989). Nest trees are often the largest tree in the nest site (Reynolds et al. 1992; Fleming 1987; Squires and Reynolds 1997). In Washington, Fleming (1987) reported that nests were placed in large trees with adequate support branches or in small sawtimber trees with mistletoe brooms. Reynolds et al. (1992) hypothesized that a heavy canopy cover layer was needed to provide a buffered microclimate for protection of the young from overexposure to the elements and predators. This cool microclimate is also beneficial to actively hunting adults throughout the heat of summer.

Reynolds (1983) defined a nest site as a suitable forest stand with a 20- to 25-acre area of consistent vegetation structure or land form, including plucking posts, roosts, and defensible areas. In Washington, goshawk nest sites are found in a wide variety of closed-canopy stands. In old-growth forests, the largest reported stand dbh was 24.5 inches from the Cascade Mountains (Fleming 1987) and in younger pole stands, the smallest stand dbh reported was 8.8 inches in the Cascade Mountains (Bosakowski and Vaughn 1996), 9.7 inches on the Olympic Peninsula (Fleming 1987), and 10 inches in Idaho (Lilieholm et al. 1993). The youngest stand age known for nesting in Washington is 40 years from second-growth forest in Lewis County (Bosakowski and Vaughn 1996). Radio-tracking studies in California have shown that the habitat of the home range was similar to nest sites (Hargis et al. 1994). Reynolds et al. (1992) summarized goshawk home range size in the lower 48 states at roughly 6,000 acres, including a nest site of about 30 acres, the post-fledging family area of about 420 acres, and the foraging area of about 5,400 acres. Hargis et al. (1994) discovered that the nest sites and home ranges had higher basal area, canopy cover, and higher tree densities than random sites.

Goshawks are generally considered an upland breeding bird, although a few nests have been found in swamps in the Northeast (Speiser and Bosakowski 1987). In Alaska, radio-tagged goshawks preferred hunting in riparian zones and beach/estuary fringe, avoided alpine zones, but showed no preference or avoidance for upland zones (Iverson et al. 1996). In Oregon, nearby water was considered important for nesting, but several dry nest sites were found (Reynolds et al. 1992). The distance of nest sites to a water source was not significantly different than for 70 random sites, suggesting that a nearby water source is not required by this extremely mobile raptor (Bosakowski and Speiser 1994). Topographically, a preference has been discovered for nesting on lower, gentle slopes, and only rarely on slopes greater than 40 percent (Shuster 1980; Reynolds et al. 1992; Hayward and Escano 1989; Squires and Ruggiero 1996). However, a few nests were reported on slopes as high as 70 to 75 percent in Washington (Fleming 1987). In temperate regions, goshawks usually avoid nesting on southern slopes to avoid summer heat (Shuster 1980; Reynolds et al. 1992; Moore and Henny 1983).

In relation to forest management, recent studies have indicated that radio-tagged goshawks use clearcuts less than expected by chance (Iverson et al. 1996). Because of their strong fidelity to the nest site (Speiser and Bosakowski 1991; Detrich and Woodbridge 1994), some goshawks will occasionally return to breed after extensive timber harvesting, but this is generally the exception rather than the rule (Crocker-Bedford 1990; Patla 1997). While clearcutting can be favorable to certain important goshawk prey, including blue grouse (*Dendragapus obscurus),* ruffed grouse (*Bonasa* *umbellus*), and snowshoe hare (*Lepus americanus*) (Irwin et al. 1989), radio-tagged goshawks appear to select foraging sites based on preferred habitat structure, rather than localities of prey abundance (Beier and Drennan 1997). In addition to habitat loss, excessive forest fragmentation has been linked with increases in potential competitors and predators, such as the red-tailed hawk and great horned owl (Moore and Henny 1983; Crocker-Bedford 1990; Bosakowski and Smith 1997).

Population in the HCP Area

Records of nesting goshawks exist throughout the Cascades region, including the far eastern half of King County (Smith et al. 1997). In the upper Green River Land Exchange Area, there were five records of individual goshawks (USFS 1998). No formal surveys were conducted to locate goshawk nests in the Green River Watershed Analysis Area (USFS 1996), but habitat models predicted 5,489 acres of suitable nesting habitat within scattered parcels. It is highly likely that goshawks are nesting in the upland forests of the upper Green River watershed, unlikely for the mid-Green River basin, and extremely unlikely for the lower Green River basin because of increasing urbanization and habitat fragmentation. Outside of nesting territories, occasional wintering goshawks could appear in all areas of the Green River basin for variable periods of time, but are less likely to take up winter residency in urbanized areas or in young regenerating forests (<40 years old).

OLIVE-SIDED FLYCATCHER *(Contopus cooperi)*

Range

This neotropical migrant ranges throughout much of the boreal forest region and extends south into the Rocky Mountains and south along the Pacific Coast from Alaska to California (Robbins et al. 1983; Peterson 1990). In Washington, the distribution of this flycatcher is restricted to forested regions (Smith et al. 1997).

Status

This bird is currently considered a federal species of concern. Marshall (1988) found that olive-sided flycatchers had disappeared from undisturbed sequoia forest in California and suspected a decline on the wintering grounds. The olive-sided flycatcher is widespread on all national forests in Oregon and Washington (Sharp 1992). However, analysis of breeding bird survey routes from 1968 to 1989 revealed that declines (26) significantly outnumbered increases (12) on 38 national forest routes (Sharp 1992). When data were separated by state, however, only Oregon national forests showed a significant decline.

Habitat Requirements

Olive-sided flycatchers are generally found in open mature stands of conifers, or along the edges of clearings created by burns, windthrow, wetlands, and clearcutting where high perches in tall trees and snags are available (Harrison 1979; Brown 1985; Sharp 1992). Nests are usually built in conifers from 7 to 72 feet above ground, but occasionally in deciduous trees (Sharp 1992). For a recent gap analysis project, Dvornich et al. (1997) described habitat in Washington as sites with large tree patches adjacent to cleared areas, burns, or waterbodies. Territory size is about 25 acres (Sharp 1992). In California, Rosenberg and Raphael (1986) found over half (52 percent) of 402 detections were on edges, and analysis revealed that olive-sided flycatchers were positively correlated with the length of edge and stand insularity, and negatively correlated with distance to edge.

Along the Oregon/California border, Ralph et al. (1991) found no clear association of olive-sided flycatcher abundance with forest age-class, but found a positive correlation with conifers and a negative correlation with hardwoods. In northwestern California, Raphael et al. (1988) reported higher densities of olive-sided flycatchers in sapling (0-20 years old) and mature forest (>100 years old) than in pole/sawtimber (20-80 years old). On managed forest in Lewis County, Bosakowski (1997) also discovered a similar bimodal distribution for olive-sided flycatchers that were present at 14.4 percent of point counts (48 out of 330). In that investigation, recent clearcuts (0-6 years old), sapling conifers (6-26 years old), and mature conifers (>45 years old) were all associated with the presence of olive-sided flycatchers. In Montana, Hutto (1995) found a similar percentage of occupied point counts (15.6 percent) in conifer stands after recent stand-replacement fires. Hutto (1995) considered the olive-sided flycatcher to be relatively restricted to early post-fire conditions. In northwestern Montana, Tobalske et al. (1991) found highest abundance in clearcuts (17 percent) and partial cuts (7 percent) compared to unlogged forest (2 percent) and natural areas (0 percent), but the overall difference between groups was not significant.

Population in the HCP Area

Olive-sided flycatchers have been recorded extensively throughout nearly all of King County (Smith et al. 1997) and are likely to be present in the HCP Area. The species is extremely likely to inhabit the upper basin, and moderately likely to inhabit the lower and mid-basin areas of the Green River.

VAUX'S SWIFT *(Chaetura vauxi)*

Range

The Vaux's swift is a neotropical migrant that breeds from northern British Columbia to northern California and eastward to western Montana. It is also a year-round resident of Central America (Bull and Collins 1993).

Status

The Vaux's swift is a state candidate for listing in Washington. It is a common breeder in forests throughout the state (Smith et al. 1997); however, it is declining in population throughout its range (Bull and Collins 1993).

Habitat Requirements

The primary habitat requirement of the Vaux's swift is the presence of large-diameter hollow trees (living or dead), which are used for breeding and roosting (Bull and Collins 1993). Nest trees are usually large live trees with broken tops or woodpecker entrance holes; they range in size from 18 to 38 inches in dbh (Bull and Cooper 1991; Bull and Hohmann 1993). Large communal roosts are often established by non-breeding adults, and later by breeding pairs and fledglings (Bull and Collins 1993). Communal roost sites are established in large hollow chimney snags, ranging from 39 to 53 inches dbh (Bull 1991).

In northeastern Oregon, Bull (1993) compared Vaux's swift observations between old-growth and logged stands. Swifts were observed in 41 percent of the old-growth stands surveyed, but only 8 percent of the logged stands surveyed. The variables most highly correlated with Vaux's swift observation were the presence of large-diameter snags and trees with conks of the Indian paint fungus (Bull 1993). In the Washington Cascades, Manuwal and Huff (1987) found swifts to be more abundant in old-growth forest (≥ 250 years old) than in either young (42 to 75 years old) or mature (105 to 165 years old) forest.

Population in the HCP Area

The Vaux's swift breeds throughout the Washington Cascades and is documented extensively in King County (Smith et al. 1997). At least 49 individuals have been reported in the upper Green River basin (USFS 1996). There is a reasonable possibility that it inhabits the lower and mid-basin areas of the Green River as well.

CALIFORNIA WOLVERINE *(Gulo gulo luteus)*

Range

Along the Pacific Coast of the United States the wolverine occurs in the Cascade Mountains of Washington and Oregon, and the Sierra Nevada Mountains of California (Ingles 1965).

Status

The California wolverine is a federal species of concern and a state monitor species. In August 1994, the USFWS received a petition to list the wolverine in the contiguous United States. In its 90-day finding of April 1995, the USFWS determined that listing was not warranted at that time (U.S. Federal Register, 19 April 1995). Records indicate that the wolverine was never common (Ingles 1965; Banci 1994), and current population densities are low (Johnson and Cassidy 1997). In Washington, the wolverine was nearly or totally extirpated and is now recovering (Johnson and Cassidy 1997).

Habitat Requirements

The wolverine is most common in alpine and subalpine habitats, but may occur in all forest zones within its range (Ingles 1965; Johnson and Cassidy 1997). For British Columbia, Stevens and Lofts (1988) describe habitat as conifer-dominated forests, alpine tundra, and freshwater emergent wetlands. In North America, wolverine home ranges vary in size from 21 to 350 square miles (Banci 1994) suggesting a need for large wilderness areas. Natal dens have been found in holes dug under fallen trees, in cavities, rock crevices, thickets, abandoned beaver lodges, old bear dens, under the root wads of fallen trees, and in old creek beds (Whitaker 1980; Banci 1994).

The habitat component of primary importance is a sufficient year-round food supply in a large wilderness area. The wolverine is an opportunistic omnivore in summer, but principally a scavenger in winter. Its summer diet is diverse; berries, small mammals, sciurids, and insect larvae are eaten because of their increased availability. Ungulate carrion is an important part of the wolverine's diet throughout the year; however, in winter they can take live prey slowed by deep snow (Banci 1994).

Population in the HCP Area

Range limits for wolverines, predicted by gap analysis modeling, include the HCP Area (Johnson and Cassidy 1997). Records show one individual observed in the Green River Watershed Analysis Area in 1983 (USFS 1996); two other sightings are known from the I-90 Land Exchange Parcels at the Cascade Crest parcels (USFS 1998). Although the species is considered rare, it is possible that the wolverine inhabits the upper basin, but not the lower and mid-basin areas of the Green River.

PACIFIC FISHER *(Martes pennanti pacifica)*

Range

The Pacific fisher once ranged from northern British Columbia south to central California (Powell and Zielinski 1994). Within Washington, it currently occurs in the Cascade and Olympic mountains, and portions of the Okanogan Highlands (Aubry and Houston 1992).

Status

The Pacific fisher is a federal species of concern and has been listed by the state of Washington as endangered. After being petitioned in 1994 to list the fisher as threatened, the USFWS found there was insufficient information presented to warrant listing (U.S. Federal Register, 1 March 1996). Nevertheless, fishers are considered to be extremely rare in Washington. It is likely that they have not recovered from over-trapping during the late 1800s and early 1900s (Aubry and Houston 1992; Stinson and Lewis 1998).

Habitat Requirements

On the west side of the Cascades, fishers show a preference for contiguous closed-canopy late-successional coniferous forests at mid-elevations (Aubry and Houston 1992; Powell and Zielinski 1994). These forest types usually have an abundance of logs and snags that provide habitat for prey and denning opportunities for fishers in the form of cavities (Johnson and Cassidy 1997). Possibly to reduce infanticide by male fishers, female fishers appear to select for pileated woodpecker cavities as den sites, the size of which allow only for the female to enter (Stinson and Lewis 1998). Additionally, second-growth forests with sufficient cover are sometimes used, particularly as hunting habitat (Johnson and Cassidy 1997; Stinson and Lewis 1998). Fishers also show a preference for utilizing riparian corridors, especially for travel and rest sites (Aubry and Houston 1992), and avoiding areas of low canopy closure and areas of high snow accumulation (Powell and Zielinski 1994). They also appear to avoid highly fragmented forests and clearcuts (Powell and Zielinski 1994).

Population in the HCP Area

Range limits for fishers, predicted by gap analysis modeling, include at least portions of the HCP Area (Johnson and Cassidy 1997). Records show one individual observed in the Green River Watershed Analysis Area in 1984 (USFS 1996). No recent sightings are known from the I-90 Land Exchange Parcels (USFS 1998). Although the species is considered rare, there is a reasonable possibility that fishers may currently inhabit the upper basin. They are not expected to inhabit the lower and mid-basin areas of the Green River.

COMMON LOON *(Gavia immer)*

Range

The breeding range of the common loon extends throughout the majority of Canada and the northern portions of the United States (Robbins et al. 1983), including Washington (Smith et al. 1977). Loons winter along the East and West coasts of the United States.

Status

The common loon is a candidate for listing by the state of Washington. Although the common loon has shown an increasing trend in population across most of its range from 1966 to 1996, it has decreased in abundance in portions of Washington during the same time period (Sauer et al. 1997) and is considered to be "local and uncommon in large freshwater lakes and reservoirs within forested landscapes" (Smith et al. 1997). Its decrease in population may be a result of disturbance to nesting loons caused by recreational use of lakes (Rodrick and Milner 1991) and long-term habitat loss from development along lakeshores (Sauer et al. 1997).

Habitat Requirements

Loons require large wooded lakes with substantial fish populations for nesting. Nests, which may be used many times but are vulnerable to disturbance, are constructed on the ground on islands or mainland within 5 feet of the water's edge. Man-made artificial islands have been used successfully by nesting loons in areas where there is a lack of natural nesting habitat (Rodrick and Milner 1991).

Population in the HCP Area

Common loons have been confirmed breeding on the Howard Hanson Reservoir (Smith et al. 1997) and on Eagle Lake located about 1 mile northeast of the reservoir (USACE 1998). In addition to breeding loons, migrant loons have been observed at other seasons (USACE 1998). Overall, these are the only two large waterbodies in the upper Green River basin that can support nesting by loons. Nesting is not expected in the lower and mid-sections of the Green River basin, given the complete lack of known breeding sites at these lower elevations in King County (Smith et al. 1997).

PILEATED WOODPECKER *(Dryocopus pileatus)*

Range

The pileated woodpecker is present throughout the eastern half of the United States, across a narrow band of central Canada, and along the Pacific Coast from northern British Columbia to central California. It is present throughout the forested portions of Washington.

Status

The pileated woodpecker is a state candidate species in Washington. It is common in mid- through late-seral forests at low to middle elevations. Its numbers have been limited by forest practices that have resulted in the loss of large-diameter snags and decadent trees. In Washington, Breeding Bird Survey data indicate a population decline of 5.5 percent per year from 1966 to 1991 (Smith et al. 1997); however, data from 1980 to 1996 indicate an increase of 8 percent (Sauer et al. 1997).

Habitat Requirements

The pileated woodpecker typically inhabits large tracts of late-successional forest (Bull and Jackson 1995) because it requires large-diameter snags and decadent live trees in which to nest, roost, and forage (Mellen et al. 1992; Aubry and Raley 1995; Bull and Jackson 1995; Parks et al. 1997). On the Olympic Peninsula, Aubry and Raley (1995) located 27 pileated woodpecker nests, of which 55 percent were in snags and 45 percent were in live trees with dead tops. The mean dbh and height for nest snags and trees combined were 39.6 inches and 130 feet, respectively. In Oregon, all nest and roost trees (n = 33) were located on stands at least 70 years old (Mellen et al. 1992). Aubry and Raley (1995) also located 155 roost sites, of which 52 percent were in snags, 40 percent in dead-topped trees, and 8 percent in sound live trees. Because pileated woodpeckers excavate a new nest every year, numerous large snags are required. Neitro et al. (1985) estimated that six suitable snags per 100 acres are required to maximize the density of breeding pairs of pileated woodpeckers.

Logs are an important foraging substrate for the pileated woodpecker (Mellen et al. 1992) because they provide habitat for forest-dwelling ants (Torgersen and Bull 1995). In northeastern Oregon, Bull et al. (1992), found that carpenter ants comprised 68 percent (by count) of the pileated woodpeckers diet. On the Olympic Peninsula, Aubry and Raley (1996) found that carpenter ants comprised 66 percent of its diet.

Pileated woodpeckers have large home ranges. On the Olympic Peninsula, pileated woodpecker pairs had a mean home range size of 2,132 acres (Aubry and Raley 1995). In Oregon, home ranges for individuals averaged 1,181 acres (Mellen et al. 1992). Aubry and Raley (1995) collected telemetry data on roosting and foraging birds. About 60 percent of the foraging locations and 88 percent of the roosting locations were in old and mature forests. About 14 percent of the foraging locations were in naturally regenerated young forest (75 years old), 16 percent in young closed pole forest, and 8 percent in open sapling/shrub habitat.

Population in the HCP Area

The pileated woodpecker breeds extensively in King County (Smith et al. 1997) and is a breeding resident of the HCP Area. Two known pairs and several other individuals have been noted in the Green River Watershed Analysis Area in 1979, 1981-1983, 1985, 1986, 1991, and 1993 (USFS 1996). There is concern for this species in the upper Green River basin since over 50 percent of the area has less than one snag per acre (USFS 1996). Large portions of the area have no suitable nest snags and no potential for recruitment for at least 70 years (USFS 1996). The species likely inhabits the lower and mid-basin areas of the Green River as well.

Literature Cited

References cited in this chapter are provided in Chapter 10 of the HCP

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AGREEMENT BETWEEN
THE MUCKLESHOOT INDIAN TRIBE
AND
THE CITY OF TACOMA
REGARDING THE GREEN/DUWAMISH RIVER SYSTEM

1995

(Sections 1, 2, 3 presented to describe instream
flow and fish restoration facility commitments.)

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AGREEMENT BETWEEN THE MUCKLESHOOT INDIAN TRIBE AND THE CITY OF TACOMA REGARDING THE GREEN/DUWAMISH RIVER SYSTEM

The Muckleshoot Indian Tribe, a federally recognized Indian tribe, and the City of Tacoma, acting by and through its Department of Public Utilities, Water Division, agree as follows:

RECITALS

A. The Muckleshoot Indian Tribe ("MIT") is a federally recognized Indian tribe located on the Muckleshoot Indian Reservation in King and Pierce Counties, Washington. MIT has rights under, and is the successor to certain bands and tribes who were parties to, the Treaty of Point Elliott (12 Stat. 927) and the Treaty of Medicine Creek (10 Stat. 1132). MIT holds federally guaranteed rights under the Treaty of Point Elliott, including fishing and hunting rights, in the Green/Duwamish River System. MIT has rights and responsibilities for the management of the fish and wildlife resources and other natural resources of the Green/Duwamish River System, including the protection of those resources from environmental degradation.

B. The City of Tacoma, by and through its Department of Public Utilities, Water Division, ("TPU") owns and operates a municipal water supply system on the Green/Duwamish River System, and controls access to the Upper Watershed of the Green River for water quality protection. As owner and operator of a municipal water supply system, TPU has a responsibility to provide a safe, adequate and affordable water supply to its customers. As part of this responsibility, TPU carries out conservation of water resources through conservation programs, water demand management programs and by augmentation of its available water supply through such means as aquifer recharge and exploration and use of additional well capacity.

C. MIT and TPU want to resolve past differences over water resource issues concerning the Green/Duwamish River System, and to work cooperatively in the future to manage the resources of the Green/Duwamish River System. MIT and TPU recognize that other Resource Agencies share responsibility for managing the resources of the Green/Duwamish River System, and MIT and TPU will work together to enlist the support of the Resource Agencies in the implementation of this Agreement.

D. This Agreement settles all MIT claims against TPU arising out of, or relating to, TPU's municipal water supply operations on the Green/Duwamish River System, including the

First and Second Diversions, the proposed Second Supply Project, and TPU's activities in the Upper Watershed of the Green River, except as set forth in Section 10 of this Agreement. MIT's claims arise out of its federally guaranteed treaty rights and other federal laws. It is not the intent of the parties to address, in this Agreement, the proposed Howard Hanson Dam Additional Storage Project, except as specifically set forth herein relating to the evaluation of feasibility studies.

E. This Agreement culminates several years of negotiations, technical analysis and working together to develop understanding and recognition of each other's needs, interests, responsibilities and requirements. The parties intend that this Agreement establishes the commitment and framework for a long-term cooperative working relationship between MIT and TPU concerning the Green/Duwamish River System.

SECTION 1. DEFINITIONS

For purposes of this Agreement, the following definitions shall apply:

1.1. "Auburn Gage" shall mean the United States Geological Service Gage No. 12113000, which is located on the Green River at approximately River Mile 32.0.

1.2. "Average to Dry Year" shall mean when Howard Hanson Dam reservoir conditions correspond to Zone 3 as described and used in Exhibit A to this Agreement.

1.3. "Bypass Reach" shall mean the stretch of the Green River between the intake for the FRF surface water supply and the surface water discharge from the FRF into the Green River.

1.4. "Capital Repair and Replacement Fund" shall be as defined in Section 3.1.5 of this Agreement.

1.5. "Ceremonial Hunt" shall mean an occasional hunt by designated MIT members for funerals and one annual function sponsored by MIT approved by the MIT Hunting Committee pursuant to MIT's Hunting Ordinance.

1.6. "cfs" shall mean cubic feet per second.

1.7. "Construction Financing" shall mean the bond proceeds from the revenue bonds sold to finance construction of the Second Supply Project and the FRF.

1.8. "Controlled Area" shall mean that portion of the Upper Watershed of the Green River closed to public access by TPU to protect the water supply of the Green River.

1.9. "Corps of Engineers" shall mean the United States Army Corps of Engineers or its successor agency.

1.10. "Drought Year" shall mean any year in which the water equivalent of the snowpack at the Stampede Pass National Weather Service snow measurement station is less than twelve (12) inches on May 1 of any year, or when Howard Hanson Dam reservoir conditions correspond to Zone 4 as described and used in Exhibit A of this Agreement after May 1 of any year.

1.11. "First Diversion" shall mean the diversion of water from the Green River under TPU's initial water right claim of 113 cfs.

1.12. "Fisheries Restoration Facility" or "FRF" shall be defined as in Section 3 of this Agreement.

1.13. "Fisheries Trust Fund" shall be as defined in Section 3.3.

1.14. "Game Management Unit 485" or "GMU 485" shall mean the area in the Upper Watershed of the Green River set by WDFW for management purposes.

1.15. "General Trust Fund" shall be as defined in Section 5.

1.16. "Green/Duwamish River System" shall mean the Green River, the Duwamish River and their tributaries, the watersheds of the Green River, the Duwamish River and their tributaries, and Elliott Bay.

1.17. "Headworks" shall mean the area at TPU's Green River diversion structures, including the dam, intake, settling basin, water control building and associated structures.

1.18. "Howard Hanson Dam" shall mean that certain dam located at approximately River Mile 64.5 of the Green River owned by the United States and operated by the Corps of Engineers.

1.19. "Howard Hanson Dam Additional Storage Project" shall mean the proposed modifications to Howard Hanson Dam that are presently being studied by the Corps of Engineers to increase substantially the water storage of Howard Hanson Dam.

1.20. "Indirect Costs" shall mean the lesser of 32.6% or the actual indirect cost rate, if any, negotiated annually between MIT and the Inspector General of the Department of the Interior. Indirect Costs are calculated by multiplying the direct costs by the indirect cost rate. Indirect Costs are in addition to direct costs.

1.21. "Limited Control Area" shall mean that portion of the Upper Watershed of the Green River outside the Controlled Area.

1.22. "MIT" shall be as defined in Recital A to this Agreement.

1.23. "O&M" shall mean the operations and routine maintenance of the FRF.

1.24. "O&M Base Amount" shall be as defined in Section 3.1.4.2 of this Agreement.

1.25. "Palmer Gage" shall mean the United States Geological Service Gage No. 12106700, which is located on the Green River 0.7 miles downstream from the diversion dam portion of the Headworks at approximately River Mile 60.3.

1.26. "Resource Agencies" shall mean those governmental agencies with responsibility for fisheries, wildlife or water resources.

1.27. "Second Diversion" shall mean the proposed diversion of Green River water under TPU's second diversion water right obtained in 1986 of up to 100 cfs.

1.28. "Second Supply Project" shall mean TPU's proposed approximately thirty-three (33) mile long pipeline from the Headworks of the Green River to the City of Tacoma, including the proposed Headworks modification and associated facilities (also known as Pipeline 5), along with aquifer recharge and groundwater referenced in Sections 2.3 and 2.4.

1.29. "Second Supply Project Operation" shall mean the Second Supply Project supplying of water directly from the Green River to the City of Tacoma, or other customers, users or Second Supply Project participants.

1.30. "State Instream Flows" shall mean those instream flows required by the State of Washington as a condition of TPU's water right for the Second Diversion issued in 1986.

1.31. "Tacoma Diversion" shall mean the diversion of water from the Green River by TPU under its first and second diversion water rights.

1.32. "TPU" shall be defined as stated in Recital B to this Agreement.

1.33. "Tribal Hunt" shall mean the annual exclusive hunt in the Controlled Area conducted by MIT under Section 6.3 of this Agreement.

1.34. "Upper Watershed of the Green River" shall mean that portion of the Green/Duwamish River System generally located upstream of the Headworks as shown on the map attached as Exhibit B.

1.35. "USFS" shall mean the United States Forest Service or its successor agency.

1.36. "WDNR" shall mean the Washington State Department of Natural Resources or its successor agency.

1.37. "WDOE" shall mean the Washington State Department of Ecology or its successor agency.

1.38. "WDOH" shall mean the Washington State Department of Health or its successor agency.

1.39. "WDFW" shall mean the Washington State Department of Fish and Wildlife or its successor agency or agencies.

1.40. "Wet Year" shall mean when Howard Hanson Dam reservoir conditions correspond to Zone 1 as described and used in Exhibit A to this Agreement.

1.41. "Wet to Average Year" shall mean when Howard Hanson Dam reservoir conditions correspond to Zone 2 as described and used in Exhibit A to this Agreement.

1.42. "1995 Dollars" shall mean actual dollars spent in 1995 or dollars spent in subsequent years adjusted for inflation as defined by the Consumer Price Index, All Urban Consumers (CPI-U), U.S. City Average Index, All Items 1982-84= 100, with changes for 1996 being defined as the value for June 1996 divided by 152.5 (the value for June of 1995), as published by the United States Department of Labor, Bureau of Labor Statistics. Subsequent years expenditures shall be adjusted accordingly.

SECTION 2. INSTREAM FLOWS

2.1. Guaranteed Minimum Instream Flow Levels That Vary With Annual Conditions

TPU shall provide the following guaranteed minimum continuous instream flows, which will vary with weather conditions during the summer months, in the Green River as measured at the Auburn Gage. For Wet Years the minimum continuous instream flow shall be 350 cfs. For Wet to Average Years the minimum continuous instream flow shall be 300 cfs. For Average to Dry Years the minimum continuous instream flow shall be 250 cfs. For Drought Years, the minimum continuous instream flow shall range from 250 to 225 cfs, depending on the severity of the drought. Before any decision to drop instream flows from 250 cfs to 225 cfs (as measured at the Auburn Gage), consultation among the Resource Agencies, MIT, the Corps of Engineers, and TPU shall explore alternatives to lowering the minimum continuous instream flow, and TPU shall comply with the requirements of Section 2.6 of this Agreement.

2.2. Instream Flow Levels for Second Diversion

TPU shall meet the continuous instream flow requirements identified in Sections 2.2.1 and 2.2.2 whenever it is withdrawing water from the Green River with its Second Diversion. TPU shall meet both sets of instream flow requirements before it can withdraw any water with its Second Diversion. To the extent that these instream flow requirements are greater than the State Instream Flows, these instream flow requirements control.

2.2.1. Instream Flow Requirements for Palmer Gage

TPU shall meet the following continuous instream flow requirements, as measured at the Palmer Gage, as a condition of withdrawing water from the Green River with its Second Diversion. From July 15 to September 15 of each year the continuous instream flow level shall be 200 cfs. From September 16 to October 31 of each year the continuous instream flow level shall be 300 cfs. For all other days of the year (November 1 to July 14), the continuous instream flow level shall be 300 cfs, which is the same as the State Instream Flows for those days.

2.2.2. Instream Flow Requirements for Auburn Gage

In addition to the instream flow requirements of Section 2.2.1, from July 15 to September 15 of each year, TPU shall meet the continuous instream flow requirement of 400 cfs, as measured at the Auburn Gage, as a condition of withdrawing water from the Green River with its Second Diversion. TPU specifically understands that if instream flows at the Auburn Gage fall below 400 cfs during the referenced period, the Second Diversion may not be used even if the instream flow requirements in Section 2.2.1 are being met.

2.3. Artificial Recharge

TPU intends to store an additional 6000 acre-feet of water, to be withdrawn from the Green River, in the aquifers in the South Tacoma Well Field or in other locations. This water will then be pumped back out into TPU's supply system during the summer to help offset the summer peak water needs of its customers.

2.4. Groundwater

TPU is investigating the availability of groundwater in the Tacoma Tideflats area. The goal is to develop an additional pumping capacity of 10 million gallons per day ("mgd") and a maximum of 6000 acre-feet of water per year to also offset the summer peak needs of its customers.

2.5. Operational Modifications and Surcharge Storage at Howard Hanson Dam

The Corps of Engineers operates Howard Hanson Dam for flood control and fish conservation. MIT and TPU desire to have the operations of Howard Hanson Dam modified to further the purposes of this Agreement. The parties acknowledge that modifications in the operations of Howard Hanson Dam, as proposed in this Section 2.5., require the cooperation of the Corps of Engineers to accomplish the intended results.

2.5.1. Modifications to Summer Operations

The operation of Howard Hanson Dam for fish conservation is designed to protect against a drought that has a probability of occurrence of one in fifty years. While maintaining that standard, the parties agree that the operations should be modified during the summer to provide additional flows in the Green River for fish. The volume of water that the parties propose for the Corps of Engineers to release during the summer would be greater than what the Corps of Engineers releases under existing Corps of Engineers operating protocols for Howard Hanson Dam. TPU agrees that if the Corps of Engineers modifies existing operations of Howard Hanson Dam to release more water during the summer months and fall precipitation does not occur in sufficient quantities to meet the instream flow requirements of Section 2.1., TPU shall restrict its withdrawals of water from the Green River by its First Diversion to allow the Corps of Engineers to recoup water required to maintain its federally mandated minimum instream flows. TPU may rely on its new well capacity to meet its demand requirements during the period it restricts its Green River withdrawals.

2.5.2. Surcharge Storage

TPU and MIT will also propose that the Corps of Engineers alter the operation of Howard Hanson Dam in a second way to store up to an extra 5000 acre-feet of water during Drought Years in the Howard Hanson Dam reservoir above the present storage of 25,000 acre feet, which the Corps of Engineers stores for release during the summer and fall for fish conservation purposes. Based on historical weather patterns, Drought Years are anticipated to occur with an annual frequency of approximately one in five years. In Drought Years, the reservoir in the summer months would be filled with an extra 5000 acre-feet of water for use in augmenting fisheries instream flows in the summer. A decision to store 5000 acre/feet of surcharge storage, will be recognition of a drought condition, and will establish the instream flow at 250 cfs as measured at the Auburn Gage, pursuant to Section 2.1. Up to 50% of the extra storage may be used in spring, summer, or fall by the Resource Agencies and MIT at their discretion as determined by formal agency coordination. Exercise of such discretion by the Resource Agencies and MIT in the spring and early summer may limit TPU's ability to support instream flow levels under Section 2.1. later in the year. TPU's ability to fulfill its obligations under Section 2.1. in Drought Years are dependent upon use of at least 2500 acre/feet of the surcharge storage.

2.5.3. Use of Surcharge Storage by TPU

Following a Drought Year when TPU has relied to a greater degree upon its groundwater system, the level of water stored in the aquifers used by TPU is often not returned to its maximum capacity by June 1, and TPU's groundwater system starts the peak demand season below optimal conditions. With the potential increased reliance upon TPU's groundwater system in certain years under this Agreement, that condition will worsen with the increased stress placed on the groundwater system in Drought Years. To counteract this condition and in an attempt to return the groundwater system back to full conditions as soon as possible following a Drought Year, in the years that the aquifer is below capacity as a result of its use during a Drought Year, TPU may use up to 5000 acre-feet of surcharge storage behind Howard Hanson Dam in non-Drought Years to provide additional water to recharge the aquifers for its groundwater system.

2.5.4. Continuing Applicability of Instream Flow Requirements

If TPU proceeds with the Second Supply Project, and if the Corps of Engineers does not make the operational changes identified in Sections 2.5.1. and 2.5.2., the instream flow requirements in Section 2.2 concerning the Second Diversion shall still apply, and the instream flow requirements in Sections 2.1 and 2.6 shall also still apply. However, TPU may determine that the Second Supply Project is not feasible, unless TPU can find a feasible alternate source of 5000 acre feet of water.

2.6. Water Use Curtailment by TPU

During periods when reservoir inflow and reservoir storage at Howard Hanson Dam are not sufficient to maintain minimum instream flows above 250 cfs at the Auburn Gage, TPU will have the option to maintain a minimum drought flow of 225 cfs whenever use of TPU's First Diversion is beginning to be partially curtailed. Thirty days prior to requesting that the instream flows required pursuant to Section 2.1. be reduced from 250 cfs to 225 cfs, TPU shall convene a drought coordination meeting with the Resource Agencies and MIT to fully explore all alternatives that will allow maintaining a 250 cfs minimum instream flow. Before lowering instream flows to 225 cfs, TPU shall, at a minimum, institute water use restrictions consistent with TPU's water use curtailment plan.

2.7. Real-time Monitoring of Steelhead Spawning and Incubation

WDFW currently monitors steelhead spawning and incubation on the Green/Duwamish River System for fisheries management purposes. MIT and TPU shall jointly develop an additional monitoring program for the steelhead spawning and incubation season, which is from April through July each year. The purpose of this program will be to assure that the Second Supply Project does not adversely affect established steelhead redds beyond the pre-Second Supply Project instream flow conditions. TPU shall fund MIT and the WDFW for the cost of this additional monitoring program, and the total estimated annual cost in 1995 Dollars is ten thousand dollars ($10,000) per year. The goal of the program will be to record the location of the steelhead redds and provide that information to MIT, Resource Agencies and TPU on a real-time basis. In the event that MIT, TPU and the Resource Agencies determine that the Second Supply Project operations are adversely affecting incubation conditions beyond those that already exist without the operation of the Second Supply Project, a timely consultation process with TPU, MIT and the Resource Agencies will be initiated to develop a response to those conditions.

2.8. Ongoing Commitment to Instream Flow Coordination

2.8.1. TPU and MIT commit to continuing the established practice of coordination of Green River flow management decisions with the Resource Agencies and the Corps of Engineers, before and during droughts, Howard Hanson Dam reservoir refill, or other management or natural events that may adversely affect Green River instream flows. TPU and MIT will develop a consultation process, pursuant to Section 9, to address instream flow issues, steelhead redd monitoring, and future diversions.

2.8.2. MIT will support TPU's request to WDOE and WDFW to clarify that the above instream flow requirements for the Second Diversion exceed and thereby encompass the 750 cfs reserved by WDFW under a separate prior agreement with TPU that was to be used annually at WDFW's discretion to support fish passage and spawning.

2.9. Future Diversions

2.9.1. TPU shall not pursue any further diversion of Green/Duwamish River System water from May through October of any year before the completion, if approved, of the Howard Hanson Dam Additional Storage Project. If the Howard Hanson Dam Additional Storage Project is approved, TPU may apply for a storage right for water stored at Howard Hanson Dam reservoir as a result of the Howard Hanson Dam Additional Storage Project, as well as a diversion right to make use of that additional stored water.

2.9.2. TPU does not anticipate, but may in the future, apply for a diversion of additional water from the Green River to occur between the months of November and April in future years. TPU shall consult with MIT, according to the consultation process contained in Section 9., before submitting a water right application to WDOE to assure any fishery impacts are properly addressed.

2.9.3. Development of any water rights in the Green/Duwamish River System by TPU in addition to the First and Second Diversion water right shall be subject to the continuous instream flow requirements of this Agreement.

2.10. Verification and Monitoring of Instream Flows, Water Supply and Water System Demand

Before the commencement of Second Supply Project Operation, TPU shall be responsible for insuring that MIT has access to United States Geological Service streamflow data, or any successor equivalent data source, for the purpose of monitoring and verifying instream flow levels at the Palmer Gage and the Auburn Gage on a current, instantaneous basis, as well as access to information regarding discharge levels and reservoir elevations at Howard Hanson Dam. TPU will make access to such data and information available at the FRF and at an MIT office location, identified by MIT, using current communications technology, which will be updated as mutually agreed upon as such technology changes. Upon request of MIT, TPU shall provide timely system water supply information, including well and municipal reservoir levels and system water demand information.

SECTION 3. FISHERIES RESTORATION AND ENHANCEMENT

3.1. Fisheries Restoration Facility (FRF)

MIT owns and operates the Keta Creek fish facility on the Green/Duwamish River System. MIT desires to further its goals of Green River fisheries restoration and enhancement through the ownership and operation of an additional, more comprehensive, fisheries facility on the Green/Duwamish River System. TPU supports the restoration and enhancement of the Green/Duwamish River System fisheries, and will help MIT in achieving its goal of a Fisheries Restoration Facility (FRF) on the Green/Duwamish River System through the means set forth below.

3.1.1. Development and Construction of the FRF

3.1.1.1. Payment of Development and Construction Costs of FRF

TPU shall pay up to eight million-five-hundred thousand dollars ($8,500,000), in 1995 Dollars, for the development of the FRF to be owned by MIT. These funds shall cover the costs of development of the FRF. Those costs include the design, engineering, environmental analyses, permitting (except water rights permitting and development as set forth in Sections 3.1.1.4., 3.1.1.5. and 3.1.1.6), site work, construction, construction management, fish release site developments, capital equipment, and contingency at fifteen percent (15%).

3.1.1.2. Design of FRF

TPU shall contract with a design engineering firm, subject to MIT's approval, to design and engineer the FRF in consultation with MIT, following the basic conceptual elements contained in Fish Pro, Inc.'s August 7, 1995, proposal for a tribal fisheries restoration facility on the upper Green River. The conceptual plan is attached as Exhibit C to this Agreement. The line item dollar figures in Exhibit C are estimates only, and the parties are not bound, in any manner, by the various line item cost estimates contained within Exhibit C, subject to the total cost as described in Section 3.1.1.1.

3.1.1.3. Construction of FRF

TPU shall be responsible for the permitting and construction of the FRF in consultation with MIT. Although the details of how to proceed with the permitting and construction processes have not been finalized, it is expected TPU will proceed with a competitive selection process and contract with a construction contractor, to be mutually agreed upon, and that TPU shall be responsible for construction management. TPU reserves the right to reject any and all bids, and, if necessary, modify the FRF to meet the development costs limitations specified in Section 3.1.1.1., or to negotiate adjustments to the selected bid proposal. Any such modifications or adjustments shall be subject to MIT approval. If the parties agree, MIT may, as owner, contract with the selected construction contractor, if it will benefit the development of the FRF, however, TPU shall still be responsible for construction management, including the processing and approval of all requests for payment under the contract. MIT and TPU shall consult, review and approve, as necessary, during each phase of design review, permitting, and construction pursuant to Section 9. MIT and TPU shall review and approve any proposed changes to the design of the FRF. TPU shall pay for any cost overruns associated with the development and construction of the FRF. Any cost savings realized by TPU in the construction of the FRF shall be used first, to offset any costs that exceed TPU's estimated costs (such estimates to be reviewed by MIT) in the permitting, development and conveyance of water to the FRF site under Sections 3.1.1.4., 3.1.1.5. and 3.1.1.6., and, second, for mutually agreed upon improvements to the FRF.

3.1.1.4. FRF Groundwater Facilities

TPU shall, at its own cost, and not as part of the funds identified in Section 3.1.1.1, provide the necessary wells, well houses, and pumping facilities to deliver 2 cfs of groundwater to the operations center area of the FRF as further provided in Section 3.1.3.1.

3.1.1.5. FRF Water Conveyance Facilities

If water rights can be obtained for the FRF, TPU shall at its own cost, and not as part of the funds identified in Section 3.1.1.1, provide surface and groundwater conveyances to the FRF via gravity fed pipe or pumps. The water conveyance facilities shall be designed for expansion to 35 cfs in the future.

3.1.1.6. Costs of Development and Conveyance of Water to FRF

TPU shall pay all the costs associated with obtaining the permits for FRF water rights, and developing and conveying the ground and surface water, and such costs shall not be charged against the funds for the FRF identified in Section 3.1.1.1.

3.1.1.7. Fish Ladder and Trap and Haul Facilities at Headworks

All costs involved in the fish ladder and trap and haul facilities proposed for the Headworks are not to be charged against the funds for the FRF identified in Section 3.1.1.1, but shall be funded and paid for separately by TPU. TPU shall design and construct the trap and haul facilities consistent with the recommendations agreed upon among the Resource Agencies, MIT and TPU. TPU shall be responsible for all operations, maintenance and other costs of the fish ladder and trap and haul facilities at the Headworks.

3.1.2. Land for FRF

3.1.2.1. Transfer of Land for FRF

TPU shall convey to MIT, or to the United States in trust for MIT if so requested by MIT, eleven (11) acres of property adjacent to the Green River and westerly of the TPU Water Control Station suitable for constructing a fisheries restoration facility as shown on Exhibit D of this Agreement. TPU shall also convey to MIT the floodway property between the Green River and the FRF.

3.1.2.2. Transfer of Land for FRF Expansion

TPU shall convey to MIT, or to the United States in trust for MIT if so requested by MIT, an additional two (2) acres of property adjacent to the property identified in Section 3.1.2.1. in the year 2007 suitable for future expansion of the FRF, should MIT deem it necessary.

3.1.2.3. Change in Use of Land

The intended use of the property identified in Sections 3.1.2.1. and 3.1.2.2. is to construct and expand the FRF. Any future proposed changes in use or new uses of this property shall be compatible with TPU's desire to protect the Upper Watershed of the Green River and protect TPU's ability to construct a water filtration facility in the future should such facility be necessary. MIT and TPU will jointly determine any future proposed changes in use or new uses of this property.

3.1.2.4. TPU's Right of First Refusal to Repurchase Land

After the FRF is completed, if MIT elects to cease operations at the FRF, and decides to sell the property identified in Sections 3.1.2.1 and 3.1.2.2. along with the FRF, TPU shall have the right of first refusal to purchase this property at fair market value. If the FRF facilities are not permitted and constructed, and MIT and TPU mutually determine that permitting and construction of the FRF, or its water supply, are not feasible pursuant to Section 3.1.7 below, TPU shall convey to MIT property that is of equal acreage from the TPU lands in the Limited Control Area in lieu of the property identified above.

3.1.3. FRF Water Supply

3.1.3.1. Groundwater

TPU shall provide to MIT, at TPU's own cost, and not as part of the funds identified in Section 3.1.1.1, up to 2 cfs of groundwater, if available, for incubation purposes at the FRF. If 2 cfs are not fully available, then TPU shall provide the remaining quantity from surface water and, if required, the facilities to treat the surface water to water quality standards sufficient for fisheries incubation needs..

3.1.3.2. Surface Water

TPU shall assist and support MIT in acquiring a 25 cfs surface water right from the Green River via a gravity pipeline and river pumping. TPU shall pay all costs associated with obtaining the water right pursuant to Section 3.1.1.6.

3.1.3.3. Surface Water for FRF Expansion

TPU shall assist and support MIT in acquiring an additional 10 cfs surface water right for future expansion of the FRF. TPU shall pay all costs associated with obtaining the water right pursuant to Section 3.1.1.6.

3.1.3.4. Determination of Use of Gravity Flow v. Pumping of Surface Water

When instream flows at the Palmer Gage are greater than the instream flows required by the State Instream Flows plus the flow required by the FRF, then the FRF water will be diverted at the Tacoma Diversion and will flow by gravity to the FRF. When instream flows at the Palmer Gage are less than State Instream Flows plus the amount of water required by the FRF, water will be pumped to the FRF from the Green River at the FRF site. TPU and MIT will jointly determine when to use the river pump to avoid impacts on spawning and incubation of any anadromous fish species in the Bypass Reach.

3.1.4. Operations and Maintenance of FRF

3.1.4.1. Payment of O&M by TPU

TPU shall pay MIT for O&M of the FRF, for the life of the FRF, commencing at the beginning of operation of the FRF. Commencement of the operation of the FRF shall mean that point at which the contractor has completed all performance tests on the FRF and TPU has accepted the FRF for operation. TPU shall make O&M payments to MIT in four equal installments to be paid at the beginning of each quarter of each year.

3.1.4.2. Amount of O&M

For the first year of operation, as defined in Section 3.1.4.1., TPU shall pay MIT for O&M of the FRF three hundred and fifty thousand dollars ($350,000) ("O&M Base Amount"). From the second year forward, the O&M Base Amount shall be subject to annual adjustment in accordance with the Consumer Price Index, All Urban Consumers (CPI-U), U.S. City Average Index as published by the United States Department of Labor, Bureau of Labor Statistics, or an equivalent successor index, for the life of the FRF. (See "1995 Dollars" definition in Section 1.42. For calculation of the index) Indirect Costs shall be calculated on the O&M Base Amount as adjusted annually in accordance with the CPI-U.

3.1.4.3. Power Costs of FRF

TPU shall pay all power costs for the FRF, which shall be paid directly to the supplier based on the actual bills for the FRF. FRF power costs shall not be included in the O&M Base Amount.

3.1.4.4. Use of Unused O&M

Any O&M Base Amount, as adjusted annually, plus Indirect Costs, not used by MIT in a calendar year for the FRF may be used by MIT for fisheries enhancement or be carried forward to the next year.

3.1.4.5. Annual Activities Report

MIT will provide an activity report (which includes financial accounting for O& M) concerning FRF operations to TPU by April 1 of each year for the life of the FRF.

3.1.5. Capital Repair and Replacement Fund

TPU, through the Tacoma City Treasurer, shall establish a Capital Repair and Replacement Fund in trust for MIT, and pay into that fund forty-five thousand dollars ($45,000) per year for 10 years to be used solely for long term renewal and/or replacement of FRF equipment or capital repairs to the FRF. TPU shall make the initial payment into the Capital Repair and Replacement Fund at the end of the first year the FRF is operational, as defined in Section 3.1.4.1. A budget for expenditures from the Capital Repair and Replacement Fund shall be determined by MIT and provided annually to TPU for review and comment. TPU shall pay MIT from the Capital Repair and Replacement Fund for items contained in the annual budget upon request from MIT. In the event of an emergency capital repair or replacement, MIT may make a request to TPU for an emergency payment from the Capital Repair and Replacement Fund. Interest accruing on the Capital Repair and Replacement Fund shall be reinvested into the Capital Repair and Replacement Fund.

3.1.6. Monitoring and Evaluation and Interim Measures

TPU shall fund monitoring and evaluation of the FRF to provide a basis for long-term watershed restoration projects. MIT and TPU will work together to develop a scope for the monitoring and evaluation program and shall develop a budget for the program. MIT and TPU may mutually agree to implement interim measures for fisheries enhancement prior to the completion and operation of the FRF. The total cost of monitoring and evaluation and interim measures shall not exceed six hundred and seventy-five thousand dollars ($675,000).

3.1.7. Contingency for FRF

MIT and TPU presently intend to proceed with the FRF, however, in the event that MIT and TPU mutually determine that permitting and construction of the FRF, or its water supply, are not feasible any time within five years of the effective date of this Agreement, then MIT shall elect one of the alternatives identified in Sections 3.1.7.1 or 3.1.7.2. below in lieu of constructing the FRF. This contingency, if chosen by MIT and TPU, only applies to those funds identified in Sections 3.1.1.1., 3.1.4. and 3.1.5. that TPU would have paid if the FRF were built, and does not affect any other obligations, financial or otherwise, of TPU under this Agreement. MIT will make its decision regarding which alternative it will select within thirty (30) days of the mutual determination not to proceed with the FRF.

3.1.7.1. Alternative A.

Within 120 days of MIT's decision to choose this alternative, TPU shall pay MIT a total of twelve million dollars ($12,000,000), in 1995 Dollars, in a lump sum into the Fisheries Trust Fund to be used for fisheries enhancement on the Green/Duwamish River System. In the event that MIT elects this alternative, TPU and MIT shall develop a joint consultation process, pursuant to Section 9, to decide the use of the funds for programs for the Green/Duwamish River System for purposes of fisheries enhancement.

3.1.7.2. Alternative B.

Within 120 days of MIT's decision to choose this alternative, TPU shall pay to MIT any and all unused funds from the funds identified in Section 3.1.1.1. in a lump sum into the Fisheries Trust Fund to be used for fisheries enhancement on the Green/Duwamish River System. TPU and MIT shall develop a joint consultation process, pursuant to Section 9, to decide the use of the funds for fisheries enhancement programs. TPU may deduct actual expenditures incurred after the effective date of this Agreement, i.e., design, permitting and construction costs (excluding costs identified in Sections 3.1.1.4., 3.1.1.5., 3.1.1.6. and 3.1.1.7) from the lump sum payment. In addition, TPU shall make annual payments to MIT, or to other entities at MIT's direction, limited to the actual operating budgets of the alternative fisheries production facilities or enhancement options, up to the O&M Base Amount, adjusted annually in accordance with Section 3.1.4.2., identified for the FRF in Section 3.1.4, for the life of said facilities or options. Indirect Costs shall be paid by TPU to MIT for payments made directly to MIT. The annual payments shall be made commencing with the operation of those alternative fish production facilities or enhancement options. The Capital Repair and Replacement Fund shall be established and managed pursuant to Section 3.1.5., but the use of such funds shall be to provide for capital repairs and replacement at the alternative fish facilities.

3.2. Interim Support

3.2.1. Interim Biologist

Upon TPU's receipt of Construction Financing for the Second Supply Project, TPU shall pay sixty-five thousand dollars ($65,000) per year plus Indirect Costs each year to support an interim project biologist to assist MIT with FRF design, consultation and permitting, until FRF O&M funds are initiated, or MIT and TPU mutually determine that permitting and construction of the FRF or its water supply are not feasible pursuant to Section 3.1.7.

3.2.2. Keta Creek Operations

TPU shall pay MIT up to one hundred and twenty-five thousand dollars ($125,000) per year plus Indirect Costs for Keta Creek Fish Facility operations. The exact amount of each year's payment will be based upon the pro rata share of fish actually planted in the Upper Watershed of the Green River. TPU shall make such payments until the FRF is operational, or MIT and TPU mutually determine that permitting and construction of the FRF or its water supply are not feasible pursuant to Section 3.1.7.

3.3. Fisheries Trust Fund

3.3.1. Establishment of Fisheries Trust Fund

MIT shall establish a Fisheries Trust Fund to be used to enhance and restore fish runs and habitat of the Green/Duwamish River System before receiving any funds under this Agreement earmarked for a Fisheries Trust Fund.

3.3.2. Lump Sum Payment by TPU into Fisheries Trust Fund

TPU shall pay MIT a lump sum payment of six million dollars ($6,000,000) to MIT in April 2007 into the Fisheries Trust Fund to assist with future expansion or adjustments in the FRF. In the event MIT decides in the future that expansion of the FRF is not feasible, or MIT decides that funds should be used for other purposes, or MIT and TPU mutually determine that permitting and construction of the FRF or its water supply are not feasible pursuant to Section 3.1.7., then MIT may, at its discretion, transfer the six million dollar ($6,000,000) payment to the General Trust Fund.

SECTION 4. TRANSFER OF REAL PROPERTY

4.1. Real Property for FRF

Upon TPU's receipt of Construction Financing for the Second Supply Project, TPU shall convey to MIT, or to the United States in trust for MIT if so requested by MIT, the property described in Section 3.1.2.

4.2. Upper Watershed of the Green River

Upon TPU's receipt of Construction Financing for the Second Supply Project, TPU shall convey to MIT, or to the United States in trust for MIT if so requested by MIT, forty (40) acres of property, including timber, from property it owns in the Upper Watershed of the Green River located in the Limited Control Area as generally shown on Exhibit E. TPU shall provide a water supply to the property sufficient for the equivalent of service to a typical residence. Conditions of land use and access shall assure compatibility with TPU's water quality protection program as identified and incorporated in the deed.

4.3. Lake Kapowsin

Upon TPU's receipt of Construction Financing for the Second Supply Project, TPU shall convey to MIT, or to the United States in trust for MIT if so requested by MIT, twelve (12) acres of property it owns on an island in Lake Kapowsin including standing timber as described and shown on Exhibit F, thirty (30) acres of property it owns in the old town site along Lake Kapowsin as described and shown on Exhibit G, and the thirteen (13) acre former resort site it owns along the southwest shore of the Lake Kapowsin as described and shown on Exhibit H. Prior to conveyance of the properties at Lake Kapowsin, TPU agrees that MIT may use the properties, provided however, that MIT may not construct any permanent improvements on the properties until the conveyance process is completed. During this interim use period, MIT agrees to indemnify and hold harmless TPU, subject to Section 11.4, from any claims, litigation or judgments for

APPENDIX C
Tacoma Public Utilities
Water Conservation Planning

Contributors to this Appendix include:
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Ninety percent of Tacoma Water's (Tacoma) municipal water supply originates from the Green River. The survival of salmon, steelhead and trout populations that spawn and rear in the Green River depends, in part, on how well Tacoma Water is able to balance its dual responsibilities to provide pure drinking water to its customers while protecting fisheries habitat and promoting a healthy river ecosystem. The less water people use, the more water is available for fish in the Green River. Conservation is especially important in the summer when river flows are at their lowest and water use is at its highest.

Tacoma has long encouraged customers to use water efficiently, but increased its focus on conservation during the summer of 1987 when a drought in the Puget Sound Region drastically reduced river flows in the Green River. The late summer drought that year made it difficult for adult chinook salmon to swim upstream to spawn. To facilitate the salmon's upstream migration, Tacoma reduced the amount of water it withdrew from the river and instituted voluntary and mandatory water use restrictions. Today, as the federal government prepares to list Puget Sound chinook salmon as threatened under the Endangered Species Act, Tacoma continues to invest considerable resources to educate its customers about the importance of conserving water.

Tacoma's conservation efforts have achieved significant success since they began just over a decade ago. Total average daily consumption is down 15 percent, from 73 million gallons in 1989 to about 62 million gallons in 1998. During this same period, the number of customers increased 10 percent, from 74,252 to 82,737.

Tacoma today provides about 62 million gallons of water a day to nearly 83,000 customers (about 250,000 people) in Tacoma and Pierce and South King counties. In 1998, Tacoma's customer statistics looked like:

Type of Customer	Number of Customers	Water Use (Million Gallons)	Percent of Total Use
Residential	77,370	8,903	39%
Commercial/Industrial (including Simpson Kraft)	4,880	11,410	51%
Government	475	709	3%
Wholesale	12	1,591	7%

Commercial/industrial customers use most of Tacoma's water supply. One customer, the Simpson Tacoma Kraft Company used 7,387 million gallons, or 33 percent of the total supply.

In planning for new water resources to meet ever-increasing demand, Tacoma Water considers water made available through conservation from its existing supplies as an additional water source. Consequently, it is cost effective for the utility to encourage its customers to use less of its product (an unusual approach to running a business in today's market-driven economy) because the cost to develop new surface and groundwater supplies is very expensive both economically and environmentally.

Tacoma began its conservation efforts within its own system. All water utilities, but particularly older ones, experience leaks from their distribution pipelines. Tacoma has been operating since the late 1800s, and at one time had a problem with water leaking from its distribution system. Several years ago, the utility implemented a leak-detection program to locate and repair leaky distribution lines. Today, Tacoma has an ongoing distribution system maintenance program, regularly checks its water meters for leakage and accuracy, and rehabilitates its storage reservoirs in the interest of conserving water. As a result, Tacoma has been able to reduce its unaccounted-for water (water lost between the treatment facilities and customer meters) from more than 13 percent in 1988 to less than 10 percent today, far less than the industry target of 15 percent.

Demand for water varies by the type of user and time of year. Residential customers' use is fairly low and stable from November through April, but increases as summer approaches, peaking in August, the driest month of the year. The reason for this is an increase in residential outdoor water use, the vast majority of which is used to water lawns and landscapes. Commercial/industrial customers' use increases in the summer, but at a more gradual rate, and with a smaller peak in August or September.

Tacoma's primary conservation strategy is to reduce peak summer demand, and ultimately to ensure the most efficient use of water by all customers. Tacoma has worked with its largest customer, the Simpson Tacoma Kraft Company, to dramatically reduce its consumption during the past decade from an average of 32.1 million gallons per day in 1989 to 20.2 million gallons per day in 1998. Simpson achieved this reduction by recycling cooling and heating water, replacing fresh water used for cooling with salt water, and replacing old and/or leaky pumps and machinery with new water-efficient equipment. Because the Simpson mill is located near the City of Tacoma's sewer treatment plant, Tacoma and the Simpson company studied the feasibility of reusing wastewater from the sewer plant in its manufacturing process. Although the reuse of this resource is not considered cost effective at this time, it remains an option for the future at the Simpson mill.

Tacoma is also working with other major industries in its service area to reduce their water use because of the potential these customers offer for significant, cost-effective water savings. Tacoma began offering in-depth water use audits to its largest industrial customers in 1999.

Since 1992, Tacoma's wholesale and residential water rates have been structured to emphasize the need to conserve water particularly during the dry season of the year. From June through September, wholesale and residential customers pay an additional 25 percent for the water they consume. Both residential and commercial customers have an additional incentive to conserve because of increasing sewer rates. Sewer bills are based on winter water use. The average residential Tacoma customer now uses roughly 116 gallons per person per day, down 7 percent from 125 gallons per person per day in 1989.

Tacoma has an adequate supply of water today to meet the needs of new customers, but future consumption is expected to exceed available summer water supplies, even with aggressive water conservation and curtailment programs, unless new resources are developed. The Washington State legislature, through RCW 90.54.180, has directed that "increased water use efficiency should receive consideration as a potential source of water in state and local water resource planning processes." Consistent with this directive, Tacoma Water updated its water conservation plan in 1991 and implemented a variety of measures to enhance wise use of water resources. Tacoma's water conservation plan must comply with 1994 Department of Health conservation planning requirements. The Department of Health considers the reduction in per capita average day residential demand relative to a 1991 baseline as one of three factors when determining acceptable implementation of conservation programs. Tacoma's method for selecting water conservation activities was refined in 1997 with a conservation assessment program to assure that existing and future conservation programs are cost effective, practical to implement, and appropriate for the utility's customers.

Following is an excerpt from Tacoma's 1998 Draft Comprehensive Water Plan Update that describes options to reduce water demand through conservation. Tacoma is required to update the plan every five years. In addition to quantifying the progress made toward reducing water demand, the plan identifies potential future conservation measures for both commercial and residential customers.

EXCERPTS FROM THE
DRAFT COMPREHENSIVE WATER PLAN UPDATE
VOLUME 1 - December 1998

Prepared for:

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4.4 Demand-Side (Conservation) Options

4.4.1 Background

As the Puget Sound region explores ways to more efficiently use existing water resources to meet existing and growing water demands, conservation has become a standard element in every utility's repertoire of water management techniques. Water conservation plans are developed to provide a systematic and coordinated approach to conservation that will ensure the wise use of available water resources.

4.4.2 Conservation Requirements

In the 1980s, a growing awareness of the limited resources in the state led the Washington State legislature to pass the Water Use Efficiency Act (Chapter 43.70.230 RCW), which directed the Department of Health (DOH) to develop procedures and guidelines relating to water use efficiency. In addition, per RCW 90.54.180: "increased water use efficiency should receive consideration as a potential source of water in state and local water resource planning processes."

In 1994, the Washington Water Utilities Council (WWUC), DOH, and the Washington State Department of Ecology (Ecology) co-authored a document entitled *Conservation Planning Requirements, Guidelines and Requirements for Public Water Systems Regarding Water Use Reporting, Demand Forecasting Methodology, and Conservation Programs* (Conservation Planning Requirements) (WWUC et al., 1994). The Conservation Planning Requirements document outlines the basic requirements of conservation plans that must be included as an integral component of a utility's comprehensive water plan.

DOH requires that a water conservation checklist be completed and included with each Comprehensive Water Plan submitted for approval. A copy of the Water Conservation Planning Requirements Checklist can be found in Appendix D.

In 1992, the state of Washington issued amendments to the 1991 Edition of the Uniform Building Code. Water efficiency requirements for plumbing fixtures installed in all new and remodeled buildings were adopted (RCW 19.27.170) in two phases, both of which have since become effective.

In the Pierce County Coordinated Water System Plan (CWSP), the County incorporated the requirements and recommendations of the state Conservation Planning Requirements (WC Policy 1). The *1994 Pierce County Comprehensive Plan* also includes three related conservation objectives:

- "Conserve resources to save money and to promote reliability of existing supply, consistent with the serving utility's public service obligations." (UT-Gen Objective 4)

- "Protect the environment while providing for utility facilities." (UT-Gen Objective 6)

- "Support water conservation measures and educate Pierce County residents on methods to conserve water." (UT-Wa Objective 23)

While the majority of Tacoma Water's service area is located in Pierce County, a portion of the northern service area is within King County; therefore, Tacoma Water must comply with King County conservation requirements. The 1989 *South King County Coordinated Water System Plan* (South King County CWSP) acknowledged that conservation was a management tool to be used in conjunction with the development of future water resources. The goal in the South King County CWSP Plan was to initiate implementation of a conservation program by 1992, achieve a 6.5 percent reduction by 1995, and achieve an 8 percent reduction in water usage by the year 2000. Conservation savings are to be measured with 1991 per capita consumption as the base water use.

King County has also adopted Ordinance No. 11210, which promotes water efficiency through the use of water budgeting and efficient irrigation design standards, and encourages the use of native plant species. A copy of the ordinance can be found in Appendix D.

4.4.3 Conservation Goals and Objectives

The goals of Tacoma Water's conservation program are designed to protect and preserve present and future water resources and to maintain or reduce present per capita water usage levels in all customer classes. Following are several objectives that Tacoma Water has formulated to accomplish this:

- To develop a conservation program that meets or exceeds state requirements for public systems
- To develop a conservation program that ensures the efficient use of water
- To coordinate and integrate water conservation programs with other Tacoma Water and Public Utilities programs
- To develop reuse programs for irrigation and/or industrial processing
- To achieve a consistent reduction in the peak 4-day demand

4.4.4. Past Program Activities

Since the 1980s, Tacoma Water has been committed to an effective conservation plan as an element of their overall water resource plan. The focus has been on developing long-term sustained conservation activities in a balanced program with both effective supply management and demand management measures. The conservation measures have been designed to increase customer awareness of conservation issues, provide incentives for reduced consumption, and reduce water losses within the system.

In a continuing commitment to conservation, Tacoma Water hired a Water Conservation Specialist in 1992 to implement the recommendations of the 1991 *Water Conservation Plan*. Also in 1992, the rate structure was modified to encourage water concentration in all customer classes. In 1994, both the Water Conservation Specialist and a member of the Utilities Grounds Maintenance Staff received Certified Irrigation Auditor status. Three conservation programs from 1997 and 1998 are highlighted below.

1. In 1997, Tacoma Water participated with water, wastewater, and energy purveyors throughout the northwest region in a market transformation effort involving the distribution of WashWise rebates for purchase of tumble-action washing machines. Fifty-dollar rebates were provided to 392 Tacoma Water customers who purchased qualifying high-efficiency washing machines in 1997 (94 of these were retroactive rebates to customers who made purchases from May until September prior to Tacoma Water participation in the WashWise region-wide campaign).
2. An outdoor water use survey was conducted among Tacoma Water's residential customers who use more than 200 billing units of water per year (1,628 survey recipients fit this classification), in addition to 1,165 randomly selected "average water use" customers whose annual water use was less than 200 ccf in 1997. Response rates were 68 percent and 56 percent, respectively. Recipients returning surveys received a water conservation related tool.

   Findings show that among both types of customers, there is a need to promote and teach water saving techniques that do not compromise lawn health and aesthetics. While many of the "high" water users are committed to keeping their lawns green and are disinclined to change unless the beauty of their yards is assured, they also have an intense interest in gardening and the financial means to change. On the other hand, average water users are much less committed to green lawns, and a notable number already let their lawns go dormant (brown). These customers are more willing to change but have less opportunity and means to do so.
3. The message "Know What Overwatering Your Lawn Does? . . . .Nothing" was advertised in nine issues of the News Tribune during the peak summer water use period (July and August) of 1998. Of the survey recipients noted above, 34 percent responded that they had seen or read Tacoma Water or Utilities information on saving water. Among numerous options, information seen by survey participants was predominantly found in TPU bill inserts (49.6 percent), in local media (27.1 percent), and in utility brochures and fliers (17 percent).

Table 4-5 summarizes those programs associated with Tacoma Water's conservation efforts to date.

Existing Conservation Savings

Tacoma Water has been keeping conservation-related records since 1988 to determine the effectiveness of various water saving measures. Figure 4-2 presents a summary of the water savings realized in the programs previously listed. Conservation savings have also been tabulated since 1991, which is the base year listed in the *Conservation Planning Requirements*.

Since 1991, Tacoma Water has achieved an estimated overall water savings of over 15 mgd, which represents an 18 percent decrease from their 1991 per capita base water consumption. The Simpson Tacoma Kraft mill accounted for nearly 10 mgd of these water savings based on their industrial conservation program implemented in 1992. The 1991 document, *Conservation Requirements,* does not set specific savings goals due to different implementation schedules and different levels of conservation needs of each system. However, Figure 4-2 demonstrates that Tacoma Water's existing conservation program has had a significant beneficial impact on the overall water demands on their system.

4.4.5 Evaluation of Conservation Measures

To evaluate the most effective measures to be pursued by Tacoma's Integrated Resource Plan (IRP) and, ultimately, to form the conservation program update, an extensive analysis was conducted of various conservation measures, and criteria, estimated water savings, and cost of implementation.

There were 128 conservation measures originally identified and evaluated for water saving potential and cost of implementation. After initial screening, 28 measures were selected for further evaluation. These measures generally fall within the following categories:

- Indoor/outdoor audits
- Low-flow fixtures (showerheads, faucets)
- Toilet and faucet retrofit devices (dual flush, dams, displacement bags, toilet leak detection, faucet aerators)
- Irrigation system devices
- Rebates/grants
- Miscellaneous measures

The measures were divided into four user classes: single family, multi-family, commercial/industrial, and public authorities. Table 4-6 presents the 28 conservation measures that were evaluated within each class.

Each conservation measure was evaluated based on quantitative data such as product useful life, cost per device, administration cost, installation cost, number of units per customer, average water savings (per person or as a percentage of indoor or outdoor use), and penetration and retention rates. Additional information and data derived from Tacoma Water consumption records or the 1991 *Water Conservation Plan* were also included in the analysis. These additional factors include the percentage of system losses, number of persons per single family and multifamily dwelling, the percentage of residential use by single family and multifamily customers, irrigated areas, use per account for schools and parks, and the amount of water used by the top 25 industrial customers.

Table 4-5 Tacoma's Existing Conservation Program			
Public Education	**Technical Assistance**	**System Measures**	**Incentives/Other Measures**
Program Promotion–annual bill enclosures and advertisements	Publications and Brochures– created by Tacoma or an organization in which Tacoma participates	Leak Detection and Repair Program–annual hydrant testing, ongoing leak detection, installation of cathodic protection on water mains and main replacement program	Conservation Pricing–seasonal inclining block rate structure for residential and wholesale and flat rate structure for commercial/ industrial
Program promotion–residential customer water use survey and outdoor water use assessment	Feasibility Studies–conducted both industrial water reuse studies and residential water use studies	Reservoir Maintenance–replace leaky reservoirs, inspect reservoirs annually, install leakage ret-urn pump at McMillin Reservoir	Rebates and Incentives–provide to residential and commercial/ industrial customers for such items as high-efficiency washers and process audits; consumption analysis for irrigation customers
School Outreach–elementary school theatrical group to present conservation and water quality skits	Purveyor and Customer Assistance–established landscape policy and customer advisory committee	Meters–meter all connections, regularly test source meters, commercial meter testing and replacement program	Simpson-Tacoma Kraft–voluntary industrial process water use reduction program
Speakers Bureau–speakers/slide shows for civic groups, industry organizations, homeowners associations, neighborhood groups, and youth organizations	Bills showing water consumption history		Residential Retrofit–direct install of showerhead and faucet aerators in conjunction with City Light, showerhead exchange, toilet kits
Theme Shows and Fairs–participate in homeshows such as Tacoma Home and Garden Show and Puyallup Fair; trade shows such as Washington State Plant Engineering & Maintenance Show			Landscape Management–encourage conversion of manual irrigation systems to automatic, centralized irrigation systems at Government facilities, consolidate plantings
Membership in local and state organizations to assist in delivery of targeted conservation messages			Recycle/Reuse–conducted water reuse studies for landscape irrigation and industrial application in the service area

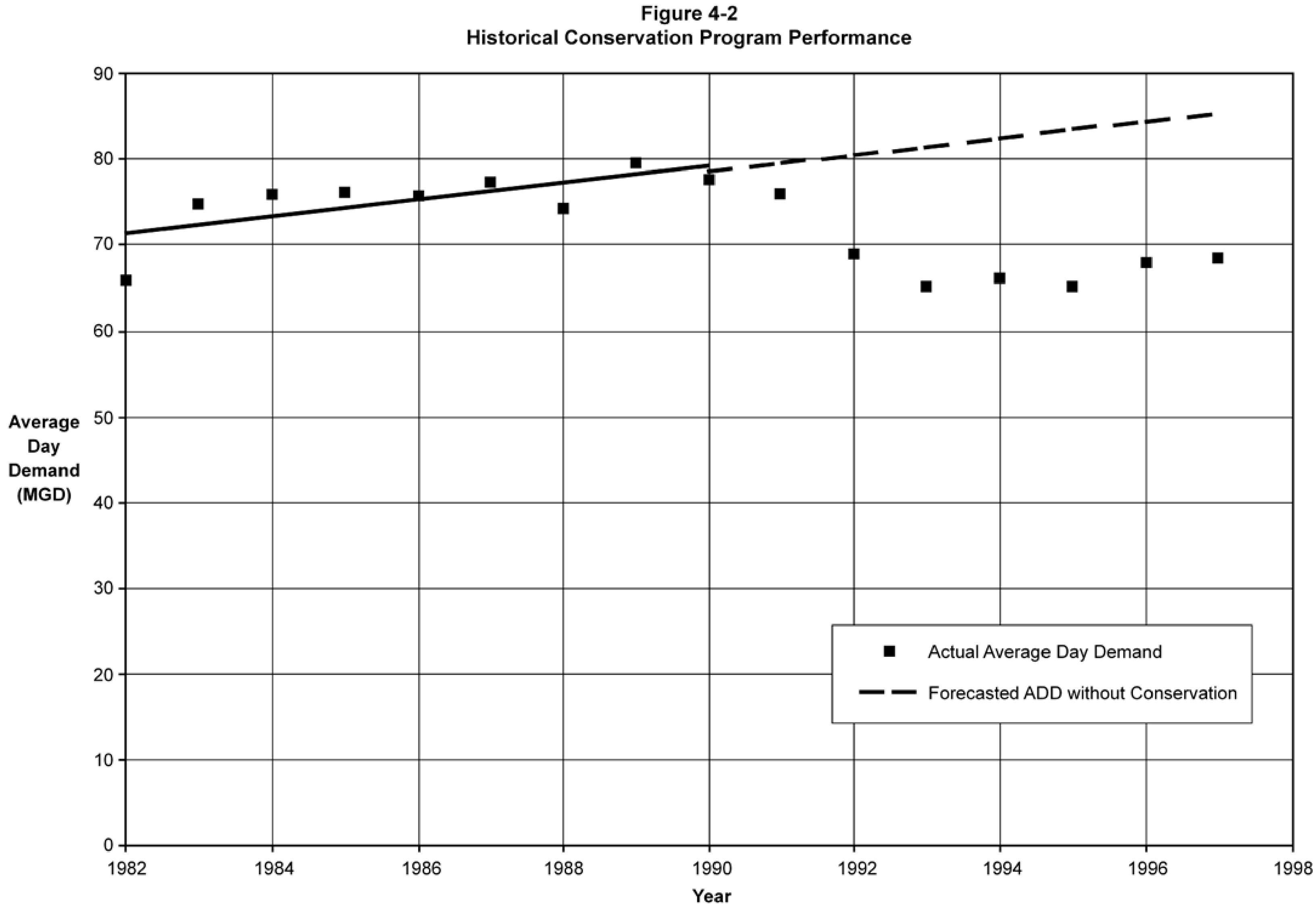


Figure 4-2
Historical Conservation Program Performance
90
80
70
60
50
40
30
20
10
0
Average
Day
Demand
(MGD)
1982
1984
1986
1988
1990
1992
1994
1996
1998
Year
Actual Average Day Demand
Forecasted ADD without Conservation

Figure 4-2

Program Savings Criteria

To perform the initial screening, the maximum potential savings available from each measure was estimated based on annual usage, summer usage, and 4-day peak usage. The maximum potential retained savings figures were adjusted to reflect device penetration and retention. The maximum savings level is used as a criteria measure to compare each measure to other measures to determine if conservation can generate sufficient demand reductions to avoid or delay the development of new supplies.

Table 4-6
Conservation Measures Evaluated

Conservation Measure	Single Family	Multi-Family	Commercial/ Industrial	Public Authorities
Indoor water audit and education	x	x	x	x
Outdoor water audit and education	x	x	x	x
Combined audit and education	x	x		
Pressure-reducing valve-retrofit	x	x		
Low-flow showerheads	x	x	x	
Low-flow faucet aerator	x	x	x	x
Electronic faucets			x	x
Dual-flush toilet devices	x	x		
Toilet dams	x	x		
Toilet-flow restrictor	x	x		
Early closure toilet devices	x	x		
Toilet displacement bags/bottles	x	x	x	
Toilet leak detection with repair	x	x	x	
Ultra-low flush toilets	x	x	x	x
Tankless hot water heater-new	x	x		
Tankless hot water heater-retrofit	x	x		
Horizontal load washing machine	x	x		
Hot water line insulation	x	x		
Self-closing hose nozzle	x	x		
Faucet timer automatic shutoff	x	x		
Irrigation system rain shutoff	x	x		
Irrigation system soil shutoff	x	x		
Irrigation soaker hoses	x	x		
Drip irrigation system	x	x		
Remote irrigation				x
Gray water system	x	x		
Building leak detection			x	
Water conservation grant incentives			x	

The cost of the various conservation devices was also assembled. A levelized cost per mgd was then computed for each measure using product life expectancy, retained water savings, cost per device, and real interest rate. The cost per mgd of water saved represents the amount of money that must be spent to achieve a 1 mgd savings. The levelized cost per mgd is a convenient method of evaluating measures of varying product life on an equivalent basis but does not imply that each measure has the potential to save 1 mgd. Most measures evaluated had a total savings potential much lower than 1 mgd. The market penetration rate was then applied to this retained savings to project the actual savings that could be realized from each measure.

Levelized Cost Ranking

Each of the various conservation measures was evaluated based on estimated water savings and costs. The measures were ranked from low to high on the basis of levelized cost in terms of average annual, summer, and 4-day peak savings and differentiated between customer class and distribution method.

Table 4-7 presents a summary of the ranked conservation measures that were selected for further consideration. Measures not selected included measures that cost more than $1 million per mgd and measures that had legal constraints. If there were two or more top-ranked measures remaining that targeted the same customer class and same category of water savings (for example, toilet dams and toilet rebates), the lowest levelized cost measure was generally selected. Typically, those measures determined to be the most cost-effective during the 4-day peak season were chosen as Program 1 because it was more desirable to reduce peak-season use rather than year-round use. The remaining measures were then grouped into similar or complimentary categories to form Program 2.

Program costs were developed for joint programs from the measures previously ranked. Table 4-7 presents the two programs with associated 4-day peak savings.

Qualitative Screening

To further develop the potential conservation measures and ensure that the conservation program was cost-effective, directly reflective of the utility's customer base, and practical to implement based on the utility's resources, Tacoma Water authorized that a Conservation Assessment be conducted (CH2M HILL, 1997). This assessment performed a second screening based on qualitative measures for the resultant conservation measures in Table 4-7, as well as four additional measures: (1) Rebate for landscape technology; (2) Multi-family irrigation audits; (3) Mobile Test and Demonstration Unit (MDTU) Program, and (4) Batelle Partnership Program.

Table 4-7 Selected Conservation Programs	
Program 1	**4-Day Peak Savings (mgd)**
Indoor industrial audit–no devices	0.73
Commercial/industrial ultra-low flush toilet rebate	0.32
Parks remote irrigation	0.04
Schools remote irrigation	0.05
Program 1 Savings	**1.14**
Program 2	
Direct mail single-family self-closing hose nozzle	0.14
Direct install public schools ultra-low flush toilets	0.14
Direct mail single-family ultra-low flush toilet rebate	0.02
Direct mail single-family horizontal load washing machine rebate	0.02
Direct install public building outdoor water audits	0.10
Direct install public schools outdoor water audits	0.05
Direct install commercial/industrial low flow showerhead	0.01
Direct install public authorities electronic faucets	0.05
Direct mail single-family faucet timer automatic shutoff	0.11
Program 2 Savings	**0.64**

Each of the conservation measures was screened using 15 qualitative criteria, ranging from customer acceptance and impacts to ease of implementation and potential for cooperative effort. From the qualitative screening exercise, the following 13 measures emerged:

- Commercial/industrial indoor water audit
- MDTU program
- Public building outdoor water use evaluation
- Public schools outdoor water use evaluation
- Multi-family irrigation audits
- Public parks outdoor water use evaluation

- Rebates for landscape technology
- Public agency rebate for landscape technology
- Commercial/industrial ultra-low flush toilet rebate
- Public schools ultra-low flush toilet rebate
- SF/MF ultra-low flush toilet rebate
- Commercial/industrial low-flow showerheads
- Public building indoor water audits

Each of the above measures was then more clearly defined, with supporting data validated to ensure that the estimated measure savings and implementation costs were based on Tacoma Water's actual customer base. Another economic screening was then conducted to assess which of the measures were cost-effective for Tacoma Water to implement when measured against the next new available water supply (see Integrated Resource Plan, Section 4.5).

Economic Screening

Twelve measures were included in the economic screening. (Information was not available at the time for the MDTU to be included in the analysis.) For each measure, the cost per ccf saved, payback period, and benefit-to-cost ratio were determined. The total measure costs were calculated over the implementation time frame of the individual measure, and the total savings were derived with the benefits calculated over the life of the measure. For each measure, the value or benefit of the water savings was based on the levelized cost of the next new resource option. For indoor conservation measures, variable sewer costs were included in the benefit analysis.

Of the 12 measures evaluated, 6 measures were considered to be cost-effective with a benefit-to-cost ratio equal to or greater than 1.0. Table 4-8 presents the results of this evaluation. Program details for these measures are included in the Water Conservation Program Assessment (CH2M HILL, 1997).

These six measures were packaged according to similarities in the measure components to form the new conservation program:

1. Indoor Water Audit Program
   - Commercial/industrial indoor water audits
   - Public buildings indoor water audits
2. Landscape Rebate Program
   - Rebate for landscape technologies
   - Public agencies rebate for landscape technologies
3. Toilet Rebate Program
   - Commercial/industrial ultra-low flush toilet rebate
4. Low-Flow Showerheads
   - Commercial/industrial low-flow showerheads

The Implementation Strategies were developed in the *Water Conservation Program Assessment* (CH2M HILL, 1997). This report identifies timelines, budgets, and key issues and recommended monitoring for the above-mentioned programs.

Table 4-8
Economic Screening

Conservation Measure	Cost Per CCF Saved	Payback Period (yrs)	Benefit/ Cost Ratio
C/I indoor water audits	$0.03	2	27.76
Public building outdoor water use evaluation	$5.49	#N/A	0.12
Public schools outdoor water use evaluation	$2.08	#N/A	0.33
Public parks outdoor water use evaluation	$1.05	#N/A	0.65
MF irrigation audits	$15.08	#N/A	0.05
Rebate for landscape technologies	$0.14	2	4.51
Public agency rebate for landscape technologies	$0.65	8	1.00
C/I ultra-low flush toilet rebate	$0.60	9	1.15
Public schools ultra-low flush toilet rebate	$0.99	#N/A	0.67
SF/MF ultra-low flush toilets	$1.47	#N/A	0.47
C/I low-flow showerheads	$0.40	3	1.81
Public buildings indoor water audits	$0.60	4	1.27

CI=commercial/industrial
MF=multi-family
SF=single family
#N/A=Payback not achieved

The 1999 Water Conservation Program will implement the following two new programs:

1. **Industrial Water Use Audits.** Water use audits will be conducted for five to ten of Tacoma Water's largest (water use) industrial customers. The program will include preliminary audits at industrial facilities to verify the potential for water conservation savings. Where further study is merited, in-depth technical audits will be performed with input from the customers. Audits will prioritize conservation options and financial approaches that may make them economically attractive to implement.

2. **Central Irrigation.** Two of the following public agencies will be selected to participate in a 2-year pilot study of new wireless central irrigation technology: Tacoma Public Utilities Grounds Maintenance, Tacoma Parks, Tacoma School District, Tacoma Public Works, or Pierce County Public Works. While centralized irrigation technology has been available for nearly two decades, the system to be piloted requires an estimated one-tenth of the capitol costs for installation because it adapts to existing irrigation equipment, and because it does not require direct connection to the irrigation system being managed. Other systems tend to require the upgrade of existing equipment and the purchase of features that are considered beneficial, but not always cost-effective, toward the conservation of water and labor resources.

Complementary to this effort are turf audits of sites where the technology will be employed.

APPENDIX D
Watershed Analysis Prescriptions
Lester Watershed Administrative Unit

The Watershed Analysis process is based on the concept of adaptive management. Resource concerns or problems specific to individual watershed administrative units are identified during the assessment portion of a Watershed Analysis and documented and summarized within a series of causal mechanism reports. Prescriptions developed through the Watershed Analysis process are appropriate solutions to those resource concerns or problems (WFPB 1997). Prescriptions developed through the Washington Watershed Analysis Process accomplish the following:

- Identify problems or events not regulated or adequately addressed by existing forest practices regulations.
- Provide protection for public resources (water supply and public works, fisheries and water quality) through prescriptions that are implemented by regulatory application.
- Provide flexibility for landowners in the form of options designed for specific situations documented within the watershed administrative units.
- Provide opportunities for resource enhancement or restoration by suggesting actions that may be undertaken voluntarily outside of regulations.
- Facilitate monitoring to evaluate the effectiveness of prescriptions and guide management adaptations.

Products of the Watershed Analysis (including assessment reports, causal mechanism reports, and prescriptions) are assumed to be valid for a period of five years, at which time the process may be repeated if necessary.

This Appendix contains copies of the mass-wasting, surface erosion and hydrology causal mechanism reports and prescriptions developed for the Lester watershed administrative unit, the only Watershed Analysis in the upper Green River watershed that has been officially approved by the Washington Department of Natural Resources as of December 1999. Draft causal mechanism reports and prescriptions have been developed for the Upper Green/Sunday and Howard Hanson/Smay Watershed Administrative Units. The draft prescriptions for those watershed administrative units are generally similar to those for the Lester watershed administrative unit, and are currently being implemented by

Tacoma, but have not yet been formally approved by the Washington Department of Natural Resources. Riparian prescriptions to be implemented under Tacoma's Habitat Conservation Plan exceed those required by draft and final watershed analysis prescriptions to date; therefore riparian prescriptions for the Lester watershed administrative unit are not included within this Appendix. Should riparian prescriptions developed through future watershed analyses or five-year reviews exceed protection provided within this Habitat Conservation Plan, the more restrictive prescriptions will be implemented.

SECTION 5

CAUSAL MECHANISM REPORTS AND PRESCRIPTIONS

Section **Page**

CAUSAL MECHANISM REPORTS AND PRESCRIPTIONS

5.0 INTRODUCTION

The following Causal Mechanism Reports and Prescriptions were specifically prepared for use in the Lester Watershed Administrative Units. The prescriptions were designed to provide flexibility for forest landowners, including several prescriptions which are identified as voluntary (implementation of which is left to the discretion of the landowner or resource manager), while providing a high degree of public resource protection.

Although strict adherence to the following prescriptions is encouraged, a landowner or resource manager may submit an alternate plan to the DNR (as per WAC 222-12-040). The applicant must show that the alternative will meet or exceed the protection provided by the prescriptions approved for a given area of resource sensitivity.

5.1 FIELD VERIFICATION OF MAPPING UNITS

Implementation of many of the prescriptions require field identification of mapping units. The mapped units are approximate boundaries because of the map scale and common use of only aerial photographs for determination of boundaries. The descriptions of the mapping units should be used as a guide to locate the actual boundaries of map units in the field during the layout of proposed timber harvest and road construction activities. The field verification and identification of map unit boundaries can typically be done by foresters and other resource managers, using the description of the mapping units in the causal mechanism reports. In some instances, geotechnical specialists may be needed to verify slope stability conditions. Refer to the Glossary section below for a description of the circumstances under which a geotechnical review is warranted, and how such reviews are to be conducted. More detailed descriptions of individual map units may be found in the assessment reports.

Field inspections will probably locate inclusions that were mapped as a more hazardous or less hazardous map unit than dictated by field conditions. If the mapped unit does not meet the definition of hazard as outlined in a causal mechanism or assessment report, standard rules are applied. Conversely, inclusions of a "more hazardous" situation within a low hazard map unit, requires the implementation of appropriate prescriptions (e.g., inner gorges identified within a low hazard unit). Ultimately, management activities within the inclusions should follow the prescriptions necessary to address conditions observed in the field, rather than on the map.

5.2 GLOSSARY

A number of terms are used in prescriptions that are either technical in nature or open to multiple interpretations. This glossary provides specific definitions to help interpret and implement prescriptions in a consistent manner.

Distances

All distances referred to in the prescriptions are horizontal distances unless otherwise noted.

Minimize, Avoid, Prevent

For the purposes of this report:

1) *Minimize* means where practicable, the activity should not be done;

2) *Avoid* means that the action can only be done when other alternatives are not practical and must include justification to the DNR; and

3) *Prevent* means the action shall not be done.

Geotechnical Evaluation

When necessary, a geotechnical evaluation will be conducted and a report will be prepared by a qualified individual. Such an individual will have successfully completed graduate-level courses in slope stability and will have at least 5 years experience in slope-stability evaluation. The report will assess the potential for the proposed activity to trigger landslides, based on methods that are reproducible, defensible and that incorporate field data pertaining to the relevant physical processes. Such field data may include local erosion mapping, measurement and analysis of soil thickness or other soil properties, and analysis of hillslope hydrology. The report will be submitted to the DNR for approval with the Forest Practice Application (FPA) for the planned activity.

Geotechnical Review Guidelines

The *Geotechnical Review Guidelines* presented below provide a method of documenting the locations of mass wasting map units and help determine whether a geotechnical evaluation is needed. This process is limited to measurable topographic features as described in the causal mechanism reports and will not make any attempt to evaluate or quantify delivery potential.

Results of the field review are to be included with the Forest Practice Application for the planned activity.

Geotechnical reviews are an important tool for implementing watershed analysis prescriptions involving slope stability. Actual (on-the-ground) boundaries of potentially unstable areas may differ somewhat from mapped boundaries, owing to map scale and the remote assessment methodologies used during boundary delineation. The degree of difference depends on the accuracy of mapping and the scale of map used, but also on the type of slope stability feature and local conditions. Also, there are often stable areas within mapped mass wasting map units assigned a moderate or high mass wasting potential. Conversely, inclusions of unstable ground in areas mapped as having "low" mass wasting potential also occur. Managers normally address these situations by relying on the mass wasting analyst's description of the mass wasting map unit features, and their experience, to verify where the identified unstable areas actually occur. In cases where the slope stability issues are complex, or the field manager is uncertain about how a proposed activity will influence local slope stability, a geotechnical expert is called in to support the decision-making process. In some instances, the need for a geotechnical expert is identified up-front during the prescription-writing process, and this becomes a required part of the prescription. In other cases, the slope stability situation is straightforward and prescriptions are written to dictate what activities are suitable to prevent or avoid triggering a mass wasting event in a given mass wasting map unit. It is the latter case where initial on-the-ground inspection of the situation is performed by the field manager (forester or engineer), prior to submitting an FPA or calling for a geotechnical review. This decision process is described in a step-by-step fashion below. Importantly, note that when a geotechnical review is called for, it is the geotechnical expert's recommendations that form the basis for acceptance or denial of particular forest management activities. When an FPA is submitted to the DNR for review, these recommendations are already incorporated into the plan.

Geotechical Review Guidelines

Step 1. Forester/Engineer/Planner (field manager) overlays map showing proposed forest management activity (harvest unit, road construction, etc.) with mass wasting map unit map. IF proposed management activity intersects one or more MWMUs with a moderate or high rating, THEN landslide potential exists: *field verification required.* **GO TO STEP 2.**

IF proposed activity does not intersect MWMUs with a moderate or high rating, THEN landslide potential is presumed low. Local manager proceeds with developing activity plan, considering current forest practice rules and regulations, and their experience with local terrain. Note: managers will evaluate affected area for potential to include areas with moderate or high mass wasting potential, using information obtained from Watershed Analysis Mass Wasting report, and personal experience. Prepare FPA and submit to DNR for review/approval.

Step 2. Manager visits site to verify that the MWMU description applies to area where activity will occur. This evaluation is done using the written descriptions of the relevant MWMU's as provided in (a) the appropriate Causal Mechanism Report and Prescription, or (b) in the Watershed Analysis Mass Wasting report for the given watershed. IF the area affected by the proposed activity DOES fit the description of terrain having a moderate to high mass wasting potential AND prescriptions have been pre-written (see above) to address the slope stability issue(s), THEN proceed with planning the activity in accordance with pre-set prescriptions. Submit plan to DNR with FPA. IF prescriptions require a geotechnical review, or the manager is uncertain about the applicability of the prescription to the site in question, THEN *a geotechnical review is required.* **GO TO STEP 4**

Note: Field managers may opt to have a geotechnical expert perform the evaluation in Step 2.

IF the area affected by the proposed timber harvest or road work clearly DOES NOT fit the description of unstable terrain in *any* MWMU having a moderate to high mass wasting potential, and mass wasting potential is deemed low based on the site conditions, the information provided in the Mass Wasting report, and the experience of the land manager, THEN the prescription for the indicated MWMU does not apply. Mapping error or inapplicable Mass Wasting potential detected. **GO TO STEP 3**

Step 3. Document the site conditions, and submit a report to the DNR along with the FPA describing why there is no mass wasting potential and the prescription does not apply. Be sure that the affected area does not lie within an adjacent MWMU with moderate to high mass wasting potential.

Step 4. Geotechnical review. Once the land manager has verified that the affected area lies within one or more MWMUs with moderate to high mass wasting potential, and no pre-set prescription is available, then a geotechnical review is usually[1] required. A geotechnical expert assesses the proposed activity in the context of the local area to determine what practices, if any, are appropriate for the area, to meet the standard of performance set forth in the causal mechanism report for the relevant MWMU. These practices are to be documented in a report that will be attached to the FPA. DNR approval of the activity is contingent upon the geotechnical expert's determination that the proposed activity can be conducted in such a way as to minimize, prevent, or avoid triggering a landslide that can deliver coarse or fine sediment to a stream in sufficient quantities to adversely alter fish habitat or water quality, or that could damage capital improvements of the state.

Channel Migration Zone

The channel migration zone (CMZ), or modern floodplain, is a geologic feature that is defined as the flat area adjoining a river channel constructed by the river in the present climate and overflowed at times of high discharge (Dunne and Leopold 1978). It is the surface that extends beyond the top of the streambank or ordinary high water mark, but is typically no more than 2 to 5 feet higher in elevation, depending on stream size. This definition includes meandering, braided, and avulsion channels. Avulsion channels are areas that streams have recently occupied (in last few years or less often decades), and would be reasonably expected to be occupied again in the near future. The primary mechanisms for channel avulsion or "channel hopping" are woody debris jams and/or formation of gravel bars during larger floods. If one streambank is substantially higher, then the channel migration zone is probably associated only with the elevation of the lower streambank (Figure 5-1).

A combination of topographic maps, aerial photographs, soil maps, vegetation surveys and field work can be used to delineated the channel migration zone. Field evidence that can be used to help define the channel migration zone includes unvegetated or sparsely vegetated side channels, wetlands, and recent signs of flood damage such as woody debris hung up in branches or deposited outside the ordinary high water mark and large amounts of sediment deposition. CMZs are principally applicable to low-gradient alluvial channel segments, such as alluvial fans and the alluvial Green River valley.

[1]A geotechnical review may not be required if the proposed activity was not identified as a triggering mechanism in the Causal Mechanism Report for a given MWMU, and in the opinion of the local forester or engineer, the activity would not contribute to mass wasting.

Channel Disturbance Zone

Channel disturbance zones (CDZ) are valley-bottom areas subject to recurrent catastrophic disturbance from dam-break floods. CDZs encompass the confined trunk segments of third and fourth-order valleys in the Lester WAU, including portions of McCain, Green Canyon, Friday, Morgan, Wolf, Champion, Rock, Lester, and Sawmill Creek (Figure 4A-3). CDZs typically span the width of confined valley bottoms and extend to the base of the hillslope on either side of the valley, encompassing the alluvial and colluvial material on the valley floor (Figure 5-1). When the valley is narrow, the CDZ is often similar in width to the channel migration zone because the present form of the valley bottoms have typically been created by alluvial processes.

CDZs generally extend downstream to canyon mouths beyond which point confinement rapidly diminishes across alluvial fans located in the Green River Valley. Channel disturbance zones are not applicable when the stream gradient across a valley segment is less than two percent, or when the floor of a given valley segment is more than 300 feet wide (e.g. K-25). At the widest portion of the largest tributary valley (i.e., Rock Creek), the CDZ reaches 250 feet in width. Along the central trunks of most tributary valleys, however, CDZs are typically less than 100 feet in width and commonly less than 50 feet in width. In areas disturbed by recent dam-break floods, the CDZ will typically be devoid of vegetation or have young alder growing on gravel substrate. Large pieces or piles of woody debris may be deposited at the edges of the channel disturbance zone.

If the lateral extent of the channel disturbance zone is in question, it can be determined in the field with a rod and level by siting to a line on the hillslope that is 5 meters in elevation above the height of the stream (as measured from the ordinary high water mark). This elevation is based on the heights of dam-break floods studied by Coho and Burgess (1993). The CDZ is then defined as extending to the base of the slope upon which the siting falls (but not more than 300 feet). This method has the greatest utility in evaluating whether relatively broad Quaternary (glacial) terraces near canyon mouths lie within the CDZ.

Large, Well Distributed Conifer Trees

Many prescriptions call for a number of *large, well distributed* conifer trees to be left in a riparian stand. For purposes of this report, well distributed is defined as the non-systematic dispersal of residual trees throughout the riparian zone. The objective is to retain the largest available conifer trees to eventually provide a stand typical of a late-successional forest. A summary of riparian management zone widths and yarding corridor requirements are contained in Table 5-1 and Table 5-2 respectively.

Inner Gorge

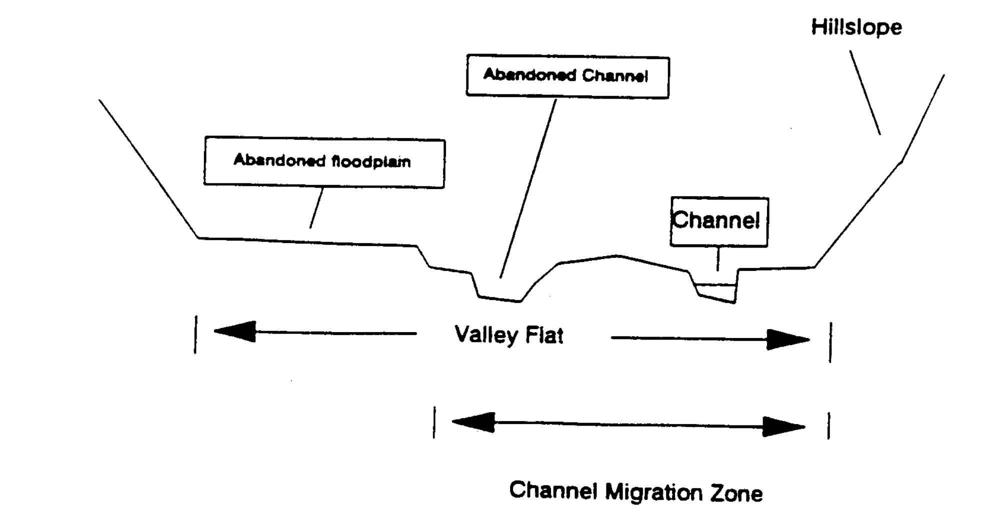
Inner gorges are streamside slopes with a slope length greater than ten feet, and with a slope angle of 35 degrees or greater. In many cases, inner gorges are bounded above by a well-defined break in slope. Inner gorge topography may occur in isolation within other units, and it commonly extends beyond MWMU-9 into the lower portions of headwall draws.

Zero-Order Basin

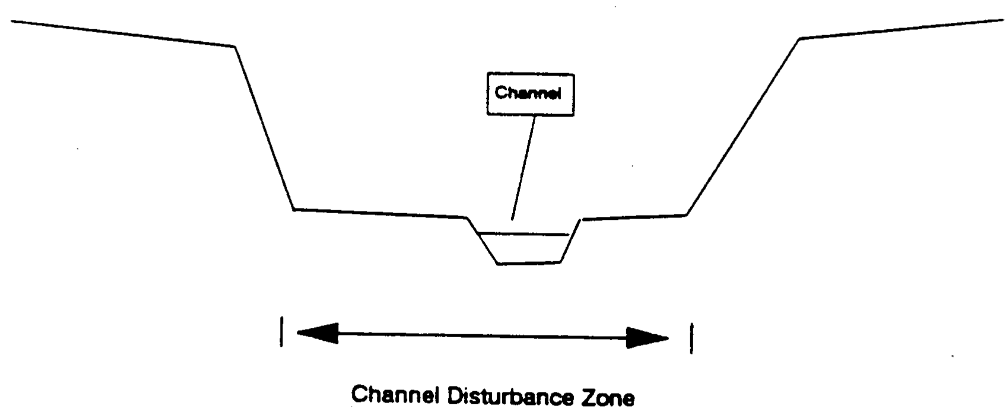
Zero-order basins are defined as the topographic area that delivers water (typically sub-surface) to defined channels (also known as the *channel head*) where surface water flows and bank incision begins (Montgomery and Dietrich 1988). They are common just above the start of headwater channels, but can occur anywhere along the channel on steep sideslopes. The basins are typically a few acres in size with the largest basins on the order of tens of acres. Zero-order basins typically do not show evidence of surface water flow, although they may be seasonally ponded or have perennial seepage. *Hollows* or *swales* are concave or planer topographic depressions within the zero-order basin that concentrate sub-surface water. Hollows or swales collect groundwater and colluvium (soil, rock fragments, organic material) through gravitational forces because the bedrock surface is concave. Vegetation is a key factor for maintining the integrity of hollows because roots can anchor the soil mass to bedrock and provide soil cohesion by binding individual particles. Debris flows/landslides commonly originate in these topographic features when located on steep slopes.

Channel Head, Hollows, Swales - see **Zero-Order Basin**

Figure 5-1. Channel Migration and Disturbance Zones



Channel Migration Zone



Channel Disturbance Zone

Table 5-1. Riparian Management Buffer Zones

Water Type	Buffer Zone Width	No Harvest Zone	Residual[3] Tree/Acre	Residual[3] Trees/1000'	Target Tree Diameter[4]
Type 1	100' plus CMZ[1] or 100' plus CDZ[2]	30'	70	161	≥30"
Types 2&3	70' from OHWM or 50' plus CMZ/CDZ	30'	70 70	112 80	≥20"
Types 4&5	25' plus CDZ	CDZ	44	25	≥15"

Note: In all cases, target shade requirements as per Standard Rules will be maintained for harvest within the RMZ.

1 Channel Migration Zone (where applicable) as identified in Section 5.3.

2 Channel Disturbance Zone (where applicable) as identified in Section 5.3.

3 Conifer trees within the 30' no-harvest, channel migration and channel disturbance zones are included with total tree count. Where operationally practicable, residual trees will be the largest, well distributed conifer available (at least 12" DBH). To retain the largest trees and provide even distribution, minor clumping will be allowed. When 12" trees are unavailable, 100 of the largest, well distributed conifer trees per acre will be left (trees in excess of 3" DBH may be counted).

4 Objective is for selection and management of conifer trees typical of late-successional forest to increase LWD recruitment and provide shade. Harvest shall leave the largest, well distributed, dominant and codominant conifer trees.

Table 5-2. Guidelines for Selection and Use of Skyline Corridors in High Mass Wasting Hazard Areas.

Skyline corridors will be allowed through areas of potentially high mass wasting hazard only when strict adherence is made to the following location and operating guidelines:

1) Individual corridors will be no wider than 30 feet.

2) Corridors will be located on slope less than 80% with no indication of seasonal saturation or recent slope movement.

3) Full ground suspension will be provided through the entire zone.

4) The total disturbed area for all skyline corridors will be no more than 20 percent of the affected mass wasting hazard area as shown by cross-hatching below.

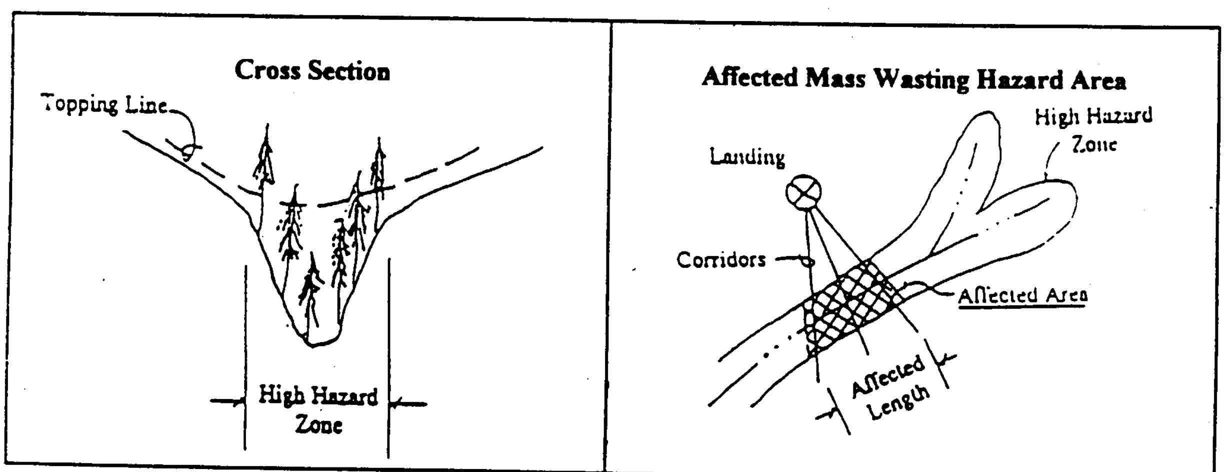
5) Yarding lines will be fully withdrawn from corridors during skyline road changes.

6) When feasible, select corridor locations that minimizes cutting of overstory conifer trees (i.e. use natural gaps in vegetation) to preserve local root strength.

7) Topping of trees as shown below or minor crown damage is preferable to felling trees (i.e. leaving residual snags).

Alternatives that do not meet Items #1 through #5 will be allowed only when the proposed location has been reviewed and approved by a slope stability specialist.

TYPICAL SKYLINE CORRIDOR VIEWS



CAUSAL MECHANISM REPORT AND PRESCRIPTION #1

Resource Sensitive Area: MWMU-3 and 3A (Kelly Butte topography)
Mass Wasting Module, Figure 4A-2

Landslide Process: Rock fall, debris avalanche, debris flow, and debris source for dam-break-flood initiation (MWMU-3), and snow avalanche (MWMU-3A)

Input Variables: coarse and fine sediment

Delivered Hazard Rating: HIGH

Resource Vulnerability: HIGH
coarse sediment: C9, C2, C1, 4; I7, 4, 3; K24, K22, K1, 5
fine sediment: C3, C9, C2; I7, I4, I3, I2; K24, K22, K2

Rule Call: PREVENT or AVOID

Situation Statement:

Snow avalanches and debris avalanches (and possibly falling rock) can initiate debris flows that travel downslope to mainstem reaches of Green River tributaries (and in other cases, rock fall and debris avalanches reach these tributaries without generating debris flows). Debris flows may travel downstream in higher-order receiving channels and can generate dam-break floods capable of reaching the Green River. Debris avalanches, debris flows, and dam-break floods carry sediment that can degrade fish habitat (primarily by filling pools, scouring channels, redistributing wood, and smothering gravel). Debris flows and dam-break floods also promote long-term indirect impacts to fish habitat (e.g., decreased shading, diminished wood recruitment, and increased erosion on denuded sideslopes) by degrading conditions in the riparian zone.

Triggering Mechanisms:

Snow avalanche (restricted to Kelly Butte locality): The loss of tree trunks and forest canopy to fires early in this century contributed to snow-avalanche initiation on the upper slopes of Kelly Butte (and it may have enabled the runout to travel farther downslope). Trunk and canopy removal probably contributes to snow-avalanche initiation by allowing greater thicknesses of snow to accumulate, by subjecting the accumulated snow to wider diurnal temperature variation, and by removing roughness elements (i.e., tree trunks) that afford frictional resistance to sliding.

Rock fall, debris avalanche, and debris flow: Root decay following fires probably contributed to debris-avalanche initiation on steep slopes throughout the unit. Debris avalanches (and possibly rock fall) can initiate debris flows in confined draws and channels, which can subsequently generate dam-break floods in higher-order receiving channels. Soils in the unit are thin (where present) and the thickest accumulations typically occur along the axes of convergent slope segments. In many instances, the base of the soil horizon probably constitutes a pronounced mechanical discontinuity that facilitates sliding.

Landsliding associated with road prisms and road drainage is not documented in the photo record, but roading is likely to contribute to debris-avalanche and debris-flow initiation (e.g., sidecast road construction above or across confined draws and channels).

Prescriptions:

Road Construction:

1) Avoid road construction in MWMU #3 and #3A.

2) If unavoidable, and road construction occurs on slopes > 60%, full-bench construction is required and all excess material must be end-hauled to a stable location shown on the harvest (forest practice application) map.

3) At stream crossings (with perennial or intermittent flow) have either a:

   a) permanent crossing using a hardened ford with a dip out of cement or clean pit-run rock or a bridge

   OR

   b) a temporary crossing (i.e., culvert) that meets the following standards:

      I) Minimum fill at stream/draw crossings.

      ii) Fill material over the culvert will be composed of clean material (very little fines).

iii) Culverts will be one standard size larger than Forest Practice Manual recommendations for the 50-year flood.

iv) All culverts will be inspected annually and after larger storms (as accessible) with maintenance as required.

v) Temporary crossings will have all fill and culverts pulled after completion of reforestation activities, but no later than three years after construction of the road.

4) Relief culverts shall not empty into concave topographic features where subsurface flow naturally concentrates (i.e., hollow or swale).

Timber Harvest:

1) If slopes are greater than 70% and harvest is planned within a zero-order basin (concave topographic features; see Glossary) that concentrates flow of water (i.e., hollow or swale), a geotechnical report (see Glossary) must be completed for the proposed plan. Timber harvest may proceed only after a site-specific analysis concludes that the planned harvest will not significantly increase the probability of mass wasting from the site.

2) If timber harvest is planned within MWMU #3A, a geotechnical report must be completed for the proposed plan. Timber harvest may proceed only after a site-specific analysis concludes that the planned harvest will not significantly increase the probability of snow avalanche initiation from the site or enhance the potential for delivery of snow avalanche runout to stream channels.

Justification for Prescriptions:

The steep slopes and naturally active mass wasting processes warrant extreme caution in this mass wasting map unit. Additionally, there is high potential delivery of sediment to Type 1-3 streams. Road construction and timber harvest are to be avoided within this map unit wherever possible. Any road construction within the map unit will meet strict standards to minimize the potential for initiation of landslides. If landslides do initiate from within the map unit, prescriptions are designed to accommodate the slide (e.g., bridge or hardened ford) or at the very least minimize the amount of material deposited into streams. Because the mapping boundaries are approximate and only aerial photographs were commonly used to determine boundaries, some flexibility has been included in the prescriptions to allow for field verification of mapping units and use of geotechnical specialist reviews.

CAUSAL MECHANISM REPORT AND PRESCRIPTION #2

Resource Sensitive Area: MWMU-4 (slump/earthflow toes)
Mass Wasting Module, Figure 4A-2

Landslide Processes: debris avalanche, debris slide, debris flow, and potential debris source for dam-break-flood initiation, rockfall

Input Variables: coarse and fine sediment

Delivered Hazard Rating: HIGH

Resource Vulnerability: HIGH
coarse sediment: 1, 3, 5; E17, E15, E1; H17, H1; K25, K24, K22, K1,
fine sediment: 1, 3, 5; E16, E18, E1; K1

Rule Call: PREVENT or AVOID

Situation Statement:

Debris avalanches, debris slides, and earth slumps on oversteepened slopes of and across from prehistoric slump/earthflows readily convey coarse and fine sediment to adjacent streams. The delivered sediment can initiate debris flows in receiving channels and has the potential to generate dam-break floods capable of reaching the Green River. The sediment thus delivered and routed through the channel can degrade fish habitat (primarily by filling pools, scouring channels, redistributing wood, and smothering gravel). Debris flows and dam-break floods also promote long-term indirect impacts to fish habitat (e.g., decreased shading, diminished wood recruitment, and increased erosion on denuded sideslopes) by degrading conditions in the riparian zone.

Triggering Mechanisms:

The toes of prehistoric slump/earthflows are typically oversteepened and mechanically weak. The encroachment of the slump/earthflows also causes streams to undercut and progressively steepen slopes on the opposite side of the channel. Shear stress resulting from the erosion of basal slopes during high stream flows commonly triggers debris avalanches, debris slides, and earth slumps (most notably in Friday and Sawmill Creeks).

Road cuts and road fills also have potential to trigger landslides by increasing the shear stress in marginally stable slopes (i.e., by loading the head or unloading the toe of the slope). Root decay following timber harvest apparently contributed to landsliding in the Friday Creek basin (and is likely to contribute to landsliding in other basins) by decreasing the shear strength of materials in the root zone. Road drainage directed into confined topography within the mass wasting units can also decrease shear strength and contribute to landsliding by elevating pore pressures (and possibly by accelerating subsurface weathering as well).

Forest hydrology may also contribute to landslide initiation in some cases. Decreased evapotranspiration following timber harvest in upslope catchment areas can increase groundwater recharge and elevate pore pressures at the toe of a slump/earthflow. Timber harvest in upstream catchment areas can increase peak stream discharges, and the increased flows can accelerate undercutting of oversteepened slopes next to the channel. Debris avalanches, debris slides, and earth slumps initiating on slump/earthflow toes have potential to generate debris flows and dam-break floods in the receiving channels, which are typically well confined.

Prescriptions:

1) The prescription for this map unit will apply from the ordinary high water mark (OHWM) to 100 feet back from the slope break or within 200 feet from OHWM, whichever is further in distance. The map unit should not extend beyond 500 feet from the stream, although other high or moderate hazard map units may be adjacent to it. Any activity within this area will require a Geotechnical Evaluation approved by DNR (see Glossary). The Geotechnical Evaluation should identify on the ground those areas where road construction or harvesting would load the head, unload the toe of the slope, or reduce root strength, thereby increasing the potential for mass wasting.

Justification for Prescriptions:

The steep slopes with potential for direct delivery of mass wasting events to streams warrants extreme caution. The 200-foot minimum and 500-foot maximum distance is based on aerial photograph and field observations of earthflow toes and associated slopes. The prescription should prevent management-related increases in the initiation of debris torrents (debris flows or dam-break-floods) by avoiding activity in areas prone to landsliding. Because the mapping boundaries are approximate and only aerial photographs were commonly used to determine boundaries, some flexibility has been included in the prescriptions to allow for field verification of mapping units and use of geotechnical specialist reviews.

CAUSAL MECHANISM REPORT AND PRESCRIPTION #3

Resource Sensitive Area: MWMU-5 (slump/earthflow bodies)
Mass Wasting Module, Figure 4A-2

Note: Relict deep-seated slides in Green Canyon Creek, the eastern edge of Friday Creek, the upper portion of the west fork of Friday Creek, and lower Champion Creek do not have active toes (MWMU #4), so these prescriptions do not apply.

Landslide Processes: earth slump, debris avalanche, and potential for increased landsliding at slump/earthflow toe

Input Variables: coarse and fine sediment

Delivered Hazard Rating: MODERATE

Resource Vulnerability: MODERATE

Rule Call: MINIMIZE

Situation Statement:

Canopy removal on slump/earthflow bodies has potential to increase landsliding downslope at the slump/earthflow toe. Landslides that originate on slump/earthflow toes are readily delivered to streams where they can initiate debris flows and dam-break floods. The sediment thus delivered and routed through the channel can degrade fish habitat (primarily by filling pools, scouring channels, redistributing wood, and smothering gravel). Debris avalanches can occur on the body of a slump/earthflow, but delivery to surface waters is commonly restricted outside of areas where steep slopes occur next to streams.

Triggering Mechanisms:

Reductions in evapotranspiration caused by wholesale canopy removal on slump/earthflow bodies can increase groundwater recharge to slump/earthflow toes. Increased pore pressure resulting from increased groundwater recharge has potential to trigger landslides at slump/earthflow toes. Road drainage that carries water onto a slump/earthflow from external slopes can also increase groundwater recharge to the slump/earthflow toe.

Root decay following timber harvest can trigger debris avalanches on the steeper slopes of a slump/earthflow body. Although potential for delivery of landslide debris to surface waters is generally low, delivery can occur where steep slopes occur next to streams.

Slump/earthflow bodies commonly have hummocky moderate-gradient slopes with numerous seeps and springs. Road construction is difficult in poorly drained areas, and unexpected seeps can contribute to recurring maintenance problems with road beds and road drainage.

Road cuts and road drainage can destabilize earth slumps within the slump/earthflow by removing lateral support. Road drainage diverted onto earth slumps can also reactivate their movement by increasing pore pressure to reduce shear strength.

Prescriptions:

Road Construction

1) Minimize road construction on slump/earthflow bodies (MWMU #5).

2) Avoid road construction on recognizable internal slumps (wet areas, steep scarps) within the slump/earthflow body (MWMU #5).

3) Divert road drainage away from unstable areas, especially from slump/earthflow toes.

4) Annual inspection of roads on slump/earthflows is required, followed with appropriate maintenance.

Timber Harvest

1) On Type 4 and 5 streams with sideslope gradients greater than 70% and channel gradients greater than 15%, provide a no-cut riparian leave strip one mature tree crown width from the break in slope (typically about 30 feet).

2) Yarding corridors through these stream buffers will be allowed as detailed in Table 5-2.

VOLUNTARY PRESCRIPTIONS:

1) Present or potential mass wasting hazards in areas identified as a high hazard (i.e., areas of potential instability as defined by MWMU #9 and #11) associated with existing roads within this MWMU should be dealt with in the Road Hazard Reduction Plan as detailed in Prescription Report #6.

2) It is recommended that timber harvest within this MWMU be spread over time in order to maintain hydrologically mature timber over a substantial portion (70%) of the unit at any given time.

3) When timber harvest within this MWMU occurs, a 3-year monitoring program may be initiated by the landowner to track mass wasting activity along the toe of the slump/earthflow. The monitoring program should gather information on current location of mass wasting, active processes, dimensions of mass wasting, vegetation cover, and estimated age of features. The purpose of the monitoring program is to track the activity of the earthflow toe over time following timber harvest activity. Monitoring is recommended prior to harvest to establish baseline conditions.

   If no significant increase (see definition below) in mass wasting is noted during the 3-year monitoring program, an additional 30% of the body may be harvested before conducting another 3-year monitoring program. If a significant increase in mass wasting is noted during the monitoring program, a geotechnical evaluation should be completed prior to any additional harvest.

   Note: For this prescription, a significant increase is defined as an increase in sediment delivery to the stream channel that would bury large woody debris and fill pools downstream of the slump/earthflow.

JUSTIFICATION FOR PRESCRIPTIONS:

The prescriptions should minimize the opportunity for initiation of mass wasting activities especially in areas with potential for direct delivery to streams for the following reasons. Road prisms that may increase drainage to internal slumps within the earthflow will be avoided in potential hazard areas. Annual road maintenance programs (including additional culverts installed in seeps) will help to prevent further drainage and erosion problems with existing roads.

Timber harvest is restricted on steep slopes with a potential to deliver sediment to streams. The effects of timber harvesting on the activity of deep-seated slump/earthflows are not well understood. The monitoring program, while voluntary, allows for an adaptive management strategy that can stop or change harvest practices if mass wasting activity is accelerated.

CAUSAL MECHANISM REPORT AND PRESCRIPTION #4

Resource Sensitive Area: MWMU-6 (slump/earthflow scarps)
Mass Wasting Module, Figure 4A-2

Landslide Processes: rock fall, debris avalanche, and debris flow

Input Variables: coarse and fine sediment

Delivered Hazard Rating: MODERATE

Resource Vulnerability: MODERATE

Rule Call: MINIMIZE

Situation Statement:

Debris avalanches and debris flows occur on the steep slopes of slump/earthflow scarps, but immediate delivery to surface waters is commonly restricted outside of areas where confined draws feed directly into streams below. Canopy removal on slump/earthflow scarps has potential to increase landsliding downslope at the slump/earthflow toe. Landslides that originate on slump/earthflow toes are readily delivered to streams where they can initiate debris flows and dam-break floods. The sediment thus delivered and routed through the channel can degrade fish habitat (primarily by filling pools, scouring channels, redistributing wood, and smothering gravel).

Triggering Mechanisms:

Reductions in evapotranspiration caused by wholesale canopy removal on slump/earthflow scarps can increase groundwater recharge to slump/earthflow toes. Increased pore pressure resulting from increased groundwater recharge has potential to trigger landslides at the toe of a slump/earthflow. Road drainage that carries water onto slump/earthflow scarps from external slopes can also increase groundwater recharge to the slump/earthflow toe.

Both timber harvest and road fills can trigger debris avalanches on slump/earthflow scarps, which may in turn initiate debris flows upon entering confined draws. Although potential for immediate delivery of landslide debris to surface waters is generally low, delivery can occur where confined draws feed directly into streams below.

Prescriptions:

Road Construction:

1) If new road construction cannot be avoided, the following standards will apply:

   a) If road construction occurs on slopes > 60%, full-bench construction is required and all excess material must be end-hauled to a stable location shown on the harvest (forest practice application) map.

   b) Minimize fill at stream/draw crossings.

   c) Relief culverts shall not discharge onto slopes > 70% or into concave topographic features where subsurface flow naturally concentrates (i.e., hollow or swale).

   d) Minimize the amount of road draining directly onto the slump/earthflow body.

Timber Harvest:

1) Minimize soil disturbance.

2) Conduct field surveys to identify inner gorges (MWMU #9) and headwall topography (MWMU #11) within this mapping unit and, if found, apply appropriate prescriptions.

Justification for Prescriptions:

This prescription focuses on identifying areas with the potential for delivery of sediment to streams because of the difficulty in evaluating delivery from aerial photographs. Roads on steeper slopes must be full bench construction to prevent sidecast failures, and road drainage diverted away from convergent topography that has a potential to initiate debris flows. Regardless of direct delivery, this prescription minimizes the opportunity for initiation of mass wasting from earthflow scarps.

CAUSAL MECHANISM REPORT AND PRESCRIPTION #5

Resource Sensitive Area: MWMU-9 (inner gorges)
Mass Wasting Module, Figure 4A-2

Landslide Processes: rock fall, debris avalanche, debris flow, and debris source for dam-break-flood initiation

Input Variables: coarse and fine sediment

Delivered Hazard Rating: HIGH

Resource Vulnerability: HIGH
coarse sediment: 1, 3, 4, 5; A1, A6, A11, A15, A16, A17, A19, A22, A24, A32, A33, A34; C9, C2, C1; D1, D2; E17, E15, E1; H17, H1; I7, I23, I21, I19; K25, K24, K22, K1
fine sediment: 1, 3, 4, 5; A33; C1; D1, D2; E1; H1; K1

Rule Call: PREVENT or AVOID

Situation Statement:

Inner gorges form the principal conduits for routing sediment from hillslopes to fish-bearing streams. Debris avalanches on inner-gorge slopes readily convey coarse and fine sediment to confined channels. The delivered sediment routinely initiates debris flows in lower-order channels, which can in turn generate dam-break floods in higher-order channels. The sediment thus delivered and routed through the channel can degrade fish habitat (primarily by filling pools, scouring channels, redistributing wood, and smothering gravel). Debris flows and dam-break floods also promote long-term indirect impacts to fish habitat (e.g., decreased shading, diminished wood recruitment, and increased erosion on denuded sideslopes) by degrading conditions in the riparian zone.

Triggering Mechanisms:

Inner-gorge topography is highly responsive to both roading and timber harvest. Relatively small debris avalanches on inner-gorge slopes readily become channeled into large debris flows that can generate dam-break floods capable of reaching the Green River.

Root decay following timber harvest triggers debris avalanches by decreasing the shear strength of materials in the root zone. Inner-gorge slopes are particularly sensitive to decreased root strength because they routinely include thick accumulations of colluvium that are predisposed to saturation during storms.

Road fills and landings placed on or near steep inner-gorge slopes are also a major source of debris avalanches. Debris jams formed behind culverts at road/stream crossings can initiate debris flows, and debris flows typically destroy road/stream crossings in their paths. Road drainage diverted onto inner-gorge slopes can also compound inherently unfavorable hydrologic conditions and further elevate pore pressures to induce landsliding.

As defined here, inner gorges are streamside slopes with a slope length greater than ten feet, and with a slope angle of 35 degrees or greater. In many cases, inner gorges are bounded above by a well-defined break in slope. Inner gorge topography may occur in isolation within other units, and it commonly extends beyond MWMU-9 into the lower portions of headwall draws.

Prescriptions:

Road Construction:

1) Avoid road construction in MWMU #9. This is the preferred alternative.

2) If unavoidable, roads can be constructed across mapped inner gorge areas and unmapped inner gorges with side slopes 70% or greater if less than 5 feet of fill at centerline is required using the following standards:

   a) Full bench excavation with no sidecast of material as the road enters and leaves the inner gorge areas (sideslopes greater than 60%).

   b) Road drainage will be diverted away from the inner gorge whenever possible.

   c) Excessive or oversteepened cutslopes will be avoided.

   d) Stream crossings (with perennial or intermittent flow) will have either a:

      i) a permanent crossing consisting of a bridge or hardened ford with a dip out of cement or clean pit-run rock;

      OR

      ii) a temporary crossing that meets the following standards:

a) Minimum fill at stream/draw crossings.

b) Fill material over the culvert will be composed of clean material (very little fines).

c) Culverts will be one standard size larger than Forest Practice Manual recommendations for the 50-year flood.

d) All culverts will be inspected annually and after larger storms (as accessible) with maintenance as required.

e) Fill material and culverts will be pulled after completion of reforestation activities, but no later than three years after construction of the road.

3) If gorge side slopes are greater than 70% and fills would be greater than 5 feet at centerline and a road with stream crossing culverts is planned, construction can occur only with a geotechnical specialist review. The review is not necessary if a bridge is placed.

4) Present or potential mass wasting hazards associated with existing roads within this MWMU will be addressed in the Road Hazard Reduction Plan detailed in Prescription Report #11.

Timber Harvest:

1) No harvest is allowed within inner gorges, including a 20-foot buffer beyond the break in slope; OR within 50 feet of the OHWM of streams where no obvious slope break is present, except as necessary for yarding corridors or road crossings.

2) Yarding corridors will be allowed as detailed in Table 5-2. Specialized equipment may be necessary to meet this objective.

3) Landings shall not be placed in and should be avoided adjacent to steep inner gorges. Any landings adjacent to inner gorges shall be pulled back and stabilized following completion of harvest or prior to end of seasonal operations.

Justification for Prescriptions:

Sidecast material on steep slopes was a major cause of previous mass wasting in this MWMU and is prohibited in this prescription. Avoidance of excessive or oversteepened cutslopes will provide additional protection for landslides triggered above the roadway. In most cases, cutslopes determined by sound geologic and engineering principles will likely remain stable. A bridge should pass debris flows that could be generated or transported through inner gorges. Temporary crossings will minimize the potential for debris flow initiation or culvert blockage. Additionally, areas with less than 5 foot of fill at centerline will input minor amounts of sediment compared to the volume of the debris flow and cause less damage to resources downstream should there be a failure.

No harvest is allowed within inner gorges because of the naturally high rate of landsliding and the importance of root strength in stabilizing slopes. The intent of a 20-foot no-cut buffer beyond the slope break is to leave 1-2 crown widths of trees above the slope break for rooting strength. Yarding corridors should not be wider than a tree crown. A maximum impacted area of 20 percent should maintain the integrity of the buffer, yet allow for operations.

CAUSAL MECHANISM REPORT AND PRESCRIPTION #6

Resource Sensitive Area: MWMU-10 (undissected hillslopes)
Mass Wasting Module, Figure 4A-2

Landslide Processes: debris avalanche, debris flow, and potential debris source for dam-break-flood initiation

Input Variables: coarse and fine sediment

Delivered Hazard Rating: MODERATE

Resource Vulnerability: MODERATE

Rule Call: MINIMIZE

Situation Statement:

The planar, divergent, and moderate-gradient slopes within MWMU-10 commonly restrict delivery of landslide debris to surface waters. Nevertheless, debris avalanches can travel moderate distances across undissected hillslopes to reach streams or draws where debris flows may initiate. Subsequent debris-flow runout to higher-order channels has potential to generate dam-break floods capable of reaching the Green River. The sediment thus delivered and routed through the channel can degrade fish habitat (primarily by filling pools, scouring channels, redistributing wood, and smothering gravel). Debris flows and dam-break floods also promote long-term indirect impacts to fish habitat (e.g., decreased shading, diminished wood recruitment, and increased erosion on denuded sideslopes) by degrading conditions in the riparian zone.

Triggering Mechanisms:

Undissected hillslopes are relatively stable in an undisturbed state, but the steeper slopes within the unit exhibit a marked sensitivity to roading. Road fills and landings are the principal sources of debris avalanches within the unit; drainage accumulation along long declines may have contributed to some of these failures. In the absence of unusually steep or locally convergent slope forms, the potential for sediment delivery to streams diminishes as the distance between roads and streams increases.

Although timber harvest is generally a secondary concern, it can nevertheless trigger debris avalanches on steeper slopes by decreasing the shear strength of materials in the root zone.

Slopes of 35 degrees (or greater) with convergent slope forms will exhibit the greatest sensitivity to timber harvest. Diversion of road drainage onto steep convergent slope segments within the unit is also likely to contribute to landslide initiation in these areas. As with roads, the potential for sediment delivery to streams is commonly restricted by intervening planar or moderate-gradient slopes.

Landslide-hazard mapping would ideally exclude all steep convergent slope segments from MWMU-10, but as it is mapped, such terrain is likely to occur locally within the unit.

Prescriptions:

1) Conduct field inspection of the area planned for timber harvest or road construction to identify areas of active mass wasting or potential instability as defined by MWMU #9 (inner gorges) and MWMU #11 (headwall topography). If areas meeting the description of MWMU #9 or #11 are found within MWMU #10, follow appropriate prescriptions. At a minimum, in areas where there is evidence of landslide activity, a buffer strip of at least 20 feet from landslide scars or associated slope breaks shall be left. If no areas of potential instability are found, standard rules apply.

2) Avoid road construction on continuous slopes that exceed 70% and can deliver sediment directly to streams. If unavoidable, use of road construction prescriptions as outlined in Prescription Report #7 (MWMU #11)is required.

Justification for Prescriptions:

Undissected hillslopes can include highly unstable areas, but in comparison to MWMU #11, these areas are localized and infrequent. The localized areas of instability within MWMU #10 cannot be accurately mapped at 1:24,000 scale; therefore, land managers must delineate these features in the field.

CAUSAL MECHANISM REPORT AND PRESCRIPTION #7

Resource Sensitive Area:	MWMU-11 and -11A (headwall topography) Mass Wasting Module, Figure 4A-2
Landslide Processes:	rock fall, snow avalanche (11A), debris avalanche, debris flow, debris source for dam-break-flood initiation, (and earth slump?)
Input Variables:	coarse and fine sediment
Delivered Hazard Rating:	HIGH
Resource Vulnerability:	HIGH
coarse sediment:	1, 3, 4, 5; A1, A6, A11, A15, A16, A17, A19, A22, A24, A32, A33, A34; C9, C2, C1; D1, D2; E17, E15, E1; H17, H1; I7, I23, I21, I19; K25, K24, K22, K1
fine sediment:	1, 3, 4, 5; A33; C1; D1, D2; E1; H1; K1
Rule Call:	PREVENT or AVOID

Situation Statement:

Debris avalanches and rock fall supply coarse and fine sediment to the head of the channel network where snow avalanches and debris avalanches entering first-order streams and draws commonly initiate debris flows. Debris-flow runout to higher-order channels can generate dam-break floods capable of reaching the Green River. The sediment thus delivered and routed through the channel can degrade fish habitat (primarily by filling pools, scouring channels, redistributing wood, and smothering gravel). Debris flows and dam-break floods also promote long-term indirect impacts to fish habitat (e.g., decreased shading, diminished wood recruitment, and increased erosion on denuded sideslopes) by degrading conditions in the riparian zone.

Triggering Mechanisms:

Snow avalanche (restricted to MWMU-11A): MWMU-11A and MWMU-11 are alike with respect to all triggering mechanisms except for those pertaining to snow-avalanche initiation. The loss of tree trunks and forest canopy to fires early in this century contributed to snow-avalanche initiation on upper slopes within MWMU-11A (and it may have also enabled the runout to travel farther downslope). The snow avalanches typically initiated debris flows upon entering confined channels. Trunk and canopy removal probably contributed to snow-avalanche initiation by allowing greater thicknesses of snow to accumulate, by subjecting the accumulated snow to wider diurnal temperature variation, and by removing roughness elements (i.e., tree trunks) that offered frictional resistance to sliding.

MWMU-11 and MWMU-11A are similar to MWMU-9 (and dissimilar to most other MWMUs) in that the sensitivity to roading is not appreciably greater than the sensitivity to timber harvest. Road fills, landings, and road/stream crossings are a major source of debris avalanches in this unit.

The failures at road/stream crossings occurred downstream of harvest units, and logging debris probably contributed to these failures by blocking culverts. Drainage accumulation along long declines probably contributed to some of the road-fill and landing failures as well. Roads and landings located close to draws or streams have the greatest potential for initiating debris flows.

Timber harvest triggers debris avalanches on steep slopes by decreasing the shear strength of materials in the root zone. Slopes of 35 degrees (or greater) with convergent slope forms will exhibit the greatest sensitivity to timber harvest. Bedrock hollows (as well as inner gorges along the lower portions of draws) are particularly sensitive to decreased root strength because they include thick colluvium that is predisposed to saturation during storms. Road drainage diverted into draws and bedrock hollows can also induce landsliding by elevating pore pressures to reduce shear strength.

Debris avalanches and snow avalanches in this unit routinely initiate debris flows upon entering streams, draws, or the inner gorges upon which they typically verge. The runout from debris flows can generate dam-break floods in higher-order receiving channels.

Prescriptions for MWMU #11 and #11A:

***Road Construction*:**

1) Avoid road construction in MWMU #11. This is the preferred alternative.

2) Conduct a field inspection of the area planned for road construction in MWMU #11 to identify any areas that do not meet the definition for MWMU #11 or have evidence of potential instability. Road construction according to standard practices is allowed within low hazard inclusions of MWMU #11.

3) If road construction occurs in MWMU #11, switchbacks shall not be placed on slopes greater than 50 percent.

4) If road construction occurs in MWMU #11 on slopes greater than 60%, the following standards shall be used:

   a) Full bench construction is required and all excess material must be end-hauled to a stable location shown on the harvest (forest practice application) map.

   b) Relief culverts shall not empty into concave topographic features that naturally concentrate subsurface water (i.e., hollow or swale), inner gorges, and long steep linear draws.

   c) Excessive or oversteepened cutslopes will be avoided.

   d) Maintain natural drainage by placing culverts at springs and seeps.

   e) Stream crossings will have either a:

      i) permanent crossing consisting of a bridge or hardened ford with dip out of cement or clean pit-run rock,

      OR

      ii) temporary stream crossing that meets the following standards:

         a) Minimum fill at stream/draw crossings.

         b) Fill material over the culvert will be composed of clean material (very little fines).

         c) Culverts will be one standard size larger than Forest Practice Manual recommendations for the 50-year flood.

         d) All culverts will be inspected annually and after larger storms (as accessible) with maintenance as required.

         e) Temporary crossings will have all fill and culverts pulled after completion of reforestation activities, but no later than three years after construction of the road.

5) Field review or geotechnical report by a qualified specialist and approved by the DNR is

required for road construction on slopes with gradients of 70% or greater if the slopes are dissected by long linear draws or bedrock hollows or show evidence of seasonal saturation (as indicated by the presence of Devil's club, seeps or other indicators) or past instability. Field review is also required for permanent stream crossings utilizing fills. As noted above, no field review is required for temporary stream crossings utilizing fills of less the 5 feet at centerline (to be abandoned within three years of construction) or for permanent stream crossings utilizing bridges or hardened fords.

6) Present or potential mass wasting hazards associated with existing roads within this MWMU will be addressed in the Road Hazard Reduction Plan detailed in Prescription Report #11.

Timber Harvest:

1) No harvest is allowed within inner gorges, including a 20-foot buffer beyond the break in slope; OR within 50 feet of the OHWM of streams where no obvious slope break is present, except as necessary for yarding corridors or road crossings.

2) No harvest is allowed in headwall areas, as identified on-the-ground, within MWMUs 11 and 11A.

3) Yarding corridors will be allowed as detailed in Table 5-2. Specialized equipment may be necessary to meet this objective.

4) Landings shall not be placed in and should be avoided adjacent to steep inner gorges. Any landings adjacent to inner gorges shall be pulled back and stabilized following completion of harvest or prior to end of seasonal operations.

Justification for Prescriptions:

The high potential for initiation of debris flows within MWMU #11 and direct delivery to fish-bearing streams warrants extreme caution. Sidecast material on steep slopes was a major cause of previous mass wasting in this MWMU and is prohibited in this prescription. Avoidance of excessive or oversteepened cutslopes will provide additional protection for landslides triggered above the roadway. In most cases, cutslopes determined by sound geologic and engineering principles will likely remain stable. A bridge should pass debris flows that could be generated or transported through inner gorges. Temporary crossings will minimize the potential for debris flow initiation or culvert blockage. Additionally, areas with less than 5 foot of fill at centerline will input minor amounts of sediment compared to the volume of the debris flow and cause less damage to resources downstream should there be a failure.

No harvest is allowed within headwall areas because of the naturally high rate of landsliding and the importance of root strength in stabilizing slopes. The intent of a 20-foot no-cut buffer beyond the slope break is to leave 1-2 crown widths of trees above the slope break for rooting strength. On slopes with lower potential for debris flow initiation, a number of precautionary actions are outlined, while those with a higher potential will require expert review prior to any activity. The localized areas without potential instability cannot be accurately mapped at 1:24,000 scale; therefore, land managers or slope stability specialist must delineate these features in the field. Yarding corridors should not be wider than a tree crown. A maximum impacted area of 20 percent should maintain the integrity of the buffer, yet allow for operations.

Additional Prescriptions for MWMU #11A:

1) Timber harvest and road construction in MWMU #11A will incorporate the prescriptions for MWMU #11.

2) Additional prescriptions for timber harvest will be based on the amount of area in various timber conditions as presented below. Prescriptions may include various combinations of partial cuts, high-stump clearcuts, and regular clearcuts.

   a) Within the identified sub-basins of MWMU #11A, a percentage of the area must be left in the vegetative conditions outlined in the table below.

Sub-Basin	Applicable Distance from Ridgeline (feet)	Percent Functional Timber (min.)	Percent Partial Cut (max.)	Percent High-stump Clearcut (max.)	Percent Open (max.)
Wolf	700	40	60	10	25
Green Canyon	1000	40	60	10	25
McCain	1000	40	60	10	25
Rock	700	40	60	10	25
Lester	700	40	60	10	25
Sawmill	1000	40	60	10	25

   b) Because the scale of mapping leads to approximate boundaries for mass wasting units, the prescriptions will apply only within the specified distances from the ridgeline as noted in the table. The specified distance for the Wolf Creek drainage, however, will be measured from the slope break at the upslope margin of the map unit (Figure 4A-2) For portions of MWMU #11A mapped further downslope (i.e., beyond specified distance from ridgeline), only prescriptions for MWMU #11 will apply.

c) The area of MWMU #11A for each sub-basin listed in the table, as well as treatment area, can be estimated (using GIS, planimeter, etc.) based on the mass wasting hazard map (Figure 4A-2) alone or from field surveys that delineate the actual boundary of the map unit. For categorization of vegetative condition, the minimum patch size is 10 acres.

d) Functional timber is defined as trees that on average have reached a minimum of 15 feet in height and 4 inches dbh with a density of at least 50 trees per acre.

e) Partial cuts are defined as harvests that leave a minimum of 50 trees per acre as defined above (15 feet in height, 4 inches dbh) evenly distributed.

f) High-stump clearcuts are defined as harvests that leave a minimum of 50% of the trees harvested with at least 5-foot high stumps as measured from the uphill side and evenly distributed.

g) Open areas are defined as areas that do not meet the definition for functional timber or high stump clearcuts, whether natural or timber management related.

Justification for Prescriptions:

The precise amount of roughness needed to hold snow on hillslopes in MWMU #11A is uncertain, as are the most likely areas for avalanche initiation within the overall map unit. Maintaining mature timber and suitably sized young trees throughout substantial portions of the map-unit within each sub-basin will reduce the risk associated with removal of trees in limited areas. The prescriptions further provide timber harvest options that attempt to preserve roughness elements (high stumps (Saeki 1982), partial cuts) throughout most of the area. We encourage landowners to experiment with these various treatments (e.g., vary the height and distribution of stump heights) to improve our understanding of timber harvesting effects on snow avalanche initiation. In combination, these prescriptions should minimize and distribute incurred risks and provide the basis for future refinements through monitoring.

CAUSAL MECHANISM REPORT AND PRESCRIPTION #8

Resource Sensitive Area: MWMU-12 (escarpments along the Green River)
Mass Wasting Module, Figure 4A-2

Landslide Processes: debris avalanche, and debris flow potential

Input Variables: coarse and fine sediment

Delivered Hazard Rating: HIGH

Resource Vulnerability: HIGH
coarse sediment: 1, 3, 4, 5
fine sediment: 1, 3, 4, 5

Rule Call: PREVENT or AVOID

Situation Statement:

Debris avalanches on steep slopes within this unit can travel downslope to the Green River and have potential to initiate debris flows that can reach the Green River. The delivered sediment can degrade fish habitat by filling pools and smothering gravel.

Triggering Mechanisms:

Debris avalanches in this unit have a high potential for direct sediment delivery given the proximity of steep slopes to the Green River. Otherwise, this unit is generally similar to MWMU-10 (undissected hillslopes).

Road fills and landings on steep slopes within the unit have the greatest potential for triggering debris avalanches. Although timber harvest is generally a secondary concern to roading, it has potential to trigger debris avalanches on steeper slopes by decreasing the shear strength of materials in the root zone. Terrace escarpments along the Green River and slopes of 35 degrees (or greater) with convergent slope forms will exhibit the greatest sensitivity to timber harvest. Diversion of road drainage into convergent slope forms may also contribute to landslide initiation in these areas.

Prescriptions:

Road Construction:

1) Avoid road construction in MWMU #12. This is the preferred alternative.

2) If unavoidable, road construction can occur in MWMU #12 on slopes > 60% if the following standards are used:

   a) Full-bench construction is required and all excess material must be end-hauled to a stable location shown on the harvest (forest practice application) map.

   b) Stream crossings (with perennial or intermittent flow) will have either a:

      i) permanent crossing consisting of a bridge or hardened ford with dip out of cement or clean pit-run rock,

      OR

      ii) temporary stream crossing that meets the following standards:

         a) Minimum fill at stream/draw crossings.

         b) Fill material over the culvert will be composed of clean material (very little fines).

         c) Culverts will be one standard size larger than Forest Practice Manual recommendations for the 50-year flood.

         d) All culverts will be inspected annually and after larger storms (as accessible) with maintenance as required.

         e) Temporary crossings will have all fill and culverts pulled after completion of reforestation activities, but no later than three years after construction of the road.

3) Relief culverts shall not empty into concave topographic features that concentrate flow of water (i.e., hollow or swale).

Timber Harvest:

1) If slopes are greater than 70%, and harvest is planned within concave topographic features that concentrate flow of water (i.e., hollow or swale), a geotechnical report must be prepared. Timber harvest may proceed only after a site-specific analysis concludes that the planned harvest will not significantly increase the probability of mass wasting from the site.

Justification for Prescriptions:

The high potential for delivery directly into the Green River warrants extreme caution on steep slopes. Concave topographic features (i.e., hollows or swales) on steep slopes are the primary initiation site for mass wasting events; therefore, prescriptions address potential increases in water flow or loss of root strength as a result of timber management in these areas. Sidecast material on steep slopes can also be a major cause of mass wasting in this MWMU and is prohibited in this prescription.

CAUSAL MECHANISM REPORT AND PRESCRIPTION #9

Resource Sensitive Area: MWMU-13 (lower canyons of mainstem tributaries)
Mass Wasting Module, Figure 4A-2

Landslide Processes: rock fall, earth slump, debris avalanche, and debris source for dam-break-flood initiation

Input Variables: coarse and fine sediment

Delivered Hazard Rating: HIGH

Resource Vulnerability: HIGH
coarse sediment: 1, 3, 5; C9, C2, C1; E15, E1; K1
fine sediment: 1, 3, 5; C1; E1; K1

Rule Call: PREVENT or AVOID

Situation Statement:

Debris avalanches and earth slumps on steep lower slopes can deliver coarse and fine sediment directly to the lower reaches of Green River tributaries. Debris avalanches on steep upper slopes have potential to initiate debris flows in confined draws, and the debris-flow runout has potential to generate dam-break floods capable of reaching the Green River. The sediment thus delivered and routed through the channel can degrade fish habitat (primarily by filling pools, scouring channels, redistributing wood, and smothering gravel). Debris flows and dam-break floods also promote long-term indirect impacts to fish habitat (e.g., decreased shading, diminished wood recruitment, and increased erosion on denuded sideslopes) by degrading conditions in the riparian zone.

Triggering Mechanisms:

All of the recorded landsliding in the unit has occurred in association with unmanaged, unroaded, immature to mature fire-regeneration stands. It is reasonable to conclude based on geomorphic similarities with other units (e.g., MWMU-3, -8, -10, -11, and -12) that road fills, landings, and road drainage can generate debris avalanches, and that these failures can become channeled into debris flows if they enter confined draws.

Timber harvest has potential to trigger debris avalanches on steeper slopes by decreasing the shear strength of materials in the root zone. Bedrock hollows and slopes of 35 degrees (or greater) with convergent slope forms will exhibit the greatest sensitivity to timber harvest. Diversion of road drainage into convergent slope forms may also contribute to landslide initiation in these areas.

Fires in the early part of the century may have had a profound influence on the thin and rocky soils in this unit, which are poorly aggregated and easily dislodged. It is worthwhile to note that surface erosion associated with yarding across these soils has potential to introduce fine sediment into streams.

Prescriptions:

Road Construction:

1) Avoid construction of roads and landings in MWMU #13. This is the preferred alternative.

2) If unavoidable, roads on slopes >65% shall have full bench construction and all excess material must be end-hauled to a stable location shown on the harvest (forest practice application) map.

3) Relief culverts shall not empty into concave topographic features that concentrate flow of water (i.e., hollow or swale).

4) Full bench construction shall not be compromised if road construction crosses rock ledges.

5) Road locations shall avoid or at least minimize crossings of confined topography within the hillslope, such as inner gorges, confined draws, and bedrock hollows. If these features meet the descriptions of other mass wasting map units (e.g., MWMU #9 and #11), those additional prescriptions will apply.

6) Road construction shall not occur on lower slopes where earth slumps are present without a Geotechnical Evaluation.

7) Any landings constructed within, or along the margin of this map unit shall be pulled back and stabilized after the associated harvest unit is logged.

Timber Harvest:

1) A geotechnical evaluation shall be completed if timber harvest is planned on lower slopes within 100 feet of:

   a) a recent earth slump larger than 50 feet in any dimension (i.e., slumps with barren scarps or aberrant deciduous vegetation,

   OR

   b) areas with evidence of concentrated debris avalanche activity or heightened potential (conditions most commonly occurring in association with oversteepened slopes or active bank cutting).

2) On middle and upper slopes, timber harvest shall set back 20 feet from the slope break above any inner gorge with side slopes of 70% or greater. If no obvious slope break is present, a set back of at least 50 feet from the ordinary high water mark shall be used.

3) A Geotechnical Evaluation is required if harvest is proposed in bedrock hollows and they feed into more pronounced concave features such as an inner gorge or a long, steep, linear draw if hillslope gradients locally exceed 70%.

   AND

   a) there is evidence of seasonal saturation expressed by seeps or vegetation such as Devil's club

   OR

   b) other bedrock hollows in the neighborhood show evidence of recent or systemic activity.

   OR

   c) if the axis of the hollow is greater than 70%.

Justification for Prescriptions:

As landslides originating in this map unit have a high probability of delivering sediment to streams, road construction and timber harvest should avoid sites where landslides are most likely to initiate (i.e., in association with slope gradients in excess of 60-70%, with convergent slope forms, and in areas where there is evidence of past landslide activity). The prescriptions for road construction across such areas, in cases where viable alternatives do not exist, require full excavation of the road bed to eliminate fill slopes and thus minimize the potential for debris avalanche.

CAUSAL MECHANISM REPORT AND PRESCRIPTION #10

Resource Sensitive Area:	Existing Roads Associated with High or Moderate Mass Wasting Hazards (MWMUs #3, #4, #5, #6, #7, #9, #10, #11, #12, and #13) Mass Wasting Module, Figure 4A-2
Landslide Processes:	initiation of landslides, debris torrents, and dam-break floods
Input Variables:	fine and coarse sediments and LWD.
Delivered Hazard:	HIGH for MWMUs #3, 4, 7, 9, 11, 12, and 13 MODERATE for MWMUs #5, 6 and 10
Resource Vulnerability:	Varies with reach. Most reaches located downstream from high mass wasting areas have the potential to be impacted (Refer to Figures 4A-2 and 4E-1).
Rule Call:	PREVENT OR AVOID / MINIMIZE (Dependent on stream reach).

Situation Sentence:

Existing roads within areas of potential instability (as described by MWMUs #3, 4, 7, 9, 11, 12, and 13) have the possibility to trigger landslides or debris torrents deliverable to fish-bearing waters. Coarse and fine sediments from these inputs may negatively impact potential spawning and rearing habitat.

Triggering Mechanism:

Roads and landings located close to draws or streams have the greatest potential for initiating debris flows. Failures at road/stream crossings occurring downstream of harvest units may have likely been triggered by culverts blocked with logging debris. Road drainage directed into confined topography within the mass wasting units can also decrease shear strength and contribute to landsliding by elevating pore pressures (and possibly by accelerating subsurface weathering as well). Drainage accumulation along long declines probably contribute to some of the road fill and landing failures. Road cuts and road fills also have potential to trigger landslides by increasing the shear stress in marginally stable slopes (i.e., by loading the head or unloading the toe of the slope).

Road surface erosion is triggered when vulnerable soils within the road prism are impacted by vehicle traffic and/or heavy equipment on an on-going basis, liberating fine sediment that is washed into streams by spring melt and rain.

Older road design, construction and maintenance techniques have dramatically increase mass wasting rates. Although subsequent repairs have erased specific failure mechanisms, likely contributors to road/ landing failures or excessive erosion may be:

1) oversteepened or poorly constructed or compacted sidecast road fills;
2) road drainage piracy or undersized/damaged culverts which may cause saturation of road fill material increasing the likelihood of failure;
3) excessive and oversteepened cutslopes which may trigger landslides above the road;
4) inadequate number of drainage relief culverts (especially in the vicinity of stream crossings); and,
5) infrequent road maintenance that may fail to correct potential problems prior to initiating a failure.

Prescriptions:

1) All existing roads within areas of high mass wasting potential (MWMUs #3, 4, 7, 9, 11, 12, and 13) will be evaluated by a specialist in slope stability and road construction/repair (as detailed in Section 5.2) for their likelihood to initiate a mass wasting event. The findings of the specialist's evaluation, along with proposed corrections or mitigation, will be incorporated into a Road Restoration Plan developed by the landowner and submitted to the DNR within one year of approval of this Watershed Analysis.

   The Road Restoration Plan submitted by the landowner or resource manager will include a prioritization and timetable for the road repairs or restorations to be made. In addition, the plan shall identify a method for inspecting roads for damage (or impending damage) immediately following major storm events. Subject to DNR approval, the plan may be amended depending on weather, emergency repair priority, or other circumstances beyond the landowner's control.

Voluntary Prescriptions:

1) All existing roads within areas of high road surface erosion potential will be evaluated by a

specialist in surface erosion and road construction (as detailed in Section 5.2) for their likelihood to contribute to road surface erosion as outlined in Causal Mechanism and Prescription Report #12 and 13 (Road Surface Erosion). This evaluation may be included in the Road Restoration Plan described above.

2) All existing roads within areas of moderate mass wasting potential (MWMUs #5, 6 and 10) will be evaluated by a specialist in slope stability and road construction (as detailed in Section 5.2) for their likelihood to initiate a mass wasting event. The findings of this evaluation, along with proposed corrections or mitigation, will be incorporated into the Road Restoration Plan described above.

Justification for Prescriptions:

Most past landslides and debris flows originated from failures associated with road/stream crossings in high mass-wasting hazard areas. Cursory maintenance may correct many potential triggering situations; however, a more intensive inspection and repair program aimed primarily at high hazard areas will significantly decrease the likelihood of road-related failures impacting fish-bearing waters.

Undoubtedly, areas of high mass-wasting hazard potential exist within zones mapped as low hazard (and vice versa), for this reason, the evaluation should be made by a specialist in both slope stability and road construction/repair to determine potential hazard and recommend proper correction or mitigation based on sound engineering principles.

CAUSAL MECHANISM REPORT AND PRESCRIPTION #11

Resource Sensitive Area: Hillslopes within 20 feet of stream channels
Surface Erosion Module, Figure 4B-3

Input Variable and Process: Fine sediment from surface erosion

Resource Sensitivity: All channel segments within the Lester WAU

Delivered Hazard Rating: HIGH

Resource Vulnerability HIGH

Rule Call: PREVENT or AVOID

Situation Statement:

Surface erosion from exposed mineral soils immediately adjacent to fish-bearing stream channels contribute fine sediments to the channels which reduces water quality in the Lester WAU. Fine sediment deposition in riffles and pools fill the interstitial spaces in gravels, thereby negatively reducing spawning and winter rearing habitat for resident and anadromous fish.

Triggering Mechanism:

Fine sediment delivered to stream channels within the Lester WAU may originate from gullies leading from skid trails or other compacted areas to the stream channels.

Prescriptions:

1) Within 20 feet of a stream, avoid disturbance of soil and understory vegetation. Any exposed soil that will deliver sediment directly to streams shall be revegetated or treated by other erosion control measures.

2) At a minimum, front end suspension is required for cable yarding across defined draws/channels. Full suspension or bump logs may be necessary in cases with potential for extensive disturbance. Ground-based yarding shall not skid logs through defined draws and channels that route surface water. Where soil disturbance has occurred grass seeding, straw bales or other preventative measures for reducing sediment into the stream channels shall be incorporated.

3) Within 20 feet of streams, leave embedded logs, stumps, and root wads.

Justification for Prescriptions:

Eliminating soil disturbance within 20 feet of streams should prevent management-related increases in surface erosion. Yarding away from defined draws will reduce exposed soil near a water source which can route sediment into streams.

CAUSAL MECHANISM REPORT AND PRESCRIPTION #12

Resource Sensitive Area: Direct-entry road surfaces and management-related mass wasting scarps within the Champion Creek and Friday Creek sub-basins
Surface Erosion Module, Figure 4B-4

Input Variable and Process: Fine sediment from surface erosion

Delivered Hazard Rating: HIGH

Resource Vulnerability: Channel segments within the Friday Creek, Champion Creek and lower mainstem Green River sub-basins.

Resource Vulnerability: HIGH

Rule Call: PREVENT or AVOID

Situation Statement:

Surface erosion from the cutslopes and road treads of direct entry road segments contributes fine sediment to Friday Creek, Champion Creek and the lower mainstem Green River. In addition, surface erosion of direct entry management-related mass wasting scarps ("secondary erosion") contributes fine sediment. The ratio of fine sediment contribution from direct entry roads and management-related mass wasting compared to the background sediment yield (which includes surface erosion from non-management related mass wasting scarps) for the sub-basin suggests that fine sediment from management activity is sufficient to produce detectable increases in turbidity, which reduces water quality in the Friday and Champion Creek sub-basins and downstream on the mainstem Green River. Fine sediment deposition in riffles and pools fill the interstitial spaces in gravels, thereby negatively impacting spawning habitat and reducing winter rearing habitat for resident and anadromous fish.

Triggering Mechanisms:

Fine sediment delivered to Friday Creek originates from 1) cutslopes, fillslopes, and road treads of logging roads; and 2) secondary erosion of direct-entry mass wasting scarps within the Friday Creek sub-basin. Surface erosion is greatest from: 1) sparsely vegetated cutslopes; road treads which are subject to frequent log truck traffic; sparsely vegetated fillslopes; and to a lesser degree 2) sparsely vegetated mass wasting scarps.

Additional Comments:

Secondary erosion of management related mass wasting scarps accounts for 26% of the management-related sediment delivery increase. Mitigation of the contributing mass wasting scarps may not be feasible

Prescriptions:

1) A road maintenance, improvement and abandonment plan shall be developed and implemented by the landowners on an annual basis. The plan shall meet or exceed the objective of reducing fine sediment delivery from road surface erosion down to 50% of background levels (natural sediment inputs as defined by the sediment budget in the Surface Erosion report) within the next five years. The road surface erosion model used in the Surface Erosion Module Version 2.1 shall be applied by the landowner to judge the adequacy of planning efforts to satisfy the 50% background objective.

2) Annual targets provide a schedule for the attainment of the sediment reduction goal over the 5-year period. Each annual target can be met through any combination of road improvement, maintenance or abandonment work. The following is a breakdown of the *cumulative* yearly target schedule:

   Year 1 - 15% sediment reduction of the five year total needed
   Year 2 - 40% sediment reduction of the five year total needed
   Year 3 - 70% sediment reduction of the five year total needed
   Year 4 - 90% sediment reduction of the five year total needed
   Year 5 -100% sediment reduction of the five year total needed

   The targets are not absolute, but the landowners are required to substantially make up any shortcomings in a given year by the end of the following season. Any new road construction plans with their expected sediment delivery from cutslopes, fillslopes, and the road surface, will also be factored into the total sediment reduction targets for the sub-basin. The plans will be reviewed annually by the DNR to ensure that sediment reduction targets are being achieved.

3) A reassessment of surface erosion from roads along with a review of this prescription may be conducted if one of the following occurs:

   a) monitoring of sediment delivery indicates that the model does not accurately predict sediment delivery to streams in the Lester watershed,

   OR

   b) the Surface Erosion module of Watershed Analysis undergoes substantial change, so that the assessment procedures used in Version 2.1 are no longer appropriate.

Justification for Prescriptions:

The objective of the prescriptions is to reduce sediment delivery from existing and new roads to 50% or less over background rates at the end of five years. At a 50% level, road surface erosion should be in a low hazard and allow the resource an opportunity to recover. Annual targets have also been established to provide additional direction on meeting the objective.

Surface erosion from management-related mass wasting scarps account for 40%and 26% of the management-related sediment delivery increase over background levels in Champion and Friday Creek respectively. As described in the Additional Comments section of this Causal Mechanism Report, the mitigation of the contributing mass wasting scarps is not feasible. Therefore, this prescription focused only on the road related surface erosion.

CAUSAL MECHANISM REPORT AND PRESCRIPTION #13

Resource Sensitive Area: Direct-entry road surfaces and management related mass wasting scarps within the Morgan Creek, Rock Creek, and Upper Mainstem sub-basins.
Surface Erosion Module, Figure 4B-4

Input Variable and Process: Fine sediment from surface erosion

Resource Vulnerability: MODERATE
Channel segments within Morgan Creek, Rock Creek and mainstem Green River.

Delivered Hazard Rating: MODERATE

Rule Call: MINIMIZE

Situation Statement:

Surface erosion from the cutslopes and road treads of direct entry road segments contributes fine sediment to Morgan Creek, Rock Creek and the mainstem Green River. In addition, surface erosion of direct entry management-related mass wasting scarps ("secondary erosion") contributes fine sediment. The ratio of fine sediment contribution from direct entry roads and management-related mass wasting compared to the background sediment yield (which includes surface erosion from non-management related mass wasting scarps) for the sub-basin suggests that fine sediment from management activity is sufficient to produce detectable increases in turbidity, which reduces water quality in the Morgan and Rock Creek sub-basins and on the mainstem Green River. Fine sediment deposition in riffles and pools fill the interstitial spaces in gravels, thereby negatively impacting spawning habitat and reducing winter rearing habitat for resident and anadromous fish.

Triggering Mechanisms:

Fine sediment delivered to Morgan Creek, Rock Creek and the mainstem Green River originates from: 1) cutslopes, fillslopes, and road treads of logging roads; and 2) secondary erosion of direct-entry mass wasting scarps. Surface erosion is greatest from: 1) sparsely vegetated cutslopes; road treads which are subject to frequent log truck traffic; sparsely vegetated fillslopes; and to a lesser degree 2) sparsely vegetated mass wasting scarps.

Additional Comments:

Secondary erosion of management related mass wasting scarps accounts for 3%, 50% and 4%, respectively, of the management-related sediment delivery increase in Morgan Creek, Rock Creek, and Upper Mainstem sub-basins. Mitigation of the contributing mass wasting scarps may not be feasible

Prescriptions:

1) A road maintenance, improvement and abandonment plan shall be developed and implemented by the landowners on an annual basis. The plan shall meet or exceed the objective of reducing fine sediment delivery from road surface erosion down to 50% of background levels (natural sediment inputs as defined by the sediment budget in the Surface Erosion report, section 4B) within the next five years. The road surface erosion model used in the Surface Erosion Module Version 2.1 (WFPB 1994) shall be applied by the landowner to judge the adequacy of planning efforts to satisfy the 50% background objective.

2) Annual targets provide a schedule for the attainment of the sediment reduction goal over the 5- year period. Each annual target can be met through any combination of road improvement, maintenance or abandonment work. The following is a breakdown of the *cumulative* yearly target schedule:

   Year 1 - 15% sediment reduction of the five year total needed
   Year 2 - 40% sediment reduction of the five year total needed
   Year 3 - 70% sediment reduction of the five year total needed
   Year 4 - 90% sediment reduction of the five year total needed
   Year 5 -100% sediment reduction of the five year total needed

   The targets are not absolute, but the landowners are required to substantially make up any shortcomings in a given year by the end of the following season. Any new road construction plans with their expected sediment delivery from cutslopes, fillslopes, and the road surface, will also be factored into the total sediment reduction targets for the sub-basin. The plans will be reviewed annually by the DNR to ensure that sediment reduction targets are being achieved.

3) A reassessment of surface erosion from roads along with a review of this prescription may be conducted if one of the following occurs:

   a) monitoring of sediment delivery indicates that the model does not accurately predict sediment delivery to streams in the Lester watershed,

   OR

   b) the Surface Erosion module of Watershed Analysis undergoes substantial change, so that the assessment procedures used in Version 2.1 (WFPB 1994) are no longer appropriate.

Justification for Prescriptions:

The objective of the prescriptions is to reduce sediment delivery from existing and new roads to 50% or less over background rates at the end of five years. At a 50% level, road surface erosion should be in a low hazard and allow the resource an opportunity to recover. Annual targets have also been established to provide additional direction on meeting the objective.

Surface erosion from management-related mass wasting scarps account for 3%, 50%, and 4% respectively, of the management-related sediment delivery increase in Morgan Creek, Rock Creek and Upper Mainstem over background levels. As described in the Additional Comments section of this Causal Mechanism Report, the mitigation of the contributing mass wasting scarps is not feasible. Therefore, this prescription focused only on the road related surface erosion.

CAUSAL MECHANISM REPORT AND PRESCRIPTION #14

Resource Sensitive Area: East Fork Friday Creek and Sawmill Creek sub-basins
Hydrology Module, Figure 4C-7

Input Variable: Peak Flows

Delivery Hazard Rating: HIGH

Resource Vulnerability: HIGH

Rule Call: PREVENT or AVOID

Situation Sentence:

Increased frequency and magnitude of peak flows may cause accelerated erosion of the toes of slump/earthflows resulting in increased deposition of coarse and fine sediment in spawning and rearing habitats in side-channels of the Green River and in portions of Friday Creek and Sawmill Creek.

Triggering Mechanisms:

Clear-cut areas and immature regenerating forest stands generate more runoff in rain-on-snow storm events than mature forest stands because removal of the forest canopy exposes snow on the ground to warm winds that accelerate melt rates (rain-on-snow). Excess runoff increases peak stream flows. The magnitude of excess runoff depends on the elevation and age distribution of forest stands. The magnitude of excess runoff is greatest in new clear-cuts and sapling stands. The magnitude of excess runoff is reduced when a dense young stand of saplings is established and canopy closure of at least 10% is achieved and less than 75% of canopy is shrub and/or hardwood vegetation (Watershed Analysis Manual Version 2.1, WFPB 1994). These are the criteria for intermediate hydrologic maturity. When canopy closure reaches a minimum of 70 percent, and less than 75 percent of the canopy is shrub and/or hardwood, then the forest stand may be considered hydrologically mature. Functionally, a mature forest stand should intercept snow and shelter the forest floor from wind in a manner similar to that of a dense, mature forest stand.

Increases in the magnitude, duration, and frequency of peak flows increase the stream energy available to erode the toe of slump/earthflow features. Toe erosion may be manifested by persistent bank erosion and/or undermining the toe causing either local rotational slope failure or local shallow-rapid slope failure. Accelerated erosion of the toe of slump/earthflows may cause increases in the creep rate of earthflows, creating renewed erosion of the toe. Slump/earthflows are classified as very active or active; the former case presents a high hazard of deliverability. The sensitivity of the sub-basin to peak flows determines the peak flow hazard relating to slump/earthflow erosion.

Additional Comments:

Erosion at the toe of slump/earthflows in Sawmill Creek and Friday Creek is relatively intense. Although the threshold of sensitivity to peak flows is not exceeded under current forest cover conditions, the high hazard of delivery and high vulnerability of resources dictate that peak flow increases beyond 10 percent be proactively avoided.

The estimated magnitude of increases of peak flows for various combinations of stand age/density and elevation have been determined using methods developed in the hydrology module of the resource assessment. The peak flow sensitivity threshold is unlikely to be exceeded under the following conditions:

Friday Creek--Additional harvest of stands classified "dense" on the cover type map not to exceed 370 acres. This assumes no decrease in cover in areas classified as "sparse".

Sawmill Creek--Additional harvest of stands classified "dense" on the cover type map not to exceed 510 acres below 2800 feet elevation (rain-on-snow zone), 1020 acres between 2800 feet and 4000 feet (snow dominated zone), and 410 acres above 4000 feet (highland zone), a total of 1940 acres OR 1950 acres above 2800 feet OR 1740 acres in any combination of elevations.

The slump-earthflows mapped in the Mass Wasting module are located in the upper portion of the Friday Creek sub-basin and in the middle portion of the Sawmill Creek sub-basin. Timber harvest in portions of these sub-watersheds located outside of the drainage areas contributing to the channel segments adjacent to slump-earthflows would not be expected to increase the deliverability hazard. Therefore, prescriptions designed to address this hazard may appropriately exclude areas downstream from the slump-earthflows.

As the logged forest stands regenerate, their hydrologic maturity gradually increases. At some time in the coming decade, many stands in the Friday Creek sub-basin that are in an intermediate state of hydrologic maturity may become hydrologically mature. This will reduce the peak flow hazard in the Friday Creek sub-basin. The determination of hydrologic maturity may be made based on the criteria in Table C-1 of the hydrologic change module (WFPB 1994; summarized above under "Triggering Mechanism"). It is suggested that an additional field assessment be made to ascertain whether the size and structure of these forest stands are comparable to other stands in the area that are classified as dense, hydrologically mature forest stands.

Prescriptions:

1) For any harvest within the basin, provide on the forest practice application the current percentage of conifer stands that are less than 25 years old or less than 70 percent crown closure.

2) a) No even-age harvest permitted when 40% or more of the basin contributing to the deep-seated landslide is either less than 25 years old or less than 70 percent crown closure.

OR

b) Begin a monitoring program when 30% of the basin is hydrologically immature (less than 25 years old or less than 70 percent crown closure). Monitoring shall consist of erosion mapping (see page 5-2; Glossary) of the toe of the slumps and earth flows within the basin to evaluate creep rate. If no evidence of acceleration of erosion is shown after 3 years of monitoring, harvest may occur to the point where 50 percent of the basin is hydrologically immature.

OR

c) ***East Fork Friday Creek Sub-basin***–Additional harvest of stands classified "dense" on the cover type map in one of the following combinations (assuming no decrease in cover in areas classified as "sparse"):

i) up to 90 acres in the snow-dominated zone only (between 2800 and 4000 feet elevation)

OR

ii) all remaining dense stands (about 58 acres) in the highland zone (above 4000 feet) and up to 40 acres in the snow dominated zone.

OR

iii) all remaining dense stands (about 39 acres) in the rain-on-snow zone (below 2800 feet) and up to 40 acres in the snow-dominated zone.

Sawmill Creek Sub-basin--Additional harvest of stands classified "dense" on the cover type map not to exceed 510 acres below 2800 feet elevation (rain-on-snow zone), 1020 acres between 2800 feet and 4000 feet (snow dominated zone), and 410 acres above 4000 feet (highland zone), a total of 1940 acres, or 1950 acres above 2800 feet, or 1740 acres in any combination of elevations.

Justification of Prescriptions:

The high hazard of delivery and high vulnerability of resources dictate that peak flow increases beyond 10 percent be proactively avoided. Data suggest that 40% to 50% of a basin could be hydrologically immature before there would be this magnitude of increase in peak flows. Further research and monitoring is necessary for providing the most effective prescriptions. An adaptive management strategy is recommended with these prescriptions.

Appendix E
Tacoma Water Response to Six Principles of Project Operation and Design for the Howard Hanson Dam Additional Water Storage Project

(This Appendix includes material drawn from letters previously submitted by John Kirner, Deputy Water Superintendent, Tacoma Public Utilities to the National Marine Fisheries Service, U.S. Fish & Wildlife Service, Washington Department of Fish & Wildlife and the U.S. Army Corps of Engineers.)

On 28 October 1997, Tacoma Water (Tacoma) sent letters to the National Marine Fisheries Service (NMFS) and Washington Department of Fish & Wildlife (WDFW) requesting support for the proposed Howard Hanson Dam Additional Water Storage Project (AWS project) currently being planned as a cooperative project in the Green River watershed by Tacoma and the U.S. Army Corps of Engineers (USACE). Mr. Stelle, NMFS Regional Administrator, and Dr. Bern Shanks, then Director of WDFW, responded with letters indicating that ultimate support for the AWS project depended on an agreement that meets permit issuance criteria and provides for satisfactory implementation of six principles of project design and operation.

During subsequent discussions regarding the development of Tacoma's Habitat Conservation Plan (HCP) for its Green River Water Supply Operations and Watershed Protection, NMFS and WDFW staff requested that Tacoma respond in writing with a commitment to each of the six principles outlined in the letters. On 22 January 1999 and 26 March 1999, Tacoma submitted letters to the NMFS and WDFW describing Tacoma's response to the six principles. Tacoma's commitments to those principles have been incorporated into various conservation measures within the HCP and are identified in this Appendix to facilitate review of the commitment by all parties.

Tacoma's co-sponsor, USACE, has committed to implementing the six principles in the AWS project. The USACE identified its commitment in the Final Environmental Impact Statement for the Howard Hanson Dam AWS project. Its response can be found on pages 2-97 through 2-100 of Appendix I in the Environmental Impact Statement (see attachment). As local sponsor of the AWS project, Tacoma supports the USACE commitment to incorporate the referenced principles into the AWS project.

Tacoma also commits to these principles in the HCP for Green River Water Supply Operations and Watershed Protection. Tacoma's responses to the principles identified by NMFS and WDFW are provided below:

Principle No. 1) A clear commitment that Howard Hanson Dam refill and storage management will be dedicated and directed to fishery resource conservation and enhancement;

As noted in Chapters 2.3 and 2.7 of the HCP, the process of storing and releasing water at Howard Hanson Dam is a USACE activity; consequently, Tacoma will not be seeking coverage under Section 10 of the Endangered Species Act for those activities. However, Tacoma supports the USACE commitment to consider input from fish and wildlife resource agencies and the Muckleshoot Indian Tribe in operating Howard Hanson Dam.

As the USACE indicated in its response to the 9 June 1998 comments provided by the WDFW on the Draft Feasibility Report and Environmental Impact Statement for the Howard Hanson Dam AWS project (Appendix I, Additional Water Storage Project, Final Feasibility Study Report & Final EIS, August 1998), non-fishery resource needs are not a designated downstream delivery objective of Howard Hanson Dam. Where non-fishery downstream resource needs do not conflict with fishery objectives, USACE will attempt to satisfy multiple uses. Recommendations on the storage and release of water from Howard Hanson Dam will be developed through the USACE coordination with the Green River Flow Management Committee (Habitat Conservation Measure 2-02, Chapter 5 of the HCP).

Because of its public health responsibility to provide drinking water to 300,000 people, Tacoma is very concerned about the quality of water stored behind Howard Hanson Dam during the spring. The Safe Drinking Water Act prohibits Tacoma from delivering water with turbidity levels in excess of 5 nephelometric turbidity units (NTUs) to its customers. We understand that resource agencies and the Muckleshoot Indian Tribe are also concerned about the potential influences of turbidity on municipal water use. Early spring runoff can be more turbid than late spring runoff, and in the past, USACE has managed Howard Hanson Dam springtime refill operations to minimize the turbidity of water stored for low flow augmentation. This operational modification has sometimes resulted in the early evacuation of turbid water stored behind Howard Hanson Dam, followed by rapid refill with less turbid water later in the spring. Opportunities to manage flows to benefit fishery resources can be constrained if the reservoir pool is evacuated to purge stored turbid water. Although under the AWS project, USACE will store runoff beginning around 15 February of each year (one to two months earlier than current and past spring refill operations), Tacoma is committed to ensuring that the USACE springtime operation of Howard Hanson Dam will not be altered to meet municipal water quality standards in a manner that substantially reduces the fisheries benefits of the AWS project.

Representatives of the U.S. Fish & Wildlife Service (USFWS), NMFS, and the WDFW met with representatives of Tacoma on 25 February 1999 to discuss the three agencies' concerns regarding the management of flow from Howard Hanson reservoir during implementation of the Howard Hanson Dam AWS project. Agency staff expressed the concern that if water, collected in the reservoir during spring refill, were to contain turbidity levels unacceptable for public water supply use, Tacoma would request USACE to both release the turbid water and subsequently dramatically curtail reservoir discharge in order to quickly refill the pool with clean water. Tacoma representatives acknowledged this concern and outlined the course of action and operational safeguards it would follow to assure that no adverse impacts to fish and wildlife would result from the collection of a high turbidity pool.

Tacoma believes there is a low likelihood that a turbidity pool behind Howard Hanson Dam would cause a long-term public water supply operational problem. Tacoma has been advised by USACE that turbidity problems, which could occur during February, March, and in rare instances April, would clear up by late May or early June. This is a major issue for Tacoma since the continuing operation of the surface water supply as unfiltered depends in large part on the ability to provide the public with water that meets rigorous federal and state water quality standards. Tacoma will insist that additional evaluations of turbidity be conducted during the pre-construction engineering and design phase of the Howard Hanson Dam AWS project. This additional evaluation will consist of hiring a consulting firm skilled in the evaluation of public water supply turbidity concerns to review the Howard Hanson Dam operation and evaluate the nature of turbidity during high flow events on the Green River. If Tacoma is unable to be convinced that turbidity in stored water will settle by late May or early June, it would be forced to delay the AWS project until filtration of the Green River municipal water supply could be accomplished, or until an alternative source of supply to meet early summer municipal water needs has been developed.

Operationally, high turbidity periods on the Green River during the spring and early summer refill period would be accommodated through the use of Tacoma's groundwater sources in lieu of reliance upon Green River surface water. Tacoma currently has 72 million gallons per day (mgd) of groundwater capacity from the North Fork Green River well field. Unfortunately, this full capacity is not available except for brief periods during the winter. It can never operate for a sustained period at 72 mgd. The only time the well field can produce 72 mgd without a water level decline is during heavy rainstorms. Aquifer capacity declines during the summer and is at its lowest during the late summer and early fall. On the average, the North Fork well field capacity declines from 48 mgd in February to 24 mgd in June (Table E-1).

Table 1. North Fork well field sustained capacities (mgd) by month during Howard Hanson reservoir refill operations

February	March	April	May	June
48	36	24	24	24

In addition to reliance on the North Fork well field during high turbidity periods, Tacoma has groundwater supplies available in the Tacoma area. Tacoma's water rights in the vicinity of the City of Tacoma are approximately 90 mgd. This capacity coupled with the water available from the North Fork well field would meet Tacoma's demands for water in the event of a turbidity emergency on the Green River. Tacoma would rely on these two primary sources of groundwater to avoid the need to draw water from a turbid pool behind Howard Hanson Dam.

In the event that conditions were to occur that Tacoma is currently unable to foresee, Tacoma agrees to take every effort to avoid actions that would be detrimental to the Green River's natural resources as the City attempts to meet its obligation to protect public health and safety through the supply of water. Tacoma would impose water use restrictions consistent with drought conditions and would consult with resource agencies and the Muckleshoot Indian Tribe prior to requesting a modification of Howard Hanson Dam operations that might adversely impact Green River fisheries. Tacoma would not make such a request unless there was an imminent risk of violating Primary Drinking Water Standards along with the associated health risk of such a violation.

Principle No. 2) Continuous project operation during refill and storage management periods;

As described in Chapter 2.3 of the HCP, the process of storing and releasing water at Howard Hanson Dam is a USACE activity to be covered by Section 7 consultation with the NMFS and USFWS under the Endangered Species Act. Tacoma supports the USACE commitment to provide continuous project operation during the spring refill and summer storage management period. As local sponsor of the AWS project, Tacoma also supports the evaluation of project automation to improve responsiveness while reducing the level of project staffing.

Principle No. 3) A state-of-the-art snow pack monitoring and runoff forecasting system;

As described in Habitat Conservation Measure 2-11 in Chapter 5 of the HCP, Tacoma and USACE are committed to enhancing snowpack monitoring and will develop details of an expanded monitoring plan during the pre-construction engineering and design phase of the AWS project. Expanding the level of snowpack monitoring may improve the ability to forecast spring runoff and enhance the opportunity to manage flows in the Green River for fishery resources; however, snowpack runoff is only part of the total runoff pattern in the Green River basin. Because much of the basin is located at low elevation, both rain events and snowmelt can influence springtime runoff. Tacoma is investigating opportunities to improve precipitation forecasts. Since 1997, Tacoma has funded studies designed to improve long-term weather forecasts, and will continue to investigate methods to improve the reliability of runoff forecasts in the Green River basin.

Principle No. 4) Effective procedures for risk sharing between municipal supply and fishery resource needs, including use of municipal storage to meet fish needs, when storage flexibilities are not adequate;

Tacoma has a long history of responding to requests for reduced water withdrawals and effectively sharing water shortfalls during drought conditions. Measures have included short-term reliance on groundwater sources to meet water use demand. While Tacoma is committed to continuing its cooperative relationship with resource agencies and the Muckleshoot Indian Tribe, it cannot guarantee curtailment of water withdrawals beyond those already identified in the HCP. Measures constraining Tacoma's use of water from the Green River during drought conditions already include:

a) Phased implementation of the AWS project (see pages 2-98 and 2-99 of the USACE response to the 9 June 1997 comments from the WDFW on the Draft Feasibility Report and Environmental Impact Statement [attached]);

b) Constraints on the First Diversion Water Right claim (see Habitat Conservation Measure 1-01, Chapter 5 of the HCP);

c) Constraints on the Second Diversion Water Right (see Habitat Conservation Measure 1-02, Chapter 5 of the HCP);

d) Providing funding support to USACE for optional storage of up to 5,000 acre-feet (ac-ft) of water to augment downstream flows for fishery purposes (see Habitat Conservation Measure 2-06, Chapter 5 of the HCP);

e) Commitment to implement water use restrictions during drought conditions consistent with Tacoma's Water Curtailment Plan (as described in the 1995 Settlement Agreement between the Muckleshoot Indian Tribe and Tacoma Public Utilities; excerpts of the 1995 MIT/TPU Agreement are provided in Appendix B of the HCP). Ongoing implementation of Tacoma's Water Conservation Plan (excerpts provided in Appendix C of the HCP), and implementation of its Water Curtailment Plan during drought conditions will ensure that water demand represents the minimum needs of Tacoma's municipal water use customers. This will allow Tacoma the greatest flexibility to curtail water withdrawals to protect instream resources during severe droughts.

Principle No. 5) Funding for, and implementation of, a fishery resource and flow monitoring program, and using results to effectively modify project procedures and design;

The proposed flow management strategy described in Habitat Conservation Measure 2-02 (Chapter 5 of the HCP) is based on a framework of monitoring and adaptive management. Monitoring and adaptive management include experimentation, monitoring, analysis, and synthesis of results. Based on the information obtained during project operation, changes in project design, management, and operations will be implemented. The adaptive management framework provides an ongoing process to ensure continued protection for fish and wildlife. Tacoma is committed to ongoing coordination with the Muckleshoot Indian Tribe, federal and state resource agencies, and members of the scientific community to ensure that strategies and decisionmaking continue to be based on sound scientific principles.

The suite of research and monitoring measures proposed for the HCP is described in Chapter 6 of the HCP. Details of the monitoring program, including annual reporting requirements, will be developed in cooperation with the NMFS and USFWS, the Muckleshoot Indian Tribe, and federal, state and local resource agencies through the Green River Flow Management Committee.

Principle No. 6) Restoration of fish habitat where appropriate and where significant benefits can be demonstrated.

Restoration of both fish habitat and the connectivity of the upper and lower Green River basin is a primary objective of conservation measures identified in Chapter 5 of the HCP. Some of the measures require funding and plan development by USACE. In order to guarantee that these measures will be implemented, Tacoma has identified those conditions, including non-Tacoma commitments that are necessary to continue operations under an Incidental Take Permit.

APPENDIX I, Agency Coordination Documents and Public Review Comments and Responses

Additional Water Storage Project, Final Feasibility Study Report & Final EIS

Howard Hanson Dam,
Green River, Washington
August 1998

prepared by
Seattle District
US Army Corps of Engineers

Tacoma Public Utilities

US Army Corps of Engineers®

Comments

STATE OF WASHINGTON
DEPARTMENT OF FISH AND WILDLIFE
16018 Mill Creek Boulevard • Mill Creek, Washington 98012 • (206) 775-1311 FAX (206) 338-1066

June 9, 1998

Ms. Kris Loll, Project Manager
U. S. Army Corps of Engineers, Seattle District
Post Office Box 3755
Seattle. Washington 98124-3755

RE: U. S. Army Corps of Engineers Howard Hanson Dam Additional Water Storage Project, Green River, Draft Feasibility Report and EIS, April 1998.

Dear Ms. Loll:

We received the above referenced documents concerning the proposed Howard Hanson Dam Additional Water Storage Project (AWSP) and have the following comments.

S02-1 At the outset, we need to make it clear these comments refer to the main report only. Detailed review of the accompanying nine appendices, totaling over 1000 pages of material involving complex issues, was simply not possible within the constraints of the preset response deadline; our good faith request for an extension of the response deadline was denied. Our comments therefore reflect only those questions or issues we were able to discover; no conclusions should be reached as to issues not discussed herein.

General Comments

Washington Department of Fish and Wildlife (WDFW) Director Bern Shanks' November 17, 1997 letter to Mark Crisson, Director Tacoma Public Utilities, and Colonel James M. Rigsby, U. S. Army Corps of Engineers, stated that "....realization of the resource benefit potential of the AWSP is absolutely dependant on commitment to and effective implementation of the following principles:

S02-2
1) clear commitment that Howard Hanson Dam refill and storage management will be dedicated to and directed to fishery resource conservation and enhancement;
2) provide for continuous project operation during refill and storage management periods;
3) state-of-the-art enhancement of snow pack monitoring and runoff forecasting;

Replies

S02-1 The draft DFR/EIS is the result of a collaborative process involving federal, state and local resource agencies (see agency resolution letters in Appendix I), the Muckleshoot Indian Tribe, non-governmental organizations, and the public. The technical appendices describe a variety of studies conducted since 1989 and include evaluations of fish and wildlife resources of the Green River Basin. Some of these studies were previously provided to WDFW in draft form for review and comment. Some of the WDFW comments on the draft DFR/EIS were addressed in the appendices. Additional fish and wildlife studies will be conducted during the three year Preliminary Evaluation and Design (PED) phase of the project; during this period WDFW will have additional opportunity to comment on Green River fish and wildlife studies.

S02-2 Below are responses to each of the stated principles:

1 - In Section 1.5 Existing Howard A. Hanson Dam Project, the current operating strategy is accurately described as reflecting a variety of natural resource needs, recreational opportunities and local community requests. The proposed operating strategy is described in Section 4.2 Recommended Plan: Hydrologic Considerations. Under Phase I of the proposed project, refill timing and release rates will be based on target instream flows that will be adjusted yearly in response to weather conditions, snowpack, the amount of forecasted precipitation and biological input from fisheries resource managers. Proposed refill rules are designed to meet project objectives for protecting instream resources, meeting existing conservation storage requirements, and providing reliability for storing additional water for M&I and low flow augmentation. Rules to provide for recreational, community and other non-fishery resource needs were not included in the description of the proposed storage and release strategy.

The proposed operating strategy involves the use of a non-dedicated block of storage. The non-dedicated storage can be directed for release or dedicated storage provided reservoir refill rule curves are satisfied for the original 22,400 ac-ft of low flow augmentation and storage of water available to Tacoma under the P5 water right. Decisions on the use of the non-dedicated block of stored water will consider consultations with fish and wildlife resource agencies. Non-fishery resource needs are not a designated downstream delivery objective; however, where those non-fishery resource needs do not conflict with fishery objectives, every attempt will be made to satisfy multiple uses.

2 - Provisions for continuous project operation during the spring refill and summer storage management period have been included in the proposed operations plan. As

S02-2 Cont stated in Section 4.12 Recommended Plan, Operation and Maintenance:

> "For 3½ months from 15 February to 1 June, the high activity rate at the fish passage facility will require up to 11 additional personnel to operate the gates, stoplogs, and fish discharge equipment. Coordinating the main gates and the fish passage gate is sufficiently time consuming to require additional staffing. The additional staff will work three shifts per day, generally three persons per shift. The rate of pool fill during this period and the rate of outmigration requires operation through the night. The design team will examine controlling the pool fill so as to eliminate the third shift by preventing the need for nighttime stop log installations. The pool raise staffing equates to 5 FTE.
>
> During the summer and fall months, stoplog changes will not be so frequent, and pool elevation can be managed to allow stoplog operation during the day shift. Personnel will be needed to remove the stoplogs, but will not be needed full time. Assuming that the outflow does not exceed 1250 cfs, the fish passage gate will control the flow and the main gates will not be needed. Therefore flow control will not require staffing above current levels. However, three man crews will be required for the occasional stop log removal. Upland habitat maintenance will be scheduled for this time. The total staffing for these months equates to 3 FTE."

Opportunities for automating project operations to improve responsiveness, while reducing the level of project staffing described in the DFR/DEIS, will be explored during the PED phase of the project.

3 - During PED we will investigate whether additional snowpack monitoring and improved runoff forecasting will benefit the reliability and flexibility of spring water storage and release. If it determined to be beneficial, the Corps and Tacoma are committed to enhancing monitoring/forecasting and will develop details of an expanded monitoring/forecasting plan during the PED project phase.

4 - Effective procedures for risk-sharing between municipal water supply and fishery resource needs have been implemented throughout the HHD AWS project. In response to agency and tribal concerns regarding potential risks to fishery resources, an Agency Resolution Process (DFR/DEIS, Paragraph 3.1.2.3b) was convened. As a result of this process, the Corps and Tacoma agreed to phased implementation of the HHD AWS Project. This phased approach incorporates an adaptive management process that conditions Phase II of the project on the demonstration that environmental impacts can be sufficiently minimized and mitigated. This phased approach presents significant risk

S02-2 Cont. to municipal and industrial water supply project benefits, a risk that is conditioned on satisfying fishery resource concerns.

Shared risk between municipal water supply and fishery resources is also demonstrated under Phase I of the HHD AWS Project. Under Phase I, only the quantity of water available for municipal and industrial use (M&I) under Tacoma's existing water right will be held as dedicated storage behind HHD. Under Tacoma's existing water right, water is only available when instream flows exceed a minimum flow regime developed in an agreement between Tacoma and the MIT. The Tacoma/MIT flow agreement specifies a minimum flow regime that exceeds Washington State instream flow requirements. During drought years, the quantity of water available for municipal and industrial use will be reduced whenever instream flows drop below the Tacoma/MIT minimum flow regime. During drought conditions, the actual quantity of dedicated municipal water held behind HHD at the end of the spring storage period reflects the shared risk between municipal water supply and fishery resource needs.

Under the HHD AWSP, operating procedures have been proposed to limit potential conflicts between municipal water supply and fishery resource needs. Under Phase I of the proposed project, proposed refill rules are designed to meet project objectives for protecting instream resources and providing reliability for storing additional water for M&I and fishery resource needs. Refill timing, storage and release rates will be adjusted on a real-time basis in response to input from fisheries resource managers.

The proposed operating strategy involves the use of dedicated and non-dedicated blocks of storage. The quantity of water available to Tacoma under the P5 water right will be held on a daily basis as dedicated storage. The non-dedicated storage (Dampen dam) can be directed for release to meet immediate fishery resource needs or stored for later low flow augmentation to benefit fishery resources. Springtime operations, where they do not conflict with flood control responsibilities, will be responsive to fishery resource agency and tribal direction. This operating strategy was designed to minimize conflicts between municipal water supply and fishery resource needs by giving fishery resource managers much greater opportunity, and responsibility, for managing flows in the Green River.

5 - A monitoring and evaluation program is proposed for the first 15 years following project construction as described in Appendix F, Section 10: Proposed Adaptive Management Monitoring and Evaluation Program. The results of these surveys will assess the efficacy of proposed mitigation and enhancement measures and identify

Comments

Ms. Kris Loll
June 9, 1998
Page 2

S02-2 Cont.

4) effective procedures for risk sharing between municipal supply and fishery resource needs, including use of municipal storage to meet fish needs when storage flexibilities are not adequate;

5) fund and implement monitoring and use results to effectively modify project procedures and design; and

6) restore fish habitats where appropriate and where significant benefits can be demonstrated."

Our endorsement of the project also hinges on the effective implementation of these very important principles. In our reading of the draft Feasibility Report and Environmental Impact Statement (DFR/DEIS), commitment to these points was unclear. We request an explicit and detailed discussion as to how each of these principles will be addressed through AWSP design, construction and operation. These are essential to fulfillment of our stated goals in regard to fishery resource protection, restoration and enhancement.

S02-3 In the DFR/DEIS, the proposed fish passage facilities and reestablishment of anadromy to the upper watershed are characterized as keystones of the restoration project. We agree with the importance of these elements. However, also very important to the overall restoration of Green River fisheries resources is greater protection of downstream resources. In broad terms, the existing project, as defined and limited by its Congressional mandate has both harmed and benefitted Green River fisheries resources. At present, the existing project benefits fall salmon spawning at the expense of spring outmigration and steelhead incubation survival. These are the consequences of spring refill, constraints on the use of conservation storage, and project operations to serve purposes other than resource protection and restoration. Effectively doubling the amount of storage that is intended to be captured every spring, while correcting rather than exacerbating existing problems, will require greatly expanded attention and dedication to meeting fishery resource needs.

S02-4 Additionally, our endorsement of the AWSP, as outlined in our November 17, 1998 letter, was only for the Phase I portion of the proposed project. At various points in the DFR/DEIS it is implied that Phase II would proceed automatically. We wish to make it clear that our approval of Phase I was with the understanding that Phase II would not proceed without specific further approval by the resource agencies and Muckleshoot Tribe.

Specific Comments

S02-5 1.5.6., page 8. With regard to Howard Hanson Dam (HHD) discharge adjustments to accommodate purposes other than fishery resource needs, the inherent incompatibility of such potential actions must be clearly recognized. One event can nullify months or years of effort to protect and restore fisheries resources.

Replies

S02-2 Cont. whether the level of project impacts are as anticipated.

The adaptive management process provides for changes in operational strategies to minimize project impacts following construction. Changes in operating guidelines for refill and storage are assumed to address many of the potential project effects. Maintenance and necessary modifications will be made to the non-fish passage related mitigation and restoration measures. Detailed study plans on the field methods and data analysis procedures to be employed will be developed during the PED phase prior to project construction.

6 - A detailed description of proposed measures to restore fish habitats in the Green River Basin is included in Appendix F, Part 1: Fish Mitigation and Restoration and summarized in Section 8: Restoration and Mitigation Plan Summary.

S02-3 Comment noted. See Comment-Reply S02-2.

S02-4 We concur. As stated in Section 4.1.2 Recommended Plan Description: Phase II, "Implementation of Phase II would be contingent upon acceptance by the regulatory agencies and the MIT".

S02-5 See response to SO2-2-1

APPENDIX F
Lands Within the Green River Watershed Owned by the City of Tacoma and Proposed for Coverage Under the Incidental Take Permit

TWP	RGE	SEC	TAX LOT	LEGAL DESCRIPTION	TAX LOT ACRES	SECTION ACRES	NOTES
T20N	R8E	1	8	POR SEC W OF C/L PSP & L TRANS R/W & E OF NPRR RELOCATION LESS FORMER NPRR R/W SUBJ TO USA ESMTS.	239.00	239.00	
		2	19	POR E 1/2 OF NE 1/4 NELY OF NPRR R/W RELOCATION.	28.45	28.45	
		6	17	W 4 FT OF NE 1/4 OF SW 1/4 & W 6 FT OF GL 7.	0.30	0.30	
		12	4	SE 1/4 OF NE 1/4 LESS N P R/W SUBJ TO USA ESMT;	39.56		
			13	NE 1/4 OF SE 1/4;	40.00		
			19	POR N 1/2 OF NE 1/4 WLY OF C/L PSP & L TRANS RW LESS NPRR R/W BY CHARTER & AS PLANNED IN STRIP A-100-1 & A 100-2 E 1/2 OF NE 1/4 OF NW 1/4 E 1/2 OF SW 1/4 OF NE 1/4 NW 1/4 OF SW 1/4 OF NE1/4 NELY 1/2 DIAGONALLY OF NE 1/4 OF SE 1/4 OF NW 1/4 & NELY 1/2 DIAGONALLY OF SW 1/4 OF SW 1/4 OF NE 1/4 SUBJ TO USA ESMTS.	114.49	194.05	
T20N	R9E	7	18	POR OF W 1/2 OF SEC LY NLY OF S LN OF BPA TRANS LN R/W & SWLY OF LN DAF - BAAP ON E LN OF SEC LY 207.6 FT S OF E 1/4 COR THOF TH N 78-18-20 W 2811.7 FT TH N 45-07-35 W 3052.4 FT TAP ON W SEC LN LY 191.6 FT SLY OF NW COR THOF & TERMINUS OF SD DESC LN - TGW POR OF SE 1/4 LY NLY OF S LN OF SD TRANS LN R/W LESS NPRR R/W & LESS POR OF SD TRANS LN R/W LY IN GL 4 SUBJ TO USA ESMTS.	236.30	236.30	
		8	18	POR OF S 1/2 OF SEC LY SLY OF C/L PSP & L CO ESMT R/W REC AF # 1687005 & 1708593 LESS 400 FT NPRR R/W.	193.48	193.48	

TWP	RGE	SEC	TAX LOT	LEGAL DESCRIPTION	TAX LOT ACRES	SECTION ACRES	NOTES
		9	11	POR OF S 1/2 OF SEC LY SLY OF C/L PSP & L CO ESMT R/W REC AF # 1889472 LESS 400 FT NPRR R/W.	217.00	217.00	
		10	1	NW 1/4 TGW N 1/2 OF SE1/4 TGW POR OF NE 1/4 LY SLY OF NLY LN OF BPA VANTAGE-COVINGTON TRANS LN R/W LESS POR FOR NPRY R/W & SUBJ TO TRANS LN ESMTS;	359.83		
			7	SW 1/4 LESS NPRR R/W.	135.24		
			11	S 1/2 OF SE 1/4 LESS NPRR R/W;	55.29	550.36	
		11	3	S 1/2 OF SW 1/4 & SW 1/4 OF SE 1/4 LESS NP RR R/W.	83.27		
			11	SE 1/4 OF SE 1/4 LESS 400 FT NP R/W SUBJ TO TRANS LN ESMTS;	36.13		
			12	N 1/2 OF S 1/2 TGW POR OF N 1/2 LY SLY OF NLY LN OF BPA VANTAGE-COVINGTON TRANS LN R/W -SUBJ TO TRANS LN ESMTS;	200.00	319.40	
		12	1	NE 1/4 TGW N 1/2 OF SW1/4 TGW E 1/4 OF SW 1/4 OF SW 1/4 TGW SE 1/4 OF SW 1/4 TGW SE 1/4 -SUBJ TO TRANS LN ESMTS;	450.00		
			17	W 3/4 OF SW 1/4 OF SW 1/4 SUBJ TO TRAN LN ESMTS.	30.00	480.00	
		13	16	N 1/2 OF SE 1/4 TGW N 1/2 OF SEC LESS POR LY NLEY OF PSP & L CO R/W LN & LESS NPRR R/W.	313.77		
			17	POR OF N 1/2 LY NLY OF C/L OF PUGET SOUND POWER & LIGHT CO TRANS LN R/W – SUBJ TO TRANS LN ESMTS;	24.46	338.23	
		14	1	NE 1/4 OF NE 1/4 LESS R/W;	28.57		
			2	NE 1/4 OF NW 1/4 TGW NW 1/4 OF NE 1/4 LESS R/W;	75.46		
			6	NW 1/4 OF NW 1/4.	37.21	141.24	
		16	1	GOV LOTS 1, 2, 3 & 4.	129.69	129.69	

TWP	RGE	SEC	TAX LOT	LEGAL DESCRIPTION	TAX LOT ACRES	SECTION ACRES	NOTES
T20N	R10E	7	9	E 1/2 OF SW 1/4 & GL 3 & 4.	149.38	149.38	
		13	18	POR OF SE 1/4 OF SE 1/4 LY S OF USFS RD;	5.85		
			19	POR OF SE 1/4 LY NLY OF NP 400 FT R/W & SLY OF NLY MGN OF VC-419 TRANS ESMT R/W REC AUD # 5829087 SUBJ TO TRANS LN ESMTS & SUBJ TO ACCESS RD ESMTS.	73.55	79.40	
		17	9	SW 1/4 LESS BNI R/W & LESS FEDERAL HWY SUBJ TO TRANS LN R/W.	155.80	155.80	
T20N	R10E	18	1	NE 1/4 TGW GL 1 TGW NE1/4 OF NW 1/4 TGW NE 1/4 OF SE 1/4 - SUBJ TO TRANS LN ESMTS;	306.59		1
			8	SE 1/4 OF NW 1/4 SUBJ TO TRANS LN R/W;	40.00		
			14	W 1/2 OF SE 1/4 LESS NP R/W SUBJ TO POWER LN ESMT LESS RD ESMT DEED TO USA 7/14/32 AUD FILE # 2751763 VOL 1537 PG 483 & LESS POR DAF-POR OF NW 1/4 OF SE 1/4 LY SLY OF ESMT DEEDED TO USA 7/14/32 AUD FILE # 2751763 VOL 1537 PG 483 & DAF BAAP ON S LN OF SD ESMT 160 FT E OF W LN OF SUBD TH S PLLW SD W LN TO N MGN OF NP R/W TH ELY ALG SD R/W 320 FT TH N TO S LN OF ESMT TH WLY ALG SD S LN TO POB;	61.00		
			16	SE 1/4 OF SE 1/4 EX NPRR R/W SUBJ TO TRANS LN R/W;	26.61		
			20	POR OF NW 1/4 & POR OF SW 1/4 OF SE 1/4 LY SLY OF ESMT DEEDED TO USA 7/14/32 AUD FILE #2751763 VOL 1537 PG 483 & DAF- BAAP ON S LN OF SD ESMT 160 FT E OF W LN OF SUBD TH S PLLW SD W LN TO N MGN OF NP R/W TH ELY ALG SD R/W 320 FT TH N TO S LN OF ESMT TH WLY ALG SD S LN TO TPOB;	4.19		
			21	PORS OF GL 2 & N 1/2 OF SW 1/4 LY NLY OF 400 FT NP R/W SUBJ TO TRANS LN ESMT.	61.74	500.13	

TWP	RGE	SEC	TAX LOT	LEGAL DESCRIPTION	TAX LOT ACRES	SECTION ACRES	NOTES
		20	1	NE 1/4 SUBJ TO TRANS LN R/W;	160.00		
			5	W 1/2 TGW SE 1/4 LESS POR SD SE 1/4 LY SLY OF C/L OF PSP & CO ESMT REC VOL 1183 PG 497 LESS NP R/W LESS FEDERAL HWY SUBJ TO TRANS LN R/W.	367.69	527.69	
		21	1	ENTIRE SEC EX NPRR R/W SUBJ TO TRANS LN R/W.	586.85	586.85	
		22	1	NE 1/4 OF NE 1/4;	40.00		
			2	NW 1/4 OF NE 1/4;	40.00		
			3	SW 1/4 & S 1/2 OF NE 1/4 ALSO SW 1/4 OF SE 1/4 & N 1/2 OF SE 1/4 SUBJ TO TRANS LN R/W LESS RY R/W LESS HWAY SUBJ TO BPA ESMT PER DEC OF TAKING CIVIL # 6088 US DIST CT W DIST OF WASH N DIV;	305.61		
			5	NW 1/4 SUBJ TO TRANS LN R/W;	160.00		
			17	GL 1.	31.45	577.06	
		23	1	NE 1/4 LY N OF TOWNSITE OF LESTER ALSO NW 1/4 LY N OF NPRR R/W LESS HWY SUBJ TO TRANS LN ESMTS & SUBJ TO N P ESMT;	191.81		
			3	S 1/2 OF NE 1/4 LY S OF LN 450 FT SLY & PLW NP R/W S 1/2 OF NW 1/4 & N 1/2 OF SW 1/4 LY SLY OF NP R/W-N 1/2 OF SE1/4 LESS POR NLY OF LN 450 FT SLY & PLW NP R/W;	172.38		
			18	STRIP OF LAND LY BET NPRR R/W & A LN 450 FT SE OF & PLL THWITH ALSO STRIP OF LAND LY BET N LN OF SD R/W & A LN 484FT NWLY OF & PLL THWITH BOTH STRIPS LN IN E 1/2 OF SECTION.	58.75	422.94	
		24	2	POR OF N 1/2 OF NE 1/4 LY NLY OF USFS RD NO 212 PER AUD FILE # 2751767;	10.09		
			3	S 1/2 OF NE 1/4 LESS NPRR R/W;	79.84		
			5	POR NE 1/4 OF NW 1/4 LY N OF S LN OF OLD NPRR R/W LESS FEDERAL HWAY;	34.00		

TWP	RGE	SEC	TAX LOT	LEGAL DESCRIPTION	TAX LOT ACRES	SECTION ACRES	NOTES
			6	POR NW 1/4 OF NW 1/4 BEG AT NXN OF W LN OF SEC & C/L OF OLD NPRR R/W TH NELY ALG C/L 475.2 FT TH 90-00-00 LEFT 200 FT TO TRUE PT OF BEG TH ON SAME BEARING 100 FT TH 90-00-00 LEFT 152.8 FT TO E LN SCHOOL LOT TH SLY 102.1 FT TO N LN R/W TH NELY 173.5 FT TO BEG;	0.37		
			7	BEG AT A PT 200 FT N OF CEN OF MAIN LINE NPRR & ON W LN OF SEC 24 TH NLY 400 FT TH E 160 FT TH S TO N LN TH SWLY TO BEG;	1.40		
			8	POR SW 1/4 OF NW 1/4 BEG AT NXN OF W LN OF SEC & C/L OF OLD NPRR R/W TH NELY ALG C/L 116 FT TH 90-00-00 RIGHT 200 FT TO S LN R/W & TRUE PT OF BEG TH ON SAME BEARING 191 FT TH 90-00-00 LEFT 300 FT TH 90-00-00 LEFT 191 FT TO R/W TH SWLY ALG R/W 300 FT TO BEG;	1.32		
			9	S 1/2 OF NW 1/4 LY S OF N P R/W LESS BEG AT NXN OF W LN OF SEC & C/L OF OLD NPRR R/W TH NELY ALG C/L 116 FT TH 90-00-00 RIGHT 200 FT TO S LN OF R/W & TPOB TH ON SAME BEARING 191 FT TH 90-00-00 LEFT 300 FT TH 90-00-00 LEFT 191 FT TO R/W TH SWLY ALG R/W 300 FT TO BEG ALSO N 1/2 OF SW 1/4 ALSO POR OF NE 1/4 OF NW 1/4LY S OF OLD NPRR R/W LESS PRESENT NPRR R/W;	155.38		
			13	GLS 1-2-3-4-5-6.	245.57		
			26	POR OF NE 1/4 LY NLY OF RELOCATED NPRR R/W & SLY OF USFS RD NO 212 AF# 2751767;	64.68		
			21	NW 1/4 OF NW 1/4 LESS SCHOOL LOT LESS NPRR R/W & LESS BEG SE COR OF SD SCHOOL LOT TH NELY ALG NLY MGN OF RR R/W 173.5FT TH LFT AT R/A 100 FT TH LFT AT R/A 152.8 FT TH S ALG E LN OF SD LOT 102.1 FT TO BEG SUBJ TO TRANS LN ESMTS;	26.79		

TWP	RGE	SEC	TAX LOT	LEGAL DESCRIPTION	TAX LOT ACRES	SECTION ACRES	NOTES
			27	BEG AT A PT 200 FT N OF CEN OF MAIN LINE NPRR R/W & ON W LN OF SEC 24 TH NLY 400 FT TH E 250 FT TH S TO N LN TH SWLY TO BEG LESS W 160 FT;	0.73	620.17	
T20N	R10E	27	5	NW 1/4.	160.00	160.00	
		28	5	NW 1/4.	160.00		
			9	SW 1/4;	192.55		
			13	GL 1;	54.91		
			14	GL 2 IN SE 1/4 TGW S 1/2 OF SE1/4 ;	135.46	542.92	
		32	3	N 1/2 OF NE 1/4-SW 1/4 OF NE 1/4 & NW 1/4 OF SE1/4.	160.00	160.00	
T20N	R11E	3	18	GL 3 & 4 POR OF S 1/2 OF N 1/2 & N 1/2 OF S 1/2 LYING NLY OF BN R/W & POR OF GL 1 & 2 LYING SLY OF BN R/W SUBJ TO TRANS R/W.	285.32	285.32	2
		7	3	S 3/4 LESS SE 1/4 OF NE 1/4 LESS C/M RGTS.	419.15	419.15	
		8	11	S 1/2 OF SW 1/4 TGW N 1/2 OF SE 1/4 LESS FEDERAL HWY SUBJ TO TRANS LN R/W LESS NPRR R/W.	156.91	156.91	
		9	18	POR OF N 1/2 OF NW 1/4 & SW 1/4 OF NW 1/4 & PORS OF W 1/2 OF NE 1/4 & SE 1/4 OF NW 1/4 & N 1/2 OF SW 1/4 LYING NLY OF BN R/W SUBJ TO TRANS R/W.	180.63	180.63	3
		17	18	POR OF W 1/2 OF SEC DAF BEG NW COR OF SEC TH ON ASSUMED BRG OF S ALG W LN OF SEC 1975 FT TO TPOB TH N 67-35-00 E 1425 FT TH S PLW W LN OF SEC 1425 FT TH S 67-35-00 W 1425 FT TAP ON W LN OF SEC TH N ALG W LN OF SEC 1425 FT TO TPOB LESS POR IN SE1/4 OF NE1/4 LYING S OF PSP&L TRANS LN & POR IN NE1/4 OF SE1/4 LYING NWLY OF USFS RD 54;	39.09		

TWP	RGE	SEC	TAX LOT	LEGAL DESCRIPTION	TAX LOT ACRES	SECTION ACRES	NOTES
			19	W 1/2 & S 1/2 OF S 1/2 OF SE 1/4 LY ELY OF BNRR R/W & ALL POR OF W 1/2 OF NE 1/4 & NW 1/4 OF SE 1/4 & SW 1/4 OF SE1/4 LYING WLY OF BNRR R/W LESS POR OF W 1/2 DAF BEG NW COR OF SEC TH ON ASSUMED BRG OF S ALG W LN OF SEC 1975 FT TO TPOB TH N 67-35-00 E 1425 FT TH S PLW W LN OF SEC 1425 FT TH S 67-35-00 W 1425 FT TAP ON W LN OF SEC TH N ALG W LN OF SEC 1425 FT TO TPOB SUBJ TO TRANS R/W.	322.53	361.62	4
		18	1	NE 1/4 SUBJ TO TRANS LN ESMTS TGW NE 1/4 OF SE1/4 LESS USFS GREEN RIVER RD #223 TGW S 1/2 OF SE 1/4 LESS POR SE1/4 OF NE1/4 LYING S OF PSP&L TRANS LN & W OF USFS RD 54 & POR IN NW1/4 OF SW1/4 LYING NWLY OF USFS RD 54;	243.13		
			5	E 1/2 OF NW 1/4 TGW N 1/2 OF SW 1/4 TGW POR OF SW1/4 OF SW 1/4 LY NWLY OF USFS RD #223 TGW POR OF SE 1/4 OF SD SW 1/4 LY NWLY OF SD USFS RD TGW POR OF S 1/2 OF SD SW 1/4 DAF BEG NXN OFC/L SD USFS RD & E LN OF SW 1/4 TH S ALG SD E LN 620 FT TO TPOB TH SWLY PLW C/L SD USFS RD 500 FT TH NWLY PRPDIC TO C/L SD RD 150 FT TH SWLY PLW C/L SD RD TO W SEC LN TH S TO SW COR OF SEC TH ELY ALG S LN OF SEC TO SE COR OF SW 1/4 TH N ALG E LN OF SD SW 1/4 TO POB SUBJ TO TRANS LN ESMTS;	199.80		
			6	GL 1;	33.12		
			7	GL 2;	33.16		
			0005	BLK A LOT 2 ACES FRIDAY CREEK HUNTING-FISHING SUBJ TO BONNEVILLE PWR LN EASMT;	0.47		

TWP	RGE	SEC	TAX LOT	LEGAL DESCRIPTION	TAX LOT ACRES	SECTION ACRES	NOTES
			0015	ACES FRIDAY CREEK HUNTING-FISHING HIDEAWAYS ADD LOTS 4 THRU 17 LOT 19 LOTS 21 THRU 25 BLK A TGW LOT 4 LOTS 6 THRU 12 LOT 14 LOTS 21 THRU 24 & LOT 26 BLK B TGW LOTS 8 THRU 16 BLK C TGW LOTS 8 THRU 16 BLK D TGW UNNUMBERED TRACT LY N OF LOT 4 BLK B SD ADD SUBJ TO TRANS LN ESMT;	20.63		
			0120	BLK B LOT 5 ACES FRIDAY CREEK HUNTING-FISHINGHIDEWAYS ADD;	0.24		
			0160	BLK B LOT 13 ACES FRIDAY CREEK HUNTING-FISHING HIDEAWAYS ADD 1/3 INT;	0.29		
			0175	BLK B LOT 15 THRU 18 ACES FRIDAY CREEK HUNTING-FISHING HIDEAWAYS ADD;	0.30		
			14	NW 1/4 OF SE 1/4 LESS USFS RD #223 LESS POR PLTD ACES FRIDAY CREEK HUNTING & FISHING HIDEAWAYS SUBJ TO TRANS LN ESMT.	17.84	548.98	
		19	3	S 1/2 OF N 1/2 OF SEC LY SLY OF RELOCATED NPRR R/W LESS C/M RGTS TGW S 1/2 OF SEC LESS C/M RGTS.	446.60		
			20	POR OF NW 1/4 BEG ON N LN OF SEC 350 FT E OF NW COR TH S 65-30-00 E 830 FT M/L TO N-S CENTER LN OF SD NW 1/4 TH N 60-30-00 E 690 FT M/L TO N LN TH W 1357 M/L TO BEG;	5.62		
			21	POR OF SEC LY NLY OF RELOCATED NPRR R/W LESS POR BEG ON N LN 350 FT E OF NW COR TH S 65-30-00 E 830 FT M/L TO N-S CENTER LN OF NW 1/4 OF SEC TH N 60-30-00 E 690 FT M/L TO N LN TH W TO BEG LESS C/M RGTS;	160.71	612.93	
		20	5	NW 1/4 SLY OF RELOCATED NPRR R/W;	63.45		
			18	POR NW 1/4 LY NLY OF RELOCATED NPRR R/W.	90.18	153.63	

TWP	RGE	SEC	TAX LOT	LEGAL DESCRIPTION	TAX LOT ACRES	SECTION ACRES	NOTES
		21	9	SE 1/4 & POR OF SW 1/4 OF NE 1/4 LYING SWLY OF ALN EXTND IN NW/SE DIR BTWN NW & SE COR OF SD SW 1/4 OF NE 1/4 & POR OF E 1/2 OF SW 1/4 LYING NELY OF A LN EXTND IN NW/SE DIR BTWN NW & SE COR OF SD E 1/2 OF SW 1/4 TGW POR NW 1/4 LY SLY & WLY OF C/L USFS RD.	336.00	336.00	5
		27	2	POR OF W 1/2 & W 1/2 OF SE 1/4 LYING SWLY OF A LN EXTD IN SELY DIR FR NW COR TO SE COR OF SW 1/4 SE 1/4.	240.00	240.00	6
T21N	R7E	13	17	400 FT FORMER NPRR R/W RUNNING ACROSS N 1/2 OF SEC & RUNNING ACROSS E 1/2 OF SE 1/4 THOF TGW POR OF S 200 FT OF SE1/4 OF NE 1/4 LY WLY OF SD 400 FT R/W & TGW POR OF NE 1/4 OF SE 1/4LY BET SD 400 FT R/W & BNI (FMR NP) RELOCATED RR R/W;	67.00		
			38	ELY 290 FT OF WLY 1030 FT OF POR OF W 1/2 OF NE1/4 LY SLY OF FORMER NPRR R/W & LY NLY OF TR C-301;	4.92		
			40	POR W 475 FT OF NE 1/4 LY SLY OF OLD NPRR R/W & NLY OF TR C-301;	5.65		
			41	ELY 265 FT OF WLY 740 FT OF POR OF W 1/2 OF NE1/4 LY SLY OF FORMER NPRR R/W & LY NLY OF TR C-301;	4.25		
			42	POR OF W 1/2 OF NE 1/4 LY SLY OF FORMER NPRR R/W & LY NLY OF TR C-301 LESS WLY 1030 FT;	3.80		
			47	POR OF E 1/2 OF NE 1/4 LY SLY & WLY OF GREEN RIVER LESS 400 FT FORMER NPRR R/W & LESS POR OF S 200 FT LY WLY OF SD FORMER NPRR R/W & LESS W 600 FT IN E1/2 OF NE1/4 LYING S OF GREEN RIVER & N OF 400 FT FORMER NPRR R/W.	8.00	93.62	
		14	25	POR OF 400 FT FORMER NPRR R/W LY ELY OF STA 11097 PLUS 76.00.	9.45	9.45	

TWP	RGE	SEC	TAX LOT	LEGAL DESCRIPTION	TAX LOT ACRES	SECTION ACRES	NOTES
T21N	R8E	2	12	SE 1/4 OF SW 1/4.	40.00	40.00	
		4	6	TRANS LN & RDWY THRU SEC PER DEED REC #5850281.	7.27	7.27	
		5	2	TRANS LN THRU SEC PER DEED REC #5850281.	56.01	56.01	
		9	18	TRANS LN & RDWY THRU SEC PER DEED REC #5850281.	65.67	65.67	
		13	2	NW 1/4 OF SE 1/4 LESS N 660 FT & GL 1 LESS N 660FT & GL 2 & 3.	118.80	118.80	
		15	18	POR S 1/2 LY ELY OF BPA COVINGTON GRAND COULEE TRANS LN R/W & WLY OF FOLG DESC LN BEG ON S LN SD SEC 1843 FT E OF S 1/4 COR & TPOB SD DESC LN TH N 65-26-54 W 215.41 FT TH N 33-30-22 W 930.54 FT TH N 01-34-23 E 156.77 FT TH N 22-12-49 E 516.49 FT TH N 09-17-34 W 447.73 FT TH N 19-45-08E 372.63 FT TH N 15-49-40 E 90 FT M/L TO PT ON E/W C/L SD SEC SD PT BEING 3980 FT E OF W 1/4 COR SD SEC & TERMINUS SD LN TGW TRANS LN PER DEED 5850281 IN W 1/2 OF SD SEC LESS RD OUTSIDE TRANS LN ESMTS PER DEED 5850281.	167.04	167.04	
		18	10	GL 3;	44.91		
			11	THAT POR OF GL 4 LY N OF NPRR R/W;	24.98		
			12	SE 1/4 OF SW 1/4 EX NPRR R/W.	31.12		
			15	SW 1/4 OF SE 1/4;	40.00		
			17	400 FT FORMER NPRR R/W OVER SW 1/4 (INCL GL 3 & 4) PER DEPT REV LTR 1/26/88.	24.96	165.97	
		19	17	400 FT FORMER NPRR R/W OVER NE 1/4 & NE 1/4 OF NW 1/4;	41.40		
			19	POR OF N 1/2 OF SEC LY SLY OF 400 FT NPRR R/W & NLY OF C/L PSP & L CO ESMT DESC UNDER VOL 1228 PG 569 & DEED AF # 41101320 TGW POR DESC IN WARRANTY DEED FROM WEYERHAUESER REC NO 841206-0634.	153.00	194.40	

TWP	RGE	SEC	TAX LOT	LEGAL DESCRIPTION	TAX LOT ACRES	SECTION ACRES	NOTES
		20	3	S 1/2 OF NE 1/4 & N 1/2 OF SE 1/4 LESS FORMER NPRR R/W;	137.30		
			7	SW 1/4 OF NW 1/4 LESS FORMER NPRR R/W;	11.13		
			17	400 FT FORMER NPRR R/W OVER S 1/2 OF NW 1/4-N 1/2 OF SW1/4-SW 1/4 OF NE 1/4 & SE 1/4.	54.08		
			21	POR OF N 1/2 OF SW 1/4 LY NLY OF C/L PSP & L CO REC VOL 4110 PG 320 LESS POR DESIG TR B-201-3 HOWARD A HANSON PROJECT LESS 400 FT NPRR R/W;	33.51		
			22	POR OF S 1/2 OF SE 1/4 LY NLY & ELY OF TR B-201-2 HOWARD A HANSON PROJECT LESS 400 FT NPRR R/W & POR OF SD S 1/2 LY SLY OF SD TR B 201-2 & NLY OF C/L OF PSP & L CO R/W REC VOL 4110 PG 320;	17.44		
			23	POR OF N 1/2 OF SW 1/4 LYING S OF C/L OF PSP&L CO TRANS LN R/W TGW POR OF S 1/2 OF SE 1/4 OF SD SEC BEG NW COR TH E ALG N LN OF SD S 1/2 OF SE 1/4 TO C/L OF PSP&L CO R/W TH SELY ALG SD TRANS LN C/L TO SLY EDGE OF PAR OF LD DESC TR B-201-2 IN DEED AF #6049640 VOL 4806 PG 510 TH SELY ALG SD SLY EDGE TO S LN OF SD SEC TH W ALG S LN OF SD SEC 20 TO SE COR OF SW 1/4 OF SE 1/4 OF SD SEC TH NWLY IN STRAIGHT LN TO NW COR OF S 1/2 OF SE 1/4 OF SD SEC & POB LESS TR CONV BY DEED AF #6155159 VOL 4911 PG 183;	45.60	299.06	
		21	16	POR OF SW 1/4 DAF - BEG NW COR OF SW 1/4 TH IN STRAIGHT LN TO SE COR OF SD SW 1/4 TH W ALG S LN OF SD SW 1/4 TO NELY R/W LN OF NORTHERN PACIFIC RAILWAY CO 400 FT CHARTER R/W TH NWLY ALG SD NELY R/W LN TO W LN OF SD SW 1/4 TH N ALG SD W LN TO POB;	45.30		

TWP	RGE	SEC	TAX LOT	LEGAL DESCRIPTION	TAX LOT ACRES	SECTION ACRES	NOTES
			17	400 FT FORMER NPRR R/W OVER W 1/2 OF SW 1/4 & SE1/4 OF SW 1/4.	16.24		
			18	POR OF SW 1/4 OF SW 1/4 LY SLY & WLY OF NPRR 400 FT R/W;	13.00	74.54	
T21N	R8E	22	1	NE 1/4 OF NE 1/4;	40.00		
			2	W 1/2 OF NE 1/4-SE 1/4 OF NE 1/4- E 1/2 OF SE 1/4 & NE 1/4 OF NW 1/4 OF SE 1/4 SUBJ TO TRANS LN ESMTS & SUBJ TO USA ESMT;	210.00		
			16	PORS OF NE 1/4 OF NW 1/4 & SE 1/4 OF NW 1/4 & SE1/4 OF NW 1/4 OF SE 1/4 & NE 1/4 OF SW 1/4 OF SE 1/4 LY SWLY OF & ADJ ORIGINAL 300 FT BONNEVILLE TRANS LN R/W & NELY OF A LN 350 FT DIST A TR/A SWLY FR & PLW RELOCATED SURVEY LN TACOMA-GRAND COULEE #1 TRANS LN ESMT SUBJ TO TRANS LN ESMTS.	18.13	268.13	
		23	7	SW 1/4 OF NW 1/4 & W 1/2 OF SW 1/4 SUBJ TO TRANS LN ESMT SUBJ TO PERPETUAL ESMT TO USA ,EAGLE GORGE RESERVOIR.	120.00	120.00	
		24	17	G L 1 & 2.	63.00	63.00	
		26	9	NE 1/4 OF SW 1/4 SUBJ TO TRANS LN R/W ESMT TGW POR TRANS LN PER DEED #5850281 LOC IN SE 1/4 OF NW 1/4 OF SD SEC LESS RD PER DEED #5850281 OUTSIDE TRANS LN ESMT;	42.84		
			17	W 1/4 OF SEC ALSO W 1/2 OF SW 1/4 OF NE 1/4 OF NW 1/4 ALSO W 1/2 OF NW 1/4 OF SE 1/4 OF NW 1/4 ALSO W 1/4 OF SE 1/4 OF SW 1/4 SUBJ TRANS LN ESMT SUBJ TO PERPETUAL ESMT TO USA ,EAGLE GORGE RESERVOIR LESS POR TRANS LN PER DEED #5850281 LOC IN SE 1/4 OF NW 1/4 OF SD SEC LESS POR RD PER DEED #5850281 NOT W/IN TRANS LNS ESMT;	179.10		

TWP	RGE	SEC	TAX LOT	LEGAL DESCRIPTION	TAX LOT ACRES	SECTION ACRES	NOTES
			18	E 3/4 OF SE 1/4 OF SW 1/4 SUBJ TO TRANS LN ESMTS LESS RD PER DEED #5850281.	28.54	250.48	
		27	1	E 1/2 OF NE 1/4 & SW 1/4 OF NE 1/4 & E 1/2 OF SE1/4 LESS C/M RGTS SUBJ TO TRANS LN ESMT & SUBJ TO USA, EAGLE GORGE RESERVOIR;	200.00		
			14	NW 1/4 OF SE 1/4 & POR OF SW 1/4 OF SE 1/4 LY NELY OF FORMER NPRR R/W LESS BEG AT PT 1185 FT N OF S 1/4 COR OF SEC TH N 335 FT TH N 61-18-00 E 510 FT TH N 31-18-00 E 310 FT TH N 75-18-00 E 310 FT TH S 79-42-00 E 200 FT TH S 17-18-00 W 180 FT TH S 18-42-00 E 330 FT TH S 03-42-00 E 260 FT TH S 15-18-00 W 300 FT TH N 76-42-00 W 100 FT TH N 06-48-00 E 250 FT TH N 17-42-00 W 220 FT TH N 39-42-00 W 210 FT TH N 83-42-00 W 230 FT TH S 19-18-00 W 260 FT TH S 58-18-00 W 340 FT TH S 68-20-50 W 263.60 FT TO BEG LESS C/M RGTS SUBJ TO PERPETUAL ESMT TO USA ,EAGLE GORGE RESERVOIR;	53.77		
			21	POR S1/2 OF SW 1/4 SWLY OF NPRR 400 FT CHARTER R/W EX TRS A-104 & F-600-2 BEING TR F-600E-2 & LAND IN SUBD CIRCUMSCRIBED THERE BY AKA TR F-617E;	31.50		
			23	POR OF SW 1/4 OF SW 1/4 LY SWLY OF TR A-104 AS SHOWN ON HOWARD HANSON PROJECT.	8.30		
			24	POR OF SW 1/4 OF NW 1/4 & POR OF NW 1/4 OF SW1/4 LY N OF POR OF PAR OF LAND DESC AS TR E-500-1 IN DEED TO USA UNDER AF #6049640 VOL 4806 PG 510 TGW POR OF NE 1/4 OF SW 1/4 OF SD SEC LY N OF POR OF PAR OF LD DESC AS TR F-600-1 LY IN SD NE 1/4 OF SW 1/4 OF SD DEED;	43.84	337.41	

TWP	RGE	SEC	TAX LOT	LEGAL DESCRIPTION	TAX LOT ACRES	SECTION ACRES	NOTES
		28	1	N 1/2 OF NE 1/4 & NE 1/4 OF NW 1/4 LESS FORMER NPRR R/W, LESS POR TO USA HOWARD A HANSON DAM PROJECT;	67.73		
			3	SW 1/4 OF NE 1/4 LESS RELOCATED NPRR R/W SUBJ TO PSP&L ESMT;	28.98		
			16	SE 1/4 OF SE 1/4 INCL POR RELOCATED NPRR R/W SUBJ TO PSP&L ESMT;	33.51		
			21	POR OF NW 1/4 OF NW 1/4 LY NELY OF TR B-201-2 &POR OF NE 1/4 OF SE 1/4 LY SELY OF B-201-1 & POR OF NW 1/4 OF SE 1/4 LY SELY OF SD B-201-1 & NELY OF C/L PSP & L CO R/W DESC UNDER VOL 4110 PG 320;	36.39		
			22	POR OF SE 1/4 OF NE 1/4 LY N & E OF POR OF PAR OF LD DESC AS TR E-500-1AS DESC AF #6049640 VOL 4806 PG 510 TGW POR OF E 1/2 OF NW 1/4 OF SE 1/4 LY S OF C/L OF PSP&L CO TRANS LN R/W AS DESC AF #5236643 VOL 4110 PG 320.	26.04	192.65	
		29	18	POR OF NE 1/4 OF NE 1/4 LY NELY OF TR B-201-2 HOWARD HANSON DAM PROJECT.	0.01	0.01	
		34	1	S 1/4 OF N 3/4 OF S 1/2 & S 1/2 OF S 1/2 OF NW 1/4 OF SE 1/4 & DIAGONAL S 1/2 OF N 1/2 OF S 1/2 OF NW 1/4 OF S1/4 & DIAGONAL S 1/2 OF S 1/2 OF SE 1/4 OF NE 1/4 OF SW 1/4 & W 1/2 OF W 1/2 OF NW 1/4 OF SW 1/4 & DIAGONAL NW 1/2 OF NE 1/4 OF NW 1/4 OF NW 1/4 OF SW 1/4 & POR OF W 1/2 OR NW 1/4 LY SWLY OF C/L PSP & L CO R/W DESC UNDER VOL 4110 PG 320 LESS POR IF ANY LY NELY OF SWLY LN OF TR A-104 LESS POR WITHIN DIAGONAL SE 1/2 OF SE 1/4 OF SW 1/4 OF NW 1/4 TGW POR OF NE 1/4 OF SE 1/4 LY SWLY OF SD TR A-104 TGW 60 FT RD WAY IN NE 1/4 OF SE 1/4;	183.42		

TWP	RGE	SEC	TAX LOT	LEGAL DESCRIPTION	TAX LOT ACRES	SECTION ACRES	NOTES
			18	NE 1/4 & E 1/2 OF NW 1/4 & POR NW 1/4 OF NW 1/4 NELY OF NPRR RELOCATION & DIAGONAL SE 1/2 OF SE 1/4 OF SW 1/4 OF NW 1/4 & POR NE 1/4 OF SE 1/4 NELY OF NPRR RELOCATION & N 1/2 OF NW 1/4 OF SE1/4 & DIAGONAL NW 1/2 OF N 1/2 OF S 1/2 OF NW 1/4 OF SE 1/4 & NE 1/4 OF SW 1/4 EX DIAGONAL SE 1/2 OF S 1/2 OF SE 1/4 THOF & E 3/4 OF NW1/4 OF SW 1/4 EX DIAGONAL NW 1/2 OF NE 1/4 OF NW 1/4 OF NW 1/4 OF SW1/4 LESS CHARTER & RELOCATED NPRR R/WS.	306.72		
			20	POR OF W 1/2 OF NW 1/4 LY SWLY OF TR A-104 & NELY OF C/L PSP & L CO ESMT DESC UNDER VOL 4110 PG 320;	5.32	495.46	
T21N	R8E	35	1	NE 1/4-E 1/2 OF NW 1/4-POR OF NE 1/4 OF SW 1/4 & OF SE 1/4 LY NLY OF FORMER NPRR R/W LESS C/M RGTS SUBJ TO PERPETUAL ESMT TO USA ,EAGLE GORGE RESERVOIR;	336.51		
			6	NW 1/4 OF NW 1/4 LESS FORMER NPRR R/W LESS C/M RGTS SUBJ TO ESMT POR OF PARCEL F-603 E-1 PER DEC OF TAKING CIVIL # 5956 US DIST CT W DIST N DIV;	39.77		
			7	SW 1/4 OF NW 1/4 LESS FORMER NPRR R/W LESS C/M RGTS SUBJ TO ESMT PARCEL F-603-E-1 DEC OF TAKING CIVIL # 5956 USDIST CT W DIST OF WASH N DIV;	31.79		
			10	POR OF NW 1/4 OF SW 1/4 LY NELY OF PARCEL H-802 EAGLE GORGE SUBJ TO ESMTS TO USA LESS C/M RGTS;	12.39		
			11	POR OF N 2/3 OF S 3/4 OF W 1/4 & ALL OF S 1/4 LY SLY OF PARCEL H- 802 EAGLE GORGE LESS NEW PARCEL DESC A-112E-2 SUBJ TO ESMTS TO USA LESS C/M RGTS.	99.89		

TWP	RGE	SEC	TAX LOT	LEGAL DESCRIPTION	TAX LOT ACRES	SECTION ACRES	NOTES
			19	POR OF N 1/2 OF SE 1/4 LY SLY OF PARCEL H-802 EAGLE GORGE SUBJ TO ESMTS TO USA LESS C/M RGTS;	3.42	523.77	
		36	3	S 1/2 OF NE 1/4 LESS 1 SQ AC IN NE COR OF S 1/2 OF SW 1/4 OF NE 1/4 SUBJ TO TRANS LN R/W SUBJ TO 60 FT ESMT FOR RD 212 TO U S A ;	79.00		
			6	NE 1/4 OF NW 1/4 SUBJ TO TRANS LN R/W;	40.00		
			7	NW 1/4 OF NW 1/4 SUBJ TO TRANS LN R/W ;	40.00		
			8	SW 1/4 OF NW 1/4 LESS GREEN RIVER LUMBER CO R/W SUBJ TO USA ESMTS;	39.68		
			9	SE 1/4 OF NW 1/4 SUBJ TO 60 FT ESMT FOR RD TO U S A;	40.00		
			10	NE 1/4 OF SW 1/4 SUBJ TO USA ESMT;	40.00		
			12	NW 1/4 OF SW 1/4 LESS FORMER NPRR R/W STRIPS SUBJ TO USA ESMT;	39.52		
			13	S 1/2 OF SW 1/4 LESS N 60 FT OF E 590 FT OF SW1/4 OF SW 1/4 LESS FORMER NPRR R/W SUBJ TO USA ESMTS;	64.50		
			16	SE 1/4 SUBJ TO USA ESMT;	160.00		
			23	1 AC IN NE COR OF SE 1/4 OF SW 1/4 OF NE 1/4;	1.00		
			26	NPRR R/W & SUCH STRIPS FOR SIDINGS & CONNECTIONS WITH MAIN LINE NPRR R/W AS FORMERLY USED BY GREEN RIVER LUMBER CO IN SW 1/4 OF NW 1/4;	1.00		
			27	N 60 FT OF E 590 FT OF SW 1/4 OF SW 1/4 SUBJ TO USA ESMT.	0.82	545.52	
T21N	R11E	33	2	SE 1/4.	160.00	160.00	7
			Total		**15,173.27**	**15,173.27**	

NOTES: Acres and descriptions reported in this list are from records of the King County Assessor's Office and acres may vary from acreage calculated from Tacoma Water's GIS database as reported in this HCP.

1 Timber reserved to Citifor Inc.until 12/31/2000 on 62 acres.
2 Timber reserved to Plum Creek Timber Co. until 12/31/2007 on 285 acres.
3 Timber reserved to Plum Creek Timber Co. until 12/31/2007 on 181 acres.
4 Timber reserved to Plum Creek Timber Co. untill 12/31/2007 on 323 acres.
5 Timber reserved to Plum Creek Timber Co. untill 12/31/2007 on 220 acres.
6 Timber reserved to Plum Creek Timber Co. untill 12/31/2007 on 240 acres.
7 Timber reserved to Plum Creek Timber Co. untill 12/31/2007 on 160 acres.

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