REASONS FOR DECLINE

Bull trout distribution, abundance, and habitat quality have declined rangewide (see 63 FR 31647, 63 FR 31647, 64 FR 58910, and references therein). Within the coterminous United States, these declines have resulted from the combined effects of habitat degradation and fragmentation, the blockage of migratory corridors, poor water quality, angler harvest and associated hooking mortality[†] , poaching, entrainment into diversion channels and dams, and introduced nonnative species. Some of the historical activities, especially water diversions, hydropower development, forestry, agriculture, and development within the core areas, may have significantly reduced important anadromous populations. Some of these early land and water developments still act to limit bull trout production in core areas. Threats from current activities are also present in all core areas of the Puget Sound Management Unit. Land and water management activities that depress bull trout populations and degrade habitat in this management unit include some aspects of operation and maintenance of dams and other diversion structures, forest management practices, agriculture practices, road construction and maintenance, and residential development and urbanization. It should be noted that many of the reasons for decline, which primarily focus on their direct impacts to bull trout and their habitat, have also indirectly impacted bull trout by affecting their prey species (*e.g.*, salmon and forage fish) and their habitats within the management unit.

These reasons for decline will be presented according to the five factors identified under the Endangered Species Act that may have negative impacts on a species, potentially leading to its decline. Those five factors are (from section 4(a) of the Act):

(A) the present or threatened destruction, modification, or curtailment of its habitat or range;

(B) overutilization for commercial, recreational, scientific, or educational purposes;

(C) disease or predation;

(D) the inadequacy of existing regulatory mechanisms;

(E) other natural or manmade factors affecting its continued existence.

Dams (Factor A)

Overview. Restoring and maintaining connectivity between remaining populations of bull trout is important for the persistence of the species (Rieman and McIntyre 1993). Migration and spawning between populations increases genetic variability and strengthens population viability (Rieman and McIntyre 1993). Barriers caused by human activities limit population interactions and may eliminate life history forms of bull trout. Bull trout that migrate downstream of dams without fish passage are unable to contribute to the bull trout population upstream. In many systems controlled by dams, this loss can be significant. Additionally, dams and diversions significantly affect downstream habitats by altering sediment transport, woody debris distribution, and natural flow and temperature regimes. Dams and diversions have reduced the level of watershed connectivity in several core areas in the Puget Sound Management Unit. In many cases, dams in the management unit have likely been constructed at or near historical natural barriers to anadromous fish passage. In these cases, impacts to bull trout habitats downstream are of greater threat than potential impacts to population connectivity. Population connectivity remains a concern even where trap and haul facilities have been implemented to address passage issues, given bull trout's complex migratory patterns and the difficulty in fully replicating volitional passage (*i.e.*, allowing fish to decide when to migrate) with these types of facilities. There are a number of proposals to develop new hydropower facilities in the Puget Sound Management Unit (Nooksack, Lower Skagit, and Snohomish-Skykomish core areas) which have the potential to further fragment or degrade bull trout habitats (FERC 1998; FERC 2002a; FERC 2002b). Many negotiated instream flows for these projects have been based on resident cutthroat or rainbow trout flow requirements, and may not meet the needs of bull trout which have different life history strategies (Bodurtha, *in litt*. 1995).

Nooksack core area. The City of Bellingham Diversion Dam on the Middle Fork Nooksack River has separated a once connected population of bull trout into two separate groups, one primarily isolated upstream of the facility and one containing anadromous bull trout below. The Upper Middle Fork Nooksack River local population includes resident and fluvial bull trout which use the mainstem river and tributaries above the City of Bellingham Diversion Dam.

Some question exists as to whether a few migratory bull trout may still occasionally negotiate the diversion dam to spawn upstream of the facility. Prior to the construction of the diversion dam it is believed that the reach upstream of the facility harbored both fluvial and anadromous bull trout. While spawning has not been observed downstream of the dam, it is thought to occur in or slightly downstream of the canyon area, since staging adults have been observed at this location (Kraemer, pers. comm. 2002). Passage through the gorge is considered possible at discharges below 1,000 to 1,500 cubic feet per second, based on limited numeric modeling of discharges and velocity refuges continuing to exist behind large boulders (Zapel, pers. comm. 2003). While the diversion dam does not have a reservoir behind it, nor interrupts routing of sediment or large woody debris, it blocks most upstream migration. This likely forces some bull trout to spawn in suboptimal areas such as the confined gorge where redd scour may occur. Spawning and early rearing habitat in the Upper Middle Fork Nooksack River local population is generally believed to be in good and improving condition, since 90 percent of the area is managed under U.S. Forest Service Late Successional Reserves or Washington Department of Natural Resource's Habitat Conservation Plan (Currence 2000). Passage past this facility would provide access to at least 15 miles of additional spawning and/or rearing habitat expected to be used by the anadromous life history form. Restoring passage would also restore connectivity for the full expression of migratory life histories, increase the potential forage base by reestablishing anadromous salmon spawning distribution, and improve genetic exchange within the core area. While the diversion dam is screened, these screens are not to current standards, and may entrain outmigrating juveniles. Additionally, 67 cubic feet per second is diverted from the river when in operation, and the current facility does not have the ability to ramp[†]. This may adversely affect bull trout in reaches downstream. In addition to ramping, minimum instream flows need to be evaluated and revised as necessary to assure that all lifestages of bull trout are adequately protected.

At Excelsior/Nooksack Falls (North Fork Nooksack River), there is an outdated hydropower facility that was damaged in a fire in the 1990's and abandoned, but this was recently restarted without appreciable upgrades that are needed to ensure protection of bull trout. The intake to this facility is located upstream of Nooksack Falls, and the powerhouse and tailrace are located on the

North Fork Nooksack River downstream of Wells Creek. Several issues need to be addressed to avoid adversely impacting bull trout. One issue is that the facility requires tailrace protection to exclude fish that are likely to be attracted to it. Pink salmon were observed congregating in the flow of the tailrace outfall when the facility was formerly operating (D. Schuett-Hames, Cooperative Monitoring and Evaluation Committee, pers. comm. 2003). Additionally, minimum instream flows should be revised as necessary to assure that all lifestages of bull trout are adequately protected. As described in the core area description, this is an important adult staging, spawning and early rearing area. The facility must be modified as needed to accommodate ramping, and operated with appropriate ramping rates to avoid impacting bull trout downstream of the facility. If bull trout exist upstream of Nooksack Falls, the intakes would need to be appropriately screened to avoid entrainment of bull trout from this isolated population.

Other small hydroelectric facilities located in spawning, rearing or foraging habitat should be evaluated and their operations adjusted and/or facilities upgraded as necessary to avoid impacts to bull trout.

Lower Skagit core area. The City of Seattle hydroelectric complex on the upper Skagit River (Gorge, Diablo, and Ross Dams) is thought to have been placed at the approximate site of a historical migration barrier(s). Genetic exchange between the upper river populations and the lower river may have been primarily one-way (downstream). Prior to construction of the dams, it is possible that on rare occasions fish in the Lower Skagit core area gained access beyond the barriers to the Upper Skagit core area, but it is not known for certain. The presence of char and rainbow trout in the upper Skagit drainage supports the supposition that these fish did gain access at some point in time. It is believed that historically bull trout could migrate upstream to at least the area near Diablo Dam. Prior to construction of Seattle City Light’s three dams, the Skagit River ran through a narrow and steep canyon for 22.5 kilometers (14 miles) from the current location of Ross Dam to the town of Newhalem (river mile 94). Biological surveys conducted by University of Washington biologists prior to the construction of Seattle City Light's dams indicated that native char were "very abundant" in the 1.6-kilometer (1-mile) section of the Skagit River immediately upstream of the town of Newhalem (Smith and Anderson 1921). These early biological surveys (Smith and Anderson 1921) and interviews with local residents (Envirosphere 1988) indicate that salmon were not able to migrate any farther than 1.6 kilometers (1 mile) upstream of Newhalem, although small numbers of steelhead trout were able to migrate as far upstream as Stetattle Creek (river mile 100) and Reflector Bar (river mile 100.5). Since steelhead trout were able to migrate this far upstream, it is possible that bull trout in the lower Skagit River could also have migrated upstream as far as Reflector Bar prior to the construction of Gorge Dam. Upstream of this point, the Skagit River flows through Diablo Canyon, a bedrock gap where the river narrows to about 2.4 meters (8 feet) in width. This narrow gap, likely the upstream limit of steelhead and bull trout migration, is located just downstream of the current location of Diablo Dam (river mile 100).

Anadromous access to the current location of Gorge Dam has been blocked to this area since 1919, after the construction of the original woodcrib dam, and the two successive replacements at the current Gorge Dam site (Williams *et al.* 1975). Bull trout in Gorge Lake, the reservoir formed by the current high dam built in 1961, are currently isolated from other populations within the Skagit River system, except for individuals from Diablo Lake passing downstream through Diablo Dam, built in 1930. There is currently a limited amount of available potential spawning habitat in the Gorge Lake system, the lower 2.7 kilometers (1.7 miles) of Steattle Creek and that portion of the Skagit River mainstem from the reservoir up to Diablo Dam (less than 1.6 kilometers; 1 mile) (WDFW 1998). The best areas for bull trout spawning is in a free-flowing section of the river located immediately upstream from Gorge Lake near the mouth of Stetattle Creek (Connor, pers. comm. 2003c). Changes in the flow regime[†] of the mainstem Skagit River below Diablo Dam and above Gorge Lake should be evaluated and considered to enhance available spawning habitat. Potential changes to the flow regime in this reach may be limited, because the current flow regime must adhere to the conditions of the Skagit Hydroelectric Project Fisheries Settlement Agreement. This agreement was signed by Seattle City Light, the Federal and State fishery agencies, and Tribes in 1991 to protect anadromous and resident fish in the 38.6-kilometer (24-mile) reach of the Skagit River downstream of Newhalem. Based on the perceived connectivity structure that existed within this system prior to construction of the three upper Skagit River dams, passage between the Lower Skagit River and Gorge Lake should be evaluated and considered. An assessment of the genetic uniqueness of individuals residing within this system will help determine how critical it is to improve connectivity with this functionally isolated group of bull trout, and whether it should be identified as a separate core area in the management unit.

In addition, the three upper Skagit River dams have prevented the transport of large wood to the Lower Skagit core area. This, in conjunction with past wood removal efforts, has significantly contributed to the reduction of historical habitat complexity in the Lower Skagit River mainstem and estuary.

Two Puget Sound Energy hydroelectric dams, Lower and Upper Baker Dams, have greatly limited fish movement in the Baker River system since 1927 and 1955, respectively (Williams *et al.* 1975; WDFW 1998). Two large reservoirs have been created by the lower and upper dams, Lake Shannon and Baker Lake, respectively. Lake Shannon has inundated 14.4 kilometers (9 miles) of riverine habitat and the lower reaches of tributaries which potentially provided historical spawning habitat. The original Baker Lake was greatly enlarged after construction of the upper dam, inundating potential spawning habitat in tributaries discharging into the lake. Early biological surveys conducted by University of Washington researchers prior to the construction of the upper dam reported that there were large numbers of native char, with fish commonly 11.0 to 17.6 kilograms (5 to 8 pounds) in size. The abundance of native char was attributed to an excellent food supply, especially juvenile sockeye salmon. These migratory native char (presumably bull trout) were observed to spawn in the upper Baker River immediately upstream of the lake (Smith and Anderson 1921). The dams on the Baker River have altered the historical connectivity with the rest of the lower Skagit River system, however, available information seems to indicate that there is currently a reluctance for bull trout to migrate from the Baker Lake complex. This may be the result of the abundant forage base that exists in the lake (juvenile sockeye and kokanee) reducing or negating the need to migrate to marine forage areas. Small numbers of bull trout are collected at the adult trap-and-haul facility at the Lower Baker Dam and transported upstream of the dams to Baker Lake each year. Connectivity is dependent on this trap-and-haul facility and the Baker and Shannon Lakes smolt traps. It is unknown to what extent bull trout migrated in and out of this system prior to the damming of the Baker River and the enlargement of Baker Lake. Improved passage past these two facilities would restore the opportunity for the full expression of migratory life histories and improve genetic exchange within the core area. Operations at the Lower Baker Dam continue to impact downstream salmonid habitats in the lower Baker and Skagit Rivers as a result of rapid changes in flow releases and the change of the lower Baker River from a free flowing river to a still water system (WSCC 2003).

Upper Skagit core area. Ross Lake is a 38-kilometer (24-mile) long reservoir impounded by Ross Dam which was completed in 1949 and is operated by Seattle City Light (Williams *et al.* 1975). This reservoir provides the foraging, overwintering, and migration habitat for the adfluvial bull trout population in this core area. Ross Lake is typically full from late June through mid-September, and then partially drawn down during the winter for flood control purposes and for maintaining flows downstream in the lower Skagit River for salmon and steelhead. Prior to construction of Ross Dam, many of the tributaries currently used by bull trout were inaccessible due to steep cascades; however, reservoir elevations have since allowed access. The formation of the reservoir has eliminated mainstem and lower tributary habitats that were likely used for spawning and rearing prior to inundation. Ross Dam is a passage barrier to the upstream and downstream migration of native char between Ross Lake and Diablo Lake, however the level of bull trout emigration from Ross Lake to Diablo Lake has not been determined. Native char were reported to be very abundant in this area before inundation by the reservoir, particularly in the lower reaches of Ruby Creek (Smith and Anderson 1921). Diablo Lake may act as a sink to the segment of the population inhabiting Ross Lake, given that there is no upstream passage between these two lakes and the limited spawning habitat in the Diablo Lake system. Studies are presently being initiated to identify whether there are genetic differences between bull trout or Dolly Varden in Ross Lake and Diablo Lake.

Chester Morse Lake core area. There is no direct evidence to suggest that this core population has declined from its historical level. However, several conditions related to the water supply and hydroelectric generating systems exist that may modify and/or restrict free movement of an unknown portion of the bull trout population both within the full extent of the reservoir system as it now exists, and/or downstream to lower reaches of the Cedar River.

The modification of the natural outlet channel of Cedar Lake (currently Chester Morse Lake) by construction of the historical wooden Crib Dam (Overflow Dike) and subsequent construction of the Masonry Dam 2.3 kilometers (1.4 miles) downstream has created an additional body of open water. Masonry Pool now exists between the two dams and is contiguous with Chester Morse Lake. Although fish can pass freely between the two bodies of water when reservoir levels are relatively high and above the current spillway height of the Overflow Dike (more than 472 meters; 1,550 feet surface elevation), annual fluctuations in the reservoir in conjunction with demands for water supply and required flow (*e.g.*, fish flows) in the lower Cedar River necessitate that reservoir levels drop below the Overflow Dike spillway. This effectively ‘disconnects’ free surface flow between the Chester Morse Lake and Masonry Pool. During these periods, water is continually released from Chester Morse Lake through a control gate at the base of the Overflow Dike. Fish may be able to pass downstream through this gate, however, they may incur some unknown degree of injury, or be killed, depending upon flow velocities and/or in what manner they contact the flow dissipation structure at the flow outlet from the control gate. The level of entrainment and extent of injury to bull trout passing through the Overflow Dike control gate structure from Chester Morse Lake to Masonry Pool is unknown (Knutzen 1997).

Any bull trout present in Masonry Pool during periods when the lake and pool are ‘disconnected’ (typically from late summer to the period of spring refill) are presumably unable to migrate upstream through the Overflow Dike (*i.e.*, velocity barrier) and subsequently into Chester Morse Lake. The effect(s) on the core population of this apparent restriction of movement is unclear, but the most significant may be that some potential bull trout spawners may be prevented from migrating upstream. No bull trout spawning activity has been observed to date in exposed stream flow reaches of Masonry Pool or in the only tributary to the pool, Lost Creek (which typically exhibits subsurface flow conditions during the bull trout spawning season) (Paige, *in litt*. 2003).

Entrainment of downstream migrating bull trout at the intake tunnel/penstock† structures (located at the Masonry Dam) for the hydroelectric facility at Cedar Falls may potentially occur because the intakes are currently unscreened. The number of bull trout in Masonry Pool is very low relative to the number found in Chester Morse Lake; however, Knutzen (1997) estimated that the loss of bull trout from entrainment may be about 200 fish per year, with the estimated number of fish lost ranging from 10 to several hundred individuals. It has not been definitively determined whether all individuals that may be entrained die. At certain levels of generation (turbine speed), it is possible for even relatively large fish to physically pass through the turbines. The key question is whether or not some fish can survive the pressures experienced in the penstocks and as they pass through the turbine generators. Any bull trout entrained at the Masonry Dam, or passing over the dam during periods of spilling, are lost to the core area because no upstream interchange can occur. Both means of fish movement out of the reservoir complex represent an irretrievable loss of individuals from the local population to a river reach where, at least at this time, there appears to be little chance for either successful establishment or maintenance of a viable bull trout population. Mortality resulting from entrainment may potentially explain the limited number of observations of bull trout in the Cedar River between Cedar Falls and Landsburg; however, there may be several other contributing factors of similar or greater potential significance (*e.g.*, temperature, habitat, interspecific competition†) that might explain the paucity of bull trout observations in the Cedar Falls/Landsburg reach.

Most bull trout in this core area spawn in lower reaches of both primary and secondary tributaries of Chester Morse Lake within a maximum distance of approximately 2.9 kilometers (1.8 miles) of the Cedar River and much closer for other streams (refer to core area discussion). Access to spawning reaches may be restricted during periods of unusually low reservoir drawdown because of potential physical barriers to passage at the ‘lip’ of delta fans, as in the case of the Cedar and Rex Rivers (WDFW 1998; City of Seattle 2000b), and by subsurface flow conditions at the confluences of secondary lake tributaries (*e.g.*, Rack and

Shotgun Creeks) (Paige, *in litt*. 2003). However, during the 2002 spawning season when both stream flow and reservoir levels were either at or approaching record low levels, bull trout were able to successfully access traditional spawning reaches in the Cedar and Rex Rivers and bull trout redd counts were the highest recorded in the Chester Morse Lake core area since counts began in the early 1990's. Bull trout were also able to take advantage of very brief period(s) of stream flow freshets to gain access and spawn in at least one of the secondary tributaries to the lake (Rack Creek) that typically supports a relatively low level of bull trout spawning activity (Paige, *in litt*. 2003).

These recent observations indicate that even under such extreme environmental and operational conditions as existed within the reservoir during fall 2002, bull trout in the Chester Morse Lake core area are not prevented, and presumably not restricted, from spawning. Stream flow and reservoir drawdown levels more extreme than those experienced in fall 2002 are predicted to be especially rare events within the watershed and adverse impacts to the bull trout population from such conditions are not expected to occur on any regular basis (City of Seattle 2000b). Also, it is even less probable that conditions sufficient to completely prevent all bull trout from accessing spawning reaches for the entire spawning period would occur during any year.

Given that the bull trout local populations have evolved within the system and probably have historically experienced complete or near complete loss of an entire age class because of peak flow, flood flows, or even low flow conditions in some instances, it could be assumed that the local populations in this core area would persist and not be critically jeopardized if spawning were restricted by the combination of environmental and operational constraints at a frequency not unlike that created by naturally occurring events. If future reservoir drawdown conditions more severe than those existing in 2002 do occur, and actually prevent bull trout from accessing traditional spawning reaches, the City has committed to the development and implementation of a ‘passage assistance plan’ under the habitat conservation plan (City of Seattle 2000b).

Because most bull trout in this core area spawn in lower reaches of the Cedar and Rex Rivers upstream of Chester Morse Lake within a distance of approximately 2.9 kilometers (1.8 miles) in the Cedar and 1.1 kilometers (0.7 mile) in the Rex, and portions of these spawning reaches are within the potential inundation zone of the reservoir during the period of spring refill, eggs and/or alevins remaining in redds when rising water levels reach specific sections of the lower rivers may be susceptible to potential adverse impacts resulting from inundation (City of Seattle 2000b). The maximum number of redds that could be inundated annually at the maximum level of reservoir refill (elevation 477 meters; 1,564 feet) is substantial, especially in the Rex River (nearly 100 percent). In actuality however, the number/percent of redds that are inundated at some point during the extended refill period is significantly less. The operational timing of reservoir refill relative to egg incubation periods and fry emergence dates at specific redd locations within the reaches substantially reduces the number of redds at risk of potential adverse effects from inundation. Presumably, the degree of any realized adverse effects to bull trout eggs and/or alevins remaining in redds at the time of inundation decreases substantially at later stages of incubation. The specific combination of the extent of inundation (*i.e.*, depth), duration of inundation, and the amount of fine sediment deposited may also have bearing on the potential adverse impacts of inundation and will be widely variable from year to year. Because the actual impacts to bull trout eggs/alevins resulting from inundation have not yet been definitively determined, and the overall effect on spawning success is not known, the potential effect of inundation on the bull trout population(s) in the Chester Morse Lake core area remains a concern. These concerns are currently being monitored and assessed under elements of the Cedar River Watershed Habitat Conservation Plan (City of Seattle 2000b).

Puyallup core area. Connectivity of the upper Puyallup and Mowich Rivers with other local populations and foraging, migration, and overwintering habitats has been limited by the Puget Sound Energy’s Electron Diversion Dam, allowing only downstream connectivity. Electron Dam had effectively isolated bull trout in the upper Puyallup and Mowich Rivers from the rest of the basin for nearly 100 years (WSCC 1999b). Recently, a new fishway was constructed to improve upstream fish passage and has been fully operational since October 13, 2000. This facility is expected to significantly improve connectivity and genetic interaction with other local populations within the core area. However, bull trout continue to be threatened by entrainment into the facility’s unscreened power canal (Ging, pers. comm. 2003). Currently, bull trout that enter the power canal are unable to migrate back out due to high water velocities. Bull trout trapped in the canal can be removed by the fish collection facility within the canal; however, recent fish rescue efforts associated with several canal drawdowns indicate that bull trout are able to avoid capture by the current fish collection facility (Feldmann, *in litt*. 2002; Ging, pers. comm. 2002a). Although minimum instream flows have improved (60 cubic feet per second between November 16 through July 14, and 80 cubic feet per second between July 15 through November 15) as a result of the 1997 Resource Enhancement Agreement between Puget Sound Energy and the Puyallup Tribe (WSCC 1999b), the diversion of water still significantly affects habitat availability in the 16.9 kilometer (10.5 mile) bypass reach.

Mud Mountain Dam, a flood control structure in the lower White River at river mile 29.6, and Puget Sound Energy’s Buckley Diversion Dam at river mile 24.2, form barriers to natural migration. Completed in 1911, the Buckley Diversion diverts water from the mainstem White River into the artificial lake, Lake Tapps, which provides storage water for power generation at the Dieringer Powerhouse. These two structures have historically been a problem for both downstream and upstream fish passage. Historically, significant numbers of salmon and bull trout have been lost when the timing of downstream migration coincides with the diversion of the White River into Lake Tapps (Heg *et al.* 1953; WDFW 1998). The Washington Department of Fisheries operated a downstream migrant trap in 1953, located on the bypass leading from the screens to the White River. Downstream bull trout migration, corrected for fish using the main channel, was estimated to be 693 bull trout between May and July of that year (Heg *et al.* 1953). However, new fish screens placed in 1996 have improved downstream passage. Upstream passage of bull trout and anadromous salmon past these two facilities has been achieved using a trap and haul facility located at the Buckley Diversion Dam, and has operated since 1941 (Heg *et al.* 1953). However, trapping efforts prior to the late 1980's were generally limited to periods during anadromous salmon runs, and it is unknown whether bull trout were consistently passed upstream. Currently, the trap and haul facility is operated year round and adult-sized fish entering the trap are captured and transported upstream above Mud Mountain Dam. The trap and haul is currently not designed to collect juvenile or small subadult upstream migrants (individuals typically less than 350 millimeters [13.8 inches] in length) (Hunter, *in litt*. 2001). The current trap design has resulted in some bull trout mortality (Ging, pers. comm. 2002b). When flows overtop the Buckley Diversion Dam by more than 0.3 meter (1 foot), the flashboard sections are designed to fail to prevent further damage to the structure. Until the flashboard sections are replaced, upstream migrants can pass into the 8-kilometer (5-mile) long reach between Mud Mountain Dam and the Buckley Diversion. These individuals are essentially precluded from further upstream migration until they drop back below Buckley Diversion Dam and enter the trap and haul facility.

Storage of peak flows behind Mud Mountain Dam results in a disruption of sediment routing and ultimate delivery to downstream reaches. This has in turn resulted in prolonged high turbidity and increased concentrations of fine sediment in the substrate. The Buckley Diversion has significantly reduced flows in the 33.8-kilometer (21-mile) bypass reach of the White River, which continues to impact habitat conditions for bull trout in this reach (WDFW 1998). Recent operational modifications of the diversion system have increased base flows in the bypass reach, thereby increasing rearing habitat quantity and quality. Water discharged from the Dieringer powerhouse is returned to the White River at river mile 3.5 via the tailrace outlet canal. This discharge has and continues to vary widely on a daily basis. This discharge has been higher in temperature and lower in dissolved oxygen levels than the mainstem White River during some years, likely impacting available foraging, migration, and overwintering habitat from the point of the outfall to the confluence with the Puyallup River. During other years, colder water has been discharged at the Dieringer powerhouse, which has raised concern over false attraction problems with the tailrace outlet canal, and associated injury or migration delays to migratory salmonids (WSCC 1999b).

While not a dam, the City of Tacoma’s water Pipeline Number 1 crossing on the White River was identified as an impediment to the upstream migration of anadromous salmonids (WSCC 1999b). Although a fish ladder had been installed to facilitate upstream passage, injuries to anadromous salmonids were noted. In 2003, the pipeline was replaced with a new pipeline section that was constructed below the grade of the river bed, so upstream fish passage has now been fully restored.

Lake Washington foraging, migration, and overwintering habitat. The Hiram H. Chittenden (Ballard) Lock system may affect bull trout migration to and from the Lake Washington system. Completed in 1916, the ship canal and lock system changed the outlet of Lake Washington from the southern end to the northern end of the lake, discharging directly into saltwater at Salmon Bay. Impacts to juvenile salmonid outmigrants have been detected in the past, but recent improvements to the facility and its operation have significantly reduced these impacts. A fish ladder is present at this facility, although fish may also be passed through the locks. The effect of the facility on bull trout movements is currently unknown but should be further evaluated, due to the bull trout's unique migratory movements as subadults and adults.

Lower Green River foraging, migration, and overwintering habitat. The City of Tacoma's Headworks diversion dam has been a barrier to upstream migration of anadromous salmonids since 1912, and Howard Hanson Dam has been a barrier to upstream migration since 1961. Since there is little historical information regarding the past distribution of bull trout within the Green River basin, it is not known how much these facilities contributed to the decline of bull trout use within this system. If migratory bull trout historically used most of the accessible areas of the upper Green River, these facilities would have prevented access to the upper watershed for over 80 years. These facilities have also reduced the available spawning habitat for anadromous salmon, which were likely an important prey species for bull trout in this system. Fish passage has recently been planned for these two facilities (Tacoma Public Utilities 2001; Pozarycki, *in litt*. 2004).

Nisqually River foraging, migration, and overwintering habitat. The Yelm Hydroelectric Project consists of a diversion dam located at river mile 26.2, which diverts water through a canal to a powerhouse located at river mile 12.7. It is unknown to what degree this facility contributed to the decline of bull trout use within this system, but we do know the initial diversion structure built in 1929 was likely a barrier to fish passage until modified after several years of operation.

A standard fish ladder did not replace the inadequate, primitive ladder until 1955. Between 1930 and 1955, the diversion canal to the powerhouse was unscreened allowing entrainment of juvenile salmonids, and between 1955 and 1968 the project effectively diverted all water during periods of low flow from the mainstem Nisqually River to the canal and through the turbines (WSCC 1999c).

For nearly 30 years, the Nisqually Hydroelectric Project at LaGrande was operated for peak power, creating rapid changes in downstream flows. This was especially adverse during the summer and fall low flow months, and is attributed with driving Nisqually spring Chinook salmon to the point of extinction by the early 1950's (NCRT 2001). If bull trout utilized this area for spawning in the past, they would have likely been similarly affected during this time period. This project has also interrupted the recruitment of large woody debris and sediment to river reaches below LaGrande Dam (WSCC 1999c).

Significant improvements in Nisqually River base flows, both upstream and downstream from the Yelm diversion, have been in effect since 1993 as a result of a special Federal Energy Regulatory Commission Proceeding to address this issue. In addition, Tacoma Public Utilities has implemented a number of measures (limits on project ramping, gravel augmentation, riparian corridor acquisition) to improve and protect habitat to meet the requirements of its operating license, issued in 1997, for the Nisqually Hydroelectric Project.

Forest Management Practices (Factor A)

Overview. Forestry activities that adversely affect bull trout and their habitat are primarily timber extraction and road construction, especially where these activities involve riparian areas. Such practices can impact stream habitat by altering recruitment of large woody debris, erosion and sedimentation rates, snowmelt timing, runoff patterns, the magnitude of peak and low flows, water temperature, and annual water yield[†] (Cacek 1989; Furniss *et al.* 1991; Murphy 1995; Spence *et al.* 1996; Spencer and Schelske 1998; Swanson *et al.* 1998). Other impacts of timber harvesting may include decreased slope stability (Chamberlin *et al.* 1991; Murphy 1995). Additional adverse effects may have resulted from the use of various pesticides on forest lands (Norris *et al.* 1991).

The Puget Sound region has a long history of timber harvest, beginning in the mid 1800's (Murphy 1995). Harvest in this region began in the Puget Sound lowlands and has progressed higher up into watersheds over time. Most of the lowlands harvested initially for timber were subsequently cleared for agriculture and development. The mainstem reaches of all core areas discharging into Puget Sound have been impacted by past timber harvest. Past forest management practices have left this region with a legacy effects† on aquatic habitats, and stream systems continue to recover from these impacts even today. Riparian and stream clearing and the construction of splash dams† to facilitate water transport of logs was common practice in western Washington streams (Sedell *et al.* 1991). Repeated splash damming resulted in major long-term damage to fish habitat as the practice caused severe scouring of stream channels, often down to bedrock (Murphy 1995). In tributaries too small for splash dams, trees were typically yarded downstream, degrading stream channels and banks in the process. Splash damming also resulted in estuarine impacts. For example, the Samish River historically had so many forks and sloughs across the delta that no channel had sufficient flow to float logs downstream (Willis 1975). In the 1880's loggers cleared a single channel and blocked off the remaining channels and sloughs to enable logs to be transported to Samish Bay when minor floods were created by opening up a series of wooden splash dams in the upper river (Willis 1973, 1975). Railroad systems were also constructed in many watersheds for transporting timber to mills. Although these forest management practices were improved somewhat by the 1950's, clearcutting to the streambank remained a common practice until the 1980's. Early truck roads were often constructed using techniques which were standard for the day, but resulted in substantial mass wasting. Downstream transport of forest products occurred in larger rivers including the Skagit and Nooksack, and channels had to be sufficiently cleared of hindrances including logjams in order to accomplish this. In the 1970's, forest practice rules began to require the removal of logging debris from streams after timber harvest (Murphy 1995); however, this resulted in complete clearing of large woody debris from many streams. Until recently, State forest practices allowed timber harvest to occur within 7.6 meters (25 feet) of salmonid bearing streams. It is now acknowledged that these minimum widths were often insufficient to fully protect riparian ecosystems (USDI *et al.* 1996).

Large networks of forest haul roads, skid trails/roads, and yarding corridors now exist in many Puget Sound watersheds. Many existing roads were built with techniques that are now considered obsolete. The road network is so large that much of it can not be maintained to current regulatory standards. Much of this road network crosses or parallels stream channels, leaving a legacy of problems such as chronic bank erosion, debris flows, fish passage barriers, chronic delivery of fine sediments, and slope failures. Rashin *et al.*(1999) found that best management practices used even in new road construction were generally ineffective or only partially effective at preventing chronic sediment delivery to streams when the activity occurred near streams. In the Columbia Basin, a recent assessment revealed that increasing road densities and their related effects are associated with declines in the status of four non-anadromous salmonid species (bull trout, Yellowstone cutthroat trout [*Oncorhynchus clarki bouvieri*], westslope cutthroat trout, and redband trout [*O. mykiss gibssi*]) (Quigley and Arbelbide 1997). It was found that bull trout were less likely to use highly roaded basins for spawning and rearing, and if present they were less likely to be at strong population levels (Quigley and Arbelbide 1997). Quigley *et al.* (1996) demonstrated that where average road densities were between 0.4 and 1.0 kilometers per square kilometer (0.7 and 1.7 miles per square mile) on National Forest lands, the proportion of subwatersheds[†] supporting "strong" populations of key salmonids dropped substantially, declining even further with higher road densities. The proportion was even lower for these road densities when land ownership was combined. Although this assessment was conducted east of the Cascades, effects from high road densities may be worse in western Washington. Higher precipitation west of the Cascades increases the frequency of surface erosion and mass wasting (USDI *et al.* 1996).

Recreational activities (camping, trail use, off-road vehicle use) in forested areas have often caused significant localized impacts. These are typically associated with riparian removal and degradation, sedimentation, and degradation of streambanks and channels. However, some of these areas have facilitated access to bull trout staging and spawning areas, and have resulted in increased illegal harvest.

Chilliwack core area. The majority of timber harvest within the Chilliwack River drainage has occurred within British Columbia. Significant timber harvest has occurred throughout the drainage within British Columbia and continues today. In the past, significant logging has occurred in all eight currently identified local populations completely or partially within British Columbia (Airplane, Borden, Centre, Depot, Foley, Paleface, Nesakwatch, and Silesia Creeks) (M.A. Whelen and Associates Ltd. and TSSHRC 1996). Although Chilliwack Lake is now entirely within the Chilliwack Lake Provincial Park, Paleface and Depot Creeks are almost entirely outside of the Provincial Park boundary with the exception of their lower reaches. The upper reaches of Depot Creek and other parts of the Chilliwack River system in Washington State are within North Cascades National Park, and therefore have been free of timber harvest impacts. The kokanee population in Chilliwack Lake is said to likely remain abundant and stable, given the Provincial Park status around the lake coupled with the view that Paleface and Depot Creeks have recently stabilized following extensive logging within these systems (Nelson and Caverhill 1999). Whether bull trout populations using these two creeks are stable is unknown, but given the much longer period of stream rearing by juvenile bull trout compared to that of juvenile kokanee, they likely have been and might continue to be more impacted by the logging that has occurred within these systems. Reaches of Silesia Creek within British Columbia currently have very little large woody debris, which has been attributed to increased riparian timber harvest (M.A. Whelen and Associates Ltd. and TSSHRC 1996).

Nooksack core area. Timber harvest and associated road building have substantially impacted spawning and rearing habitat in the Nooksack core area. Much of the upper Nooksack watershed is naturally prone to mass wasting due to steep topography, inherently unstable geology, and high precipitation, but forest practices have substantially increased the magnitude and frequency of mass wasting events. Natural slope instability combined with the timber management history have combined to disproportionately impact this core area. The Washington State Conservation Commission (WSCC 2002a) summarized a number of landslide inventories for the three river forks, and reports 632 mass wasting events in the North Fork (36 percent associated with roads, 28 percent associated with clearcuts), 480 mass wasting events in the Middle Fork (36 percent associated with roads, 32 percent associated with clearcuts), and 1,216 mass wasting events in the South Fork (37 percent associated with clearcuts, 32 percent associated with roads). The highest landslide densities in the North Fork are in Cornell, Racehorse, Gallop, Boulder, Coal, Canyon, and Glacier Creek drainages respectively (WSCC 2002a). Porter, Canyon Lake and Clearwater Creek drainages have the highest landslide densities respectively in the Middle Fork basin (WSCC 2002a). Landslide densities are very high in the small drainages of the lower 21 kilometers (13 miles) of Skookum Creek and in the upper South Fork including Wanlick Creek, and densities are moderate in the Hutchinson Creek drainage (WSCC 2002a).

While many landslides result in sediment delivery that routes to downstream habitat, the most devastating mass wasting events are those that initiate debris flows that travel through bull trout spawning and rearing areas. North Puget Sound has a higher frequency of debris flows than South Puget Sound (J. Grizzel, Washington Department of Natural Resources, pers. comm. 2003), and debris flows are generally triggered during high precipitation storm events, including rain on snow events. The history of mass wasting and debris flow impacts demonstrate the magnitude and frequency of landslide events during the timber management period that have impacted bull trout in this core area. Most of this history reflects the legacy of past road building and timber management practices, with current rules and best management practices substantially improved. Improved road maintenance through time is essential to achieving adequate sediment reduction. Even if debris flow frequencies and magnitudes approach background levels, many of the impacts that have recently occurred will be relatively long term, and habitat recovery will continue to occur over the next several decades or longer.

Numerous spawning and rearing streams have had recent debris flows travel though their anadromous bull trout reaches. After debris flow events in 1984 and 1989 in Canyon Creek, the emergency response included the use of heavy machinery in the lower reaches after both events (Nichols, pers. comm. 2002). An extensive riprap wall was constructed after the 1989 event to protect houses and other structures built on the alluvial fan, and a new channel was also excavated in the debris flow deposition zone[†]. The Jim Creek deep-seated landslide, located just downstream of Canyon Creek falls, had a 700 percent increase in annual sediment delivery from 1983 to 1991 compared to the previous period from 1940 to 1983 (Ballerini 1993). From 1983 to 1991, total coarse and fine sediment delivery from this slide was estimated to be 774,500 cubic yards. In Boulder Creek, between 1962 and 1989, the State Route 542 bridge located at river mile 0.2 was buried by flood debris at least eleven times. A 4-kilometer (2.5-mile) long reach along Boulder Creek, which had an eighteen-fold increase in landsliding area, produced much of this debris (Gowan 1989). Debris flows also traveled through Deadhorse Creek in 1962 and 1989 (Nichols, pers. comm. 2002). Landslide related dam break flood events occurred in Glacier Creek in 1962 and 1989 which resulted in surge flow and appreciable bedload movement (Nichols, pers. comm. 2002). Heavy equipment was used to dig out the State Route 542 bridges on lower Glacier and Cornell Creeks after the event in 1989 (R. Roames, Washington Department of Natural Resources, pers. comm. 2003). In the Middle Fork, Porter and Canyon Lake Creeks had debris flows through their accessible habitat in 1989, with wood and sediment removals occurring at both Mosquito Lake Road bridges (Roames, pers. comm. 2003). Clearwater Creek has had debris flows through the accessible bull trout habitat in 1975, 1983, and 1990 (Nichols, pers. comm. 2002). A Deer Creek debris flow in 1995 was initiated below a road and traveled over three miles to the river (Crown Pacific, *in litt*. 1995). In the Howard Creek drainage an estimated 2.5 million cubic meters (3.3 million cubic yards) of sediment input occurred between 1940 and 1986 from landslides in timber harvested areas (Peak Northwest 1986). The mainstem South Fork also has numerous large landslides adjacent to the river, which are chronic sources of sediment delivery, particularly fine sediment. While this is the non-glacial fork, suspended sediment[†] levels frequently exceed those in the glacially influenced North and Middle Forks (Soicher 2000).

Forest management activities have also impacted riparian conditions in the core area. The spawning and rearing areas are primarily located in forested or forest management areas, with predominately Federal forest zoning higher in each fork. Commercial forestry and rural forestry become progressively more dominant downstream in each of the forks. The lower South Fork also has agriculture zoning (Coe 2001). Riparian conditions correlate with the zoning, and overall are in better condition (increased large wood recruitment and shading) in the upper portions of the mainstem North and South Forks, and more degraded in the lower portions (Coe 2001). The mainstem Middle Fork has relatively consistent riparian conditions, and in all three forks riparian conditions in their tributaries are usually better in those streams located higher in each fork. Overall, the riparian conditions and the habitat functions associated with them are in better condition for local populations located higher in the forks, and are more degraded for local populations located further downstream (Coe 2001).

While many spawning and rearing tributaries are temperature impaired, the mainstem of the South Fork Nooksack River has the most serious temperature problems, with water temperatures as high as 24 degrees Celsius (75 degrees Fahrenheit) reported (Maudlin *et al.* 2002). The South Fork is on the Washington Department of Ecology's 303(d) list of impaired waterbodies for insufficient instream flows, elevated fine sediment, and temperature. Recent data indicate the lower river also has low dissolved oxygen levels (Doremus *et al.* 2003). Thermal impairment begins far upstream in the timber management zone. While the absence of glacial melting and the amount of snowpack influence temperatures in the South Fork Nooksack River, forest management has also affected it through removal of river and tributary riparian vegetation, through the initiation of debris flows in tributaries, through increased sediment delivery from landsliding which resulted in river channel widening and increased unvegetated gravel bars, and possibly through hydrologic changes associated with clearcutting and forest roads. In August 2001, a longitudinal temperature profile of the South Fork was created from a forward looking infrared flight (Watershed Sciences LLC 2002). The results show a fairly rapid increase in temperature progressing downstream of Wanlick Creek (river mile 34), some cooling in the vicinity of Bear Creek outlet, additional increases in temperature to approximately the confluence with Cavenaugh Creek, and cooling from this area to downstream of Skookum Creek. Thermal heating then continues downstream, in the predominately agricultural area. The cooler areas of the river identified in this flight may be important refugia for rearing, migrating adults and foraging subadults. Temperatures in lower Bear Lake outlet, Cavenaugh, Skookum, and Hutchinson Creeks were 6.5, 4.4, 3.4, and 4.9 degrees Celsius (11.7, 7.9, 6.1, and 8.8 degrees Fahrenheit) cooler, respectively, than the river that was adjacent to them. These, other tributaries, and several cool seeps identified in this flight likely provide important temperature refugia areas for bull trout in the South Fork Nooksack River. The South Fork Nooksack River has also lost its deep salmon and trout holding pools that were created by former complex logjams (Maudlin *et al.* 2002).

Recreational off-road vehicle use is high in many forest management areas in the Nooksack core area, such as in areas around Racehorse and Bear Creek Sloughs, and Hutchinson Creek. These trails have caused erosion, riparian impacts, and direct impacts by driving through anadromous streams with known and presumed bull trout use (*e.g.*, lower Hutchinson Creek and tributaries to Bear Creek Slough).

Lower Skagit core area. Timber harvest and associated road building has had impacts to habitat in a number of watersheds in the Lower Skagit core area, including the Lower White Chuck (northside tributaries), Tenas Creek, Straight Creek, Lime Creek, Illabot Creek, Upper North Fork Sauk River, and South Fork Sauk River. Approximately 40 percent of the Sauk River drainage has been logged, with about 22 percent of the National Forest System lands consisting of forested stands established after 1920 (USFS 1996). The majority has occurred outside of the Sauk Forks watershed. Areas were initially harvested via railroad systems, followed by extensive road systems in the mid-1950's to 1960's. Road densities for the Sauk drainage as a whole are 1 kilometer per square kilometer (1.6 miles per square mile), with highest densities within the Sauk River watershed, with an open road density of over 1.2 kilometers per square kilometer (2 miles per square mile) (USFS 1996).

Tributaries to the Skagit River that have been seriously impacted by forest and County roads include Finney Creek and Grandy Creek. Both streams have high sediment loads and warm water temperatures caused by landslides triggered by roads and logging, and by warm water temperatures resulting from impacts to the riparian corridor and widening of the stream channels due to high sediment loads. Both of these streams are currently on the Washington Department of Ecology’s 303(d) list of water quality impaired streams due to excessive warming and high sediment loads. Historical accounts suggest that both streams were used by native char prior to degradation caused by road building and timber harvest (Connor, *in litt*. 2003).

Some impacts to habitat in the upper South Fork Sauk River and North Fork Sauk River have occurred from recreational activities (*e.g.*, camping, recreational mining). The Buck Creek and Downey Creek local populations have had localized impacts from the Buck Creek and Downey Creek campgrounds located near the Suiattle Road.

Upper Skagit core area. Timber harvest activities continue to be a threat to bull trout habitat in the upper Skagit River watershed within British Columbia. Timber harvest is an ongoing activity within sections of Skagit Provincial Forest, British Columbia, which is located in the northwestern portion of the Upper Skagit watershed. Bull trout are designated as a “Blue Listed” species by the Provincial government, and as such receive some habitat protections from land management activities including logging. That portion of the Upper Skagit core area within Washington State is within North Cascades National Park, Ross Lake National Recreation Area, Mount Baker-Snoqualmie National Forest, and Pasayten Wilderness and therefore has generally been free of timber harvest impacts.

Snohomish-Skykomish core area. The Snohomish-Skykomish core area has had some impacts from logging and associated road building as well as impacts from various recreational activities on forest lands (camping, inappropriate use of four-wheel drive vehicles). These impacts continue to occur in the watershed. Past timber harvest activities, including removal of riparian vegetation and the construction of haul roads, has degraded stream habitat conditions in parts of the upper watershed (Pilchuck, Snoqualmie, South Fork Skykomish, Tolt Rivers).

Stillaguamish core area. Most of the Stillaguamish basin was logged by the 1940's (WSCC 1999a). It has been reported that only about 12 percent of the basin currently contains mature stands and that there are virtually no continuous forest stands of significant size (USACE and SC 2000). The North Fork spawning tributaries of Deer Creek and Canyon Creek have experienced the effects of heavy logging (Kraemer 1994). Loss of riparian cover, slope failures, stream sedimentation, peak flows, channel incision, scour, and increased stream temperatures due to logging practices have adversely affected bull trout and all other fish species in Deer Creek (WDFW 1998; USACOE and SC 2000). Other limiting factors in the North Fork include loss of deep holding pools for adults, flood flows, and low summer flows (WDFW 1998; USACOE and SC 2000). Habitat conditions in the South Fork Stillaguamish have also been degraded by logging practices, resulting in higher stream temperatures, flooding, sedimentation, and loss of large woody debris (WDFW 1998). It has been reported that 74 percent of the inventoried landslides in the Stillaguamish watershed have resulted from logging roads (22 percent) or clearcuts (52 percent), while 98 percent of the volume of sediment is associated with these two sources (WSCC 1999a). Forty percent of the 851 landslides that delivered sediment to stream channels delivered it directly to fish-bearing waters. Years of heavy logging above and adjacent to the large slide near the Gold Basin area have contributed to the sediment delivery in the South Fork Stillaguamish, and has also contributed to the loss of large woody debris in the channel and has likely resulted in the loss of juvenile rearing and adult holding habitats (USFS 1995a).

Chester Morse Lake core area. This watershed (Cedar River Municipal Watershed) experienced extensive clearcut logging from the late 1800's, beginning in western sections at low elevation and proceeding progressively eastward to high elevation basins, until a moratorium was placed on all timber harvest on City-owned lands in 1985. During that period, 84 percent (71,588 acres) of the old-growth forest in the municipal watershed was harvested. Within the core area approximately 74 percent (36,841 acres) of the old-growth forest, mostly at mid- to relatively high elevations, was harvested (City of Seattle 2000b). After 1985, within the core area only a few units in old-growth forest were harvested by the U.S. Forest Service, mostly at higher elevations. The City also harvested approximately a dozen small units in second-growth forest outside of the core area, in the lower municipal watershed. These units were not clear-cut, but were harvested using ‘new forestry’ methods (City of Seattle 2000b).

As of 1997, the forested landscape of the total core area was approximately 26 percent old growth (190+ years old) and 74 percent second-growth, ranging in age from 0 to 189 years. Of the second-growth forest, the vast majority (95.4 percent) was between 10 and 69 years of age, distributed approximately evenly in each 10-year age class, only 2.4 percent had been recently harvested (0 to 9 years old), and 2.1 percent was 70 to 79 years old.

Harvest in the municipal watershed during the next 50 years will be guided by the habitat conservation plan under which no old-growth forest will be cut and no commercial timber harvest will be conducted. Harvest of trees will be limited to thinning selected areas of forest to meet ecological objectives, for accelerating the development of late-successional and old-growth structural characteristics in second-growth forest, and to develop habitat for selected wildlife species where and when appropriate. Ecological thinning will be conducted in second-growth forest, primarily in forest from 30 to 70 years of age and restoration thinning will be conducted in young forest, primarily less than 30 years old (City of Seattle 2000b). Current forest management within this core area is not considered a threat to bull trout. In addition, substantial habitat restoration will be implemented in both aquatic and terrestrial ecosystems, including riparian corridors throughout the core area.

Puyallup core area. Logging activities in conjunction with agriculture and development have reduced summer flows, decreased riparian canopy cover[†], increased winter peak flows and increased stream sedimentation in the Puyallup River, Carbon River, and White River systems. Present and past timber harvest has reduced the ability of riparian areas to provide wood and shade to stream channels in the upper Puyallup River and upper White River watersheds, and continue to contribute fine sediments from related road construction and landslides (WSCC 1999b). These activities have severely affected major tributaries used by steelhead, and it is likely that they have adversely affected those areas used by bull trout (WDFW 1998). Intensive logging continues on private lands in the Upper Puyallup and Mowich Rivers local population. Numerous barriers exist on tributary streams as a result of poorly constructed or designed road culverts and debris jams from past forest practices (WSCC 1999b). Road densities in the Mowich River were reported to be over 1.9 kilometers per square kilometer (3.0 miles per square mile) (USFS 1998).

As a result of the flood in 1977 and subsequent cleanup operations, the Greenwater River (White River tributary) experienced a total loss of large woody debris. Sections of the Clearwater and Greenwater Rivers are on Washington State's 303(d) list for 1998 due to temperature accedences (Appendix 1), attributed to loss of riparian cover (WSCC 1999b).

Nisqually foraging, migration, and overwintering habitat. Logging has had some negative impacts to the habitat along the mid to lower reaches of the Nisqually River. Logging near unstable slopes has created major landslides in the past which have increased sedimentation and temperature and degraded salmonid spawning and rearing habitat. These impacts can also affect bull trout foraging use of these reaches. A major landslide occurred in 1991 and temporarily blocked the river; heavy sedimentation into the river resulted (WDFW 1998). Most riparian areas in the lower and mid reaches of the Nisqually River are currently second-growth stands of hardwoods and conifers, with riparian areas impacted primarily by existing dikes and encroachments due to agriculture and various residential developments (WSCC 1999c). Although historical and current use of the Mashel River by bull trout is unknown, this is the largest accessible tributary to anadromous salmonids, and has been extensively logged over the past 50 years.

Agriculture and Livestock Grazing Practices (Factor A)

Overview. Agricultural practices have affected most of the core areas within the Puget Sound Management Unit. The most significant impacts are seen in the lower elevation areas of watersheds, the mainstem rivers and major tributaries, and the estuaries. Diking, water control structures, draining of wetlands, channelization, and the removal of riparian vegetation has significantly impacted the floodplains, natural hydrologic functions, and resulted in the loss of approximately 80 percent of historical estuary and wetland habitats. Practices including stream channelization and bank armoring, diking, and the removal of instream woody debris and riparian vegetation, have degraded and simplified aquatic and riparian habitats (Spence *et al.* 1996; WSCC 1999a; WSCC 1999b; WSCC 2002a; WSCC 2002b). The Nooksack, Lower Skagit, Stillaguamish, Snohomish-Skykomish, and Puyallup core areas have been significantly altered by diking of their floodplains and estuaries. These impacts have affected bull trout foraging, migration, and overwintering habitat and blocked access to many historical wetland areas.

The Skagit River delta, the largest estuary in Puget Sound, was one of the first to be converted from tidal wetlands to agriculture. The Estuarine Research Federation estimates that 93 percent of the historical wetlands in the lower Skagit have been converted by agricultural activities over the past 150 years (Dean *et al.* 2000). In the Snohomish River estuary, approximately 74 percent of the wetlands were diked and drained for agricultural purposes (WSCC 2002b) and in the lower Stillaguamish tidal marsh and wetland habitats within the anadromous zone have been reduced by 96 percent of historical levels (WSCC 1999a). Most of the major impacts occurred in the early part of the century but construction of revetments and water control structures continued into the 1960's in some areas. The Nooksack is one of the few rivers in Puget Sound where significant estuarine habitat loss from diking has not occurred, although the river was diverted from Lummi Bay to Bellingham Bay about 100 years ago.

Agricultural practices have also contributed to the loss of side channel areas and riparian vegetation in the floodplain. The effects of livestock grazing, dairy operations, and crop production often extend many miles upriver and into areas managed primarily for timber. In the Skagit, farms and pastures extend approximately 112 kilometers (70 miles) upriver to the community of Concrete. Agriculture is most pronounced in the Nooksack River core area, where farming activities comprise almost 12 percent of the entire watershed and extend at least 69 kilometers (43 miles) up the mainstem and another 16 kilometers (10 miles) up the South Fork Nooksack River. In the Stillaguamish, the construction of dikes and revetments has resulted in a loss of over 31 percent of the historical side channel habitat and the combined impact of agriculture and residential development has reduced the riparian vegetation in these areas by nearly 90 percent. With the steady increase in urbanization and population growth in Puget Sound, agricultural lands are steadily being converted to residential and urban developments. The impacts associated with this conversion will be addressed below under the Residential Development and Urbanization section.

In Washington, the Puget Sound was selected for inclusion in the National Water Quality Assessment program. Livestock production often impacts water quality with nutrients while large quantities of pesticides are often applied to crops such as potatoes, berries, and row crops, which can leach into the water table and enter streams from surface water runoff (Rao and Hornsby 2001; Spence *et al*. 1996). A number of pesticides have been detected in small streams and sloughs within agricultural and urban sites tested within Puget Sound (Bortleson and Davis 1997). In addition, elevated nutrient concentrations from animal manures and agricultural fertilizer application can contribute to excessive growth of aquatic plants and reduced levels of dissolved oxygen in Puget Sound waterbodies, which can adversely affect fish (Embrey and Inkpen 1998). The Nooksack and Samish Rivers were reported to receive the largest nutrient inputs from animal manures and agricultural fertilizers.

Nonnative plant introductions are an emerging threat to aquatic ecosystems. These have been introduced both intentionally and unintentionally in the past through agriculture practices, development, and for ornamental purposes, and are slowly replacing less aggressive native species. *Spartina spp.* (cordgrass) has invaded nearshore habitats in north Puget Sound and threatens to exclude native fish species and reduce intertidal acreage (WSCC 1999a). These intertidal areas provide critical foraging habitats for anadromous bull trout and their prey species. In a number of core areas, invasive plant species such as Japanese knotweed (*Polygonum cuspidatum*) and reed canary grass (*Phalaris arundinacea*) are invading disturbed riparian areas and stream channels, altering and impairing these habitats and impeding the restoration and natural recovery of these areas by outcompeting native vegetation, including trees, which provide more important habitat benefits such as increased shade and large woody debris. All core areas are probably affected by one or more of these species, and while lowlands are more affected, infestations can occur quite high up in the watersheds.

Chilliwack core area. Although agriculture does not occur within that portion of the mainstem Chilliwack River system in the United States, it is extensive within the lower Chilliwack system in British Columbia. Agriculture production in the Chilliwack Valley is dominated by dairy and other livestock operations, followed by row crop and greenhouse production. Within its major tributary, the Sumas River, over 48 percent of the drainage within the United States is zoned agriculture (Blake and Peterson 2002). Within British Columbia, 59 percent of the land use in the Sumas River valley is agriculture, which in addition to urban/industrial lands contributes a variety of pollutants to the Sumas

River (Healey 1997). Between 1919 and 1923, Sumas Lake was drained for flood control and to create additional farmland. This resulted in the loss of 12,000 hectares (29,600 acres) of lake habitat for fish (Slaney *et al*. 1996).

Nooksack core area. In the Nooksack River watershed, agriculture comprises approximately 12 percent of the area (Blake and Peterson 2002). Nearly all of the lower watershed is in agricultural production. Whatcom County (primarily Nooksack core area) has the highest number of dairy operations and row crop producers in all of western Washington. Whatcom County is the 12th largest dairy county in the United States. Channel straightening, diking, and loss of riparian vegetation have impacted nearly all of the agricultural waterways and essentially converted what was once a vast marshland into a gridwork of drainage ditches and water conveyance channels. For example, the South Fork Nooksack River downstream of Hutchinson Creek has been extensively altered, with 60 percent of its length being diked on one or both sides, and in combination with the loss of logjams, there has been an 86 percent loss of sloughs and side channels since 1938 (Crown Pacific, Inc. 1999).

Riparian conditions are highly degraded in agricultural zoned areas, with overall near-term large woody debris recruitment potential being low in 84.9 percent, moderate in 12.3 percent, and high in only 2.8 percent of the areas sampled (Coe 2001). Most of this land use is along the mainstem Nooksack River, lower South Fork, and along the larger tributaries (Coe 2001). Several streams in these areas are listed on the Washington Department of Ecology 303(d) list as water quality impaired for parameters including temperature, dissolved oxygen, and instream flow. In many cases hydrology has also been altered and streams, including Fishtrap Creek, Pepin Creek (Double-ditch), and many of the small tributaries flowing down from the border, include appreciable areas with straightened channels that lack habitat complexity. The freshwater forage base for migrating subadults and adults is considered substantially reduced from historical conditions.

Additionally, while settings include a variety of land uses, many streams in the Nooksack watershed are seasonally or fully closed to issuance of additional instream water rights[†] because they do not meet the legally established minimum instream flows. Included in this list are the lower North Fork Nooksack River and tributaries including Bells, Kendall, and Racehorse Creeks, the Middle Fork Nooksack River drainage, and the South Fork Nooksack River and tributaries including the Skookum and Hutchinson Creeks (Blake and Peterson 2002). Mainstem tributaries that also have partial or total closures include Anderson, Smith, Tenmile, Fishtrap, Bertrand, Silver, and Wiser Lake Creeks.

While Whatcom County's Critical Area Ordinance provides for farm plan development in place of the minimum riparian buffer requirements on fish-bearing streams, a relatively small number of non-dairy farm plans have been developed to date (G. Boggs, Whatcom County Conservation District, pers. comm. 2003).

Lower Skagit core area. Agricultural practices over the past 100 years have significantly altered the natural functions of the lower river and estuary. The lower Skagit River delta and estuary was historically a huge saltmarsh and freshwater wetland complex that extended from the community of Mount Vernon to Padilla and Skagit Bays. Tide gates, pump stations, and a network of drainage canals and levees effectively drained the wetlands and created the largest subtidal agricultural area in the State. What was once a productive salmon rearing area is now drained and virtually completely blocked off to anadromous fish. The loss of sloughs and brackish water, slow-water overwintering areas, connectivity, and rearing habitat for juvenile salmon impacts the Skagit River bull trout because the duration that these prey species spend in the nearshore environment has been shortened. In addition to the loss of estuary habitat and access, agricultural practices have had significant impacts to the hydrology and water quality. The drainage network increases peak flows and velocities, and flushes sediments that would historically have been deposited in the wetlands, out into Skagit Bay. The result is a build-up of the tidal flats beyond the levees. Because the hydrologic conveyance system has reached capacity, there is currently a proposal to construct a bypass canal that would divert Skagit River floodwaters into Padilla Bay during high flow events. This action may result in the re-designation of the floodplain and open agricultural areas to development.

Water quality impacts from V-ditching and dredging of the drainage canals contributes to elevated sediment levels in the waterways and decreases the levels of dissolved oxygen during the low flow season. Extensive use of pesticides, fertilizers, and herbicides also impacts water quality within several sloughs, including Joe Leary.

Agricultural practices upstream from the city of Mount Vernon are dominated by livestock grazing and hay production. These practices impact riparian vegetation, long-term recruitment of large woody debris, and contribute to bank erosion and water quality impacts where livestock have direct access to the streams.

Stillaguamish core area. Much of the lower watershed has been significantly altered by conversion from forest to open pastures or agricultural fields, as well as to urban and rural settlements. Riparian areas have been changed the most dramatically from pre-settlement conditions, with the majority of present day riparian areas either devoid of trees or dominated by young stands of alder or second-growth conifers. Agricultural practices (commercial and non-commercial) have also contributed to poor water quality in the system, especially in the lower watershed (WDFW 1998; USACOE and SC 2000). Agricultural practices have also resulted in the channelization and dredging of many streams for flood control, resulting in the loss of instream habitat complexity. The majority of intertidal habitat in the lower Stillaguamish River basin has been altered or destroyed by a combination of draining, diking, and filling of aquatic habitats for agricultural purposes (USACOE and SC 2000). Although agriculture practices in the Stillaguamish River system have primarily eliminated or degraded bull trout foraging, migration and overwintering habitats used by subadult and adult life stages, some juvenile rearing habitats may also have been affected.

Snohomish-Skykomish core area. As elsewhere, farming in the floodplain required drainage of wetlands and channelization of many streams in the lower watershed. Several agricultural practices have been identified as having significantly impacted the floodplain and fish habitat in the lower river, including diking of the mainstem and estuary and installation of water-control structures for drainage. Most of these structures still hinder or completely block fish passage

(Marshland and French Creek Pump Stations and tide gates on many of the sloughs). The conversion of the Marshland Marsh for agricultural uses in the 1880's was the largest single loss of off-channel habitat in the watershed. Re-construction of pump stations and tide gates to provide fish passage was identified as a priority restoration need by Federal, County, and State agencies as well as the Tulalip Tribe (Haas and Collins 2001). Livestock and dairy operations impact water quality and contribute to bank erosion and loss of riparian vegetation. Fencing and the implementation of riparian buffers under the revised (2003) Critical Areas Ordinance will help to improve conditions.

Puyallup core area. Agriculture in conjunction with extensive urban growth, a large marine port, and an extensive revetment and levee system has significantly altered the lower watershed (WSCC 1999b). Many of the historical agricultural lands have now been converted into urban and residential developments. Remaining commercial and non-commercial (hobby farms) agriculture contributes to reduced riparian areas, floodplain encroachment, and reduced water quality in some parts of the lower Carbon River and White River systems (WSCC 1999b). Agriculture practices in the Puyallup River core area have primarily degraded bull trout foraging, migration and overwintering habitats used by subadult and adult life stages.

Samish River foraging, migration, and overwintering habitat. Agriculture is the major land use within this system. Agricultural practices and residential development have impacted habitat through river diking, draining and filling of wetlands (WSCC 2003). The Samish River and Friday Creek are said to have generally poor riparian conditions as a result of land conversions to non-forest land uses. Agricultural practices likely contribute to the poor water quality within the system (WSCC 2003).

<u>Transportation Networks (Factor A)</u>

Overview. Dunham and Rieman (1999) found that the density of roads at the landscape level was negatively correlated with bull trout occurrence. Roads not only facilitate excessive inputs of fine sediment and possible habitat degradation in streams, they also increase human access which may induce angling mortality and introductions of nonnative fishes, often create barriers to fish migration, and increase the potential for water pollution through impervious surfaces and accidental spills (Spence *et al.* 1996; MBTSG 1998; Ruediger and Ruediger 1999; Trombulak and Frissell 2000). Roads and bridges can degrade shorelines, stream channels, floodplains, and wetlands by altering hydrodynamics and sediment deposition (Trombulak and Frissell 2000). The transportation network's stream crossings also cumulatively affect large woody debris routing and distribution, and the removal of large woody debris from culvert inlets and bridge pilings is a frequent occurrence. Road systems also change the hydrology of slopes and stream channels, and can change the routing of shallow groundwater and surface flow. The impervious surfaces related to road networks have contributed to changes in timing and routing of runoff. Extensive bank armoring has often been employed where roads parallel streams and other waterways, restricting channel migration, degrading or eliminating off-channel habitats, degrading riparian areas, and generally simplifying instream habitat. Contaminants deposited from automobiles include oil, grease, hydraulic fluids, antifreeze, and particles from tires and brakes, which can make their way to fishbearing waterbodies as a component of highway runoff (Ruediger and Ruediger 1999). A widely held principle of managing for the survival and recovery of threatened and endangered aquatic species is that remaining stronghold areas for the species and associated high quality habitats be preserved and reconnected. Wilderness, National Park land, and unroaded areas contain most of the best available remaining habitat for bull trout, steelhead, and salmon (Frissell 1993; WDFW 1998).

Extensive transportation networks have been constructed within the Puget Sound region. These include unimproved and improved roadways, railways and ferry systems. There are basically four major highway systems within the Puget Sound region, which also support a number of associated arterial networks. These include the Interstate 5 corridor running north and south along Puget Sound, which crosses all west Cascade river systems discharging into Puget Sound, the State Route 20 corridor running east and west through the Skagit River watershed, the U.S. Route 2 corridor running east and west through the Snohomish-Skykomish watershed, and the Interstate 90 corridor running east and west through portions of the Lake Washington and Snoqualmie watersheds. The most intensive development in the region has occurred along these transportation corridors. Numerous arterial networks expand along these corridors, but the most dense are associated with the urban centers along the Interstate 5 corridor.

Within the management unit, a number of railways have been constructed along the lower reaches of major watersheds, along the Puget Sound nearshore, and roughly adjacent to the Interstate 5 corridor. These railways have links to the major shipping ports in the region, Port of Tacoma and Port of Seattle, which are located in what was once extensive estuarine habitat (WSCC 1999b; KCDNR and WSCC 2000). Similar to the highway and arterial road networks in the region, these railway corridors cross numerous stream systems, or travel along, or across, nearshore habitat areas. Construction of these railways has contributed to the loss of side channel habitat, the filling of estuarine habitat, the degradation of nearshore habitat, and constrained river channel migration zones (WSCC 1999a; WSCC 1999b; KCDNR and WSCC 2000; WSCC 2002a; WSCC 2002b).

A unique transportation network in the Puget Sound Management Unit is the Washington State ferry system. Although relatively small when compared to other transportation networks, infrastructure associated with ferry terminals have contributed to loss in continuity and degradation of some nearshore habitats.

Forest road networks have had and continue to have similar and in some cases greater impacts on the landscape occupied by bull trout. Due to their inherent connection to forest management, their contribution to the reasons for decline are discussed in this document under the section on “Forest Management Practices.”

Nooksack core area. The Nooksack core area has been substantially impacted by the transportation network. Forest roads have significantly increased the rate of landsliding in the core area and in many local population areas (as discussed under “Forest Management Practices,” above). A variety of State, County and private road crossings are also partial or total migration barriers to spawning and rearing or foraging habitat, some of which are discussed under the sections on “Current Distribution and Abundance” and also “Fragmentation and Isolation.” Inadequate spacing and/or frequency of cross drain culverts on lowland roads in the basin has also resulted in the redirection and concentration of surface runoff, with resulting ditch scour and sediment and pollutant delivery to streams such as Anderson Creek (Coe and Currence 2001). Stream-adjacent roads have also impacted channel migration, especially State Route 542 along the North Fork. This road has substantially reduced the North Fork Nooksack River's channel migration. In one area, less than 30 percent of the natural channel migration zone is available to the river (GeoEngineers, 2001). The traditional response to river movements toward this road has been the placement or riprap bank armoring. This road also crosses numerous bull trout spawning and rearing streams such as lower Boulder Creek. In addition to interrupting large woody debris routing, roads and bridges in these locations constrain or prevent natural channel migration. The Washington Department of Transportation has commissioned studies to determine the best long-term course of action for State Route 542, and the recommendations include relocating significant portions of the road away from the river and to the upper end of the alluvial fans (GeoEngineers 2001; Gowan 1989). Another cumulative effect of the transportation network is the interruption of large woody debris routing by culverts and bridges intercepting wood debris moving downstream. The mainstem Nooksack River and lower South Fork presently have no areas with high large woody debris recruitment potential (Coe 2001). Large woody debris jams are critical to restoring complex channel habitat, including off-channel habitats in these areas. In the North and South Forks, recruitment potential improves progressively upstream, with the best short-term opportunity for increased wood loading for the mainstem and lower North and South Forks, being the routing of trees from upstream. In addition to interrupting wood routing, bridges frequently constrict channel areas. The Mosquito Lake Road bridge over the lower North Fork has reduced the North Fork's potential channel migration area by 96 percent (GeoEngineers 2001).

Railroad corridors have also impacted this core area and its associated nearshore marine habitat. Where the railroad corridor follows the lower South Fork Nooksack River, bank armoring and channel constriction has occurred. The crossing of Jones Creek also blocks access to foraging habitat in this tributary. The railroad corridor in Bellingham Bay and Chuckanut Bay occupies former nearshore habitat and has narrow channel openings to nearshore habitat behind it, such as at Post Point and Chuckanut Bay. The railroad corridor is frequently armored with riprap where it is located across or along the nearshore habitat in Bellingham, Chuckanut, and Samish Bays. The effects of this railroad include reduced foraging areas, reduced large wood recruitment potential to nearshore habitat, and reduced shading and interruption of sediment recruitment which are important for nourishing and preventing thermal heating of surf smelt and sand lance (bull trout prey species) spawning areas. Roads and associated armoring have caused similar impacts to nearshore habitat; one example is the Lummi Shore Road, located on the northwest side of Bellingham Bay.

Lower Skagit core area. The Upper South Fork Sauk local population has had some impacts from the road leading to the Monte Cristo townsite. The tributaries on the northside of the White Chuck River have been impacted by the White Chuck River Road. Some impacts to the Tenas Creek local population have occurred from the Suiattle Road, which parallels much of the Suiattle River. The Buck Creek, Downey Creek and Sulphur Creek local populations have also had localized impacts from the Suiattle Road. The Mountain Loop Highway, which parallels much of the mainstem Sauk River and lower South Fork Sauk River, has had some impacts to habitat occupied by the Forks of the Sauk River local population. Sections of this road fall within stream riparian areas.

Upper Skagit core area. Highway 20 parallels the entire length of the mainstem of Ruby Creek and then continues adjacent to the tributary Granite Creek, the smaller of the two major tributaries to the Ruby Creek local population. This stream has been impacted by accumulations of coarse sand and fine sediment. The stream is lower in gradient than Canyon Creek, and substrates are mainly composed of cobble and sand dominated runs, riffles, and shallow pools. Habitat conditions are considered to be relatively poor for native char in Granite Creek due to the major accumulations of granitic sand, which covers much of the streambed. The accumulations of granitic sand in Granite Creek can largely be attributed to natural geological processes. However, Highway 20 has triggered several slope failures that have resulted in localized impacts to habitat in this stream (Molesworth, pers. comm. 2003).

Stillaguamish core area. The Mountain Loop Highway impacts Palmer Creek and a number of tributaries to the South Fork Stillaguamish River as it parallels the river mainstem. A recent road failure on Forest Service Road 40, part of the Canyon Creek road system, now delivers unknown quantities of sediment into a major tributary of Canyon Creek. Construction of the railroad grade and State Route 530 along the North Fork Stillaguamish River has contributed to the loss of side channel habitat and limited natural channel migration (WSCC 1999a). Overall, side channels of the North and South Forks are reported to have been decreased by about one-third of their historical levels, due to the combined effects of bank revetment, agriculture and other land uses.

Chester Morse Lake core area. The transportation system within the City of Seattle municipal watershed is extensive, including approximately 999 kilometers (621 miles) of forest roads. As of 2000, forest road density in individual stream subbasins within the Chester Morse Lake core area averaged 2.5 kilometers per square kilometer (3.97 miles per square mile) and ranged from 0.4 to 4.1 kilometers per square kilometer (1.6 to 6.6 mile per square mile) (City of Seattle 2000b). Forest road density averaged slightly less 2.4 kilometers per square kilometer (3.88 mile per square mile) in the five major tributary basins within the Chester Morse Lake core area: Chester Morse Lake 2.5 kilometers per square kilometer (4.1 mile per square mile); Upper Cedar River 2.2 kilometers per square kilometer (3.5 mile per square mile); Rex River 2.6 kilometers per square kilometer (4.2 mile per square mile); North Fork Cedar 1.7 kilometers per square kilometer (2.8 mile per square mile); and South Fork Cedar 2.9 kilometers per square kilometer (4.8 mile per square mile) (City of Seattle 2000b).

Of the 999 kilometers (621 miles) of forest road that exist within the municipal watershed, 322 kilometers (200 miles) will be decommissioned during the next 20 years as an element of the habitat conservation plan. Roads that present chronic problems such as initiating debris flows or that repeatedly deliver sediment to critical stream reaches such as bull trout spawning reaches will be prioritized under this program. Another focus of the decommissioning program will be to evaluate, remove, and/or relocate sections of forest roads that are immediately adjacent to stream courses so that sediment delivery can be eliminated and more natural stream function can be restored. Such road-related projects will be combined with other types of aquatic and terrestrial restoration projects under the habitat conservation plan whenever possible (City of Seattle 2000b). The principal goals of the road decommissioning and road improvement/maintenance programs are to reduce sediment input to surface waters so as to improve water quality and habitat for fish, especially focusing on bull trout habitat within the core area, to improve aquatic function, and to lower long-term forest road maintenance costs (City of Seattle 2000b).

Puyallup core area. Road construction has had significant impacts in this core area. In the Upper Puyallup and Mowich Rivers local population, portions of the 24, 25, and 62 Road systems have been responsible for significant sediment inputs and past debris flows as the result of road failures facilitated by past flood events (WSCC 1999b).

State Route 167 has contributed to constriction of the White River floodplain and has contributed to significant development within the floodplain by facilitating access. There is one new highway proposed for the area, an extension of State Route 167.

Mining (Factor A)

Overview. Recreational mining and commercial mining (gravel, mineral) can significantly alter the physical structure and stability of instream habitat (Spence *et al.* 1996). In-channel gravel mining can result in both upstream and downstream downcutting which further destabilizes streambanks, leads to channel simplification, changes bedload movements, and alters groundwater hydrology which may reduce summer base flows (Spence *et al.* 1996). Although there have been recent revisions to the State rules and regulations for mineral prospecting and placer mining to be more protective of aquatic species ("Gold and Fish" pamphlet; WDFW 1999), habitat impacts (especially cumulative and frequency impacts) from ongoing recreational mining are still a concern in bull trout spawning and rearing streams. The negative effects of small-scale dredge mining may be minor and localized if the extent of the dredging is small (*in re* area or length of stream), operations are timed to avoid direct excavation of salmonid eggs and fry, operators do not disturb or destabilize streambanks, vegetation, large woody debris, or boulders, and the reconfigured streambed does not reduce the stability of interstitial spawning and rearing habitats during subsequent peak flow events (MBTSG 1998).

Nooksack core area. The most significant impact recorded in this core area is from the Excelsior Mine on the Upper North Fork Nooksack River where mining spoils were dumped directly into Wells Creek, a known bull trout spawning stream (USFS 1995b). This facility operated from 1900 to 1914. A rockfall in the mid-1970's that created a partial barrier to anadromous fish in lower Wells Creek is suspected of being caused by old mine tunneling activities (USFS 1995b).

Lower Skagit core area. Mining activity in the Monte Cristo area from 1890 to 1898 may have resulted in the elimination of all fish species in the South Fork Sauk River downstream of the mining site. The concentration of heavy metals in the South Fork Sauk River associated with ore-crushing eliminated the fish and likely most aquatic life in the early 1900's for an unknown number of years (USFS 1996). Both winter run steelhead and bull trout have subsequently recolonized the area, but it is unknown how current abundance compares to pre-mining levels. Recreational mining has occurred extensively in past in the upper South Fork Sauk River basin. However, in recent years, State permits for mining in the South Fork Sauk have been routinely denied by the Washington Department of Fish and Wildlife.

Upper Skagit core area. Historical and ongoing mining activities continue to threaten bull trout habitat in the upper Skagit River watershed. Recreational mining is still allowed in the area of the Ruby Creek local population located on National Forest Service lands (Pasayten Wilderness). Mining activities include hydraulic suction dredging at a number of mining claims that were established along Ruby and Canyon Creeks prior to the Federal Wilderness designation for this area. Under current State mining regulations, suction dredging is limited to the early summer and ends just prior to the fall bull trout spawning period. However, these mining activities can have significant impacts on the morphology of the stream channel and on the distribution of spawning-sized gravel in these streams. Bull trout spawning occurs prior to the winter high flow periods which restore the stream channel to the natural bed forms that are important for providing spawning habitat.

The Azurite Mine, a large gold and silver mine located on a tributary to Canyon Creek, is a source of heavy metal contamination that may impact the native char spawning areas located downstream in Canyon and Ruby Creeks. This mine, which was closed in the 1950's, is currently being considered for designation as an EPA Superfund remediation site by the U.S. Forest Service (Molesworth, pers. comm. 2003).

Residential Development and Urbanization (Factor A)

Significant development and urbanization has occurred within portions of most core areas. The greatest impacts have been to lower mainstem river channels, estuarine, and nearshore marine habitats, but many subbasins in the lower part of major watersheds have been altered as well. Some impacts have also occurred in spawning and rearing areas such as the lower portions of Canyon Creek, Glacier Creek, Racehorse Creek, and Hutchinson Creek in the Nooksack core area. More than 50 percent of the tidal flats and intertidal areas in major embayments of Puget Sound have been lost since 1850 (Bortleson *et al.* 1980 cited in PSWQAT 2000). Some highly urbanized areas, such as Commencement Bay, have lost more than 99 percent of historical marsh habitat and more than 89 percent of historical intertidal mudflats (USACOE *et al.* 1993). More recent reports state that over 98 percent of the historical intertidal and subtidal habitats in Commencement Bay have been lost (WSCC 1999b). Many estuarine and nearshore areas of Puget Sound have been filled or have had overwater structures installed to provide upland development sites for commercial/industrial, and to some extent residential, development. They have also been dredged extensively to maintain navigation and provide access to piers. Significant portions of nearshore and shoreline habitats have also been altered with vertical or steeply sloping bulkheads and revetments to protect various developments and structures (*e.g.*, railroads, piers) from wave-induced erosion, to stabilize banks and bluffs, to retain fill, and to create moorage for vessels (BMSL *et al.* 2001). It has been estimated that one-third of Puget Sound’s shoreline has been modified, with over half of the main basin of Puget Sound having been altered (PSWQAT 2000).

Nearly 100 percent of the Duwamish estuary and Elliott Bay shoreline has been modified by some type of armoring (BMSL *et al.* 2001). In areas where nearshore habitats currently remain intact or only partially modified, development continues to threaten these habitats (WSCC 1999a; BMSL *et al.* 2001). Functional estuarine and nearshore habitats are critical to anadromous bull trout for foraging and migration (WDFW *et al*. 1997) and to their prey species (*e.g.*, herring, surf smelt, sandlance) for spawning, rearing, and migration (WDFW 2000a; BMSL *et al.* 2001).

Other impacts to shorelines include stormwater runoff from residential development and urbanization, which continues to be a significant contributor of non-point source water pollution in core areas and foraging, migration, and overwintering habitat areas (WSCC 1999a; WSCC 1999b; KCDNR and WSCC 2000). Contaminants in this runoff may include oil, grease, and heavy metals from roadways and other paved areas, and pesticides from residential developments. Recent observations of high numbers of pre-spawn mortalities in coho salmon returning to small streams in urban and developing areas of Puget Sound have caused increasing concern over stormwater runoff (Ylitalo *et al*., *in litt*. 2003). Although the implications for bull trout are uncertain, some life stages of bull trout appear to have greater sensitivity than other salmonids to some contaminants (Guiney *et al*. 1996; Cook *et al*., *in litt*. 1999), and bull trout may be exposed numerous times to nonpoint sources due to their life history and migratory behavior. Other sources of toxic contaminants are discharges of municipal and industrial waste water, leaching contaminants from shoreline structures, and channel dredging. Even though discharges from sewage treatment plants may be treated prior to discharge into receiving waters, according to the literature the treatment likely does not adequately remove potentially harmful compounds that are considered persistent, bioaccumulative, and toxic, or those that may have endocrine disrupting properties (Bennie 1999; CSTEE 1999; Daughton and Terns 1999; Servos 1999). Estuarine and nearshore areas such as Bellingham Bay and Commencement Bay are on the State of Washington 303(d) list for a number of industrial and development related contaminants. Cherry Point within the Strait of Georgia supports the largest herring stock in Washington, and it has experienced a precipitous decline. In 1993 nearly 12,000 metric tons (13,000 short tons) of herring spawned, but by 1998 that number had dropped to just over 1,181 metric tons (1,300 short tons) (EVS Environment Consultants Inc. 1999). The stock has experienced a loss of older age classes, and the authors concluded that there is a moderate likelihood that organic contaminants are incrementally affecting this stock. The decline of this stock may be affecting the forage base for anadromous bull trout in this region of Puget Sound.

Lower river channels in many core areas have been significantly altered by dredging, channelization, and the construction of dikes and revetments for flood control and bank protection. These activities have simplified once complex stream channels, degrading and eliminating important foraging, migration, and overwintering habitat for bull trout. Many historical floodplain areas that were originally diked and drained for agricultural use have been or are now being converted to residential and industrial developments. These developments can reduce or preclude options for restoration of floodplain areas important for reestablishing off-channel habitats and maintaining groundwater recharge.

Scientific studies indicate there is a strong relationship between the amount of forest cover, levels of impervious and compacted surfaces in a basin, and the degradation of aquatic systems (Klein 1979; Booth *et al.* 2002). Impervious surface associated with residential development and urbanization creates one of the most lasting impacts to stream systems. Changes to hydrology (increased peak flows, increased flow duration, reduced base flows) as a result of loss of forest cover and increases in impervious surfaces and degradation or loss of riparian areas are typically the most common outcomes of intensive development in watersheds (May *et al.* 1997; Booth *et al.* 2002). Increased peak flows and flow duration often lead to the need to engineer channels to address flooding, erosion, and sediment transport concerns. Although recent changes have been made to most regional and local development regulations to provide protection (*i.e.*, buffer zones) for riparian areas, the integrity of these areas is frequently compromised by encroachment (May *et al.* 1997). For many small stream systems, riparian areas are highly degraded or no longer exist, and their restoration is precluded by existing development. Although functional riparian areas have the capacity to mitigate for some of the adverse impacts of development (Morley and Karr 2002), they cannot effectively address significant impacts from changes to stream hydrology resulting from significant losses of forest cover (May *et al.* 1997; Booth *et al.* 2002).

Although an "imperfect measure of human influence," basin imperviousness is commonly used as an indicator of basin degradation (Booth *et al.* 2002). Reduction in forest cover and conversion to impervious surfaces can change the hydrological regime of a basin by altering the duration and frequency of runoff, and by decreasing evapotranspiration and groundwater infiltration (May *et al.* 1998, Booth *et al.* 2001). Such changes can be detected when the total percentage of impervious surface in the watershed is as low as 5 to 10 percent (Booth *et al.* 2002). Watershed degradation, however, likely occurs with incremental increases in impervious surfaces below these levels, and is exacerbated by other factors such as reduced riparian cover and pollution (Booth 2000; Karr and Chu 2000; Booth *et al.* 2002). Booth *et al.* 2002 state, "The most commonly chosen thresholds, maximum 10 percent effective impervious area and minimum 65 percent forest cover, mark an observed transition in the downstream channels from minimally to severely degraded stream conditions." They further assert, "Development that minimizes the damage to aquatic resources cannot rely on structural best management practices because there is no evidence that they can mitigate any but the most egregious consequences of urbanization. Instead, control of watershed land-cover changes, including limits to both imperviousness and clearing, must be incorporated."

To date, residential development and urbanization are believed to have primarily affected bull trout foraging, migration, and overwintering habitats, and in some cases post-dispersal rearing habitats. Because of bull trout's proclivity for cold water, the continued loss and degradation of springfed and groundwater fed tributaries providing cool water refugia in foraging, migration, and overwintering habitats will likely constrain migratory bull trout use of these areas. Generally, most past development has occurred in the lower elevations of watersheds where bull trout spawning and early rearing are not known to occur. This may change in the future as development pressures move further up into watersheds.

Fisheries Management

Directed and Illegal Harvest (Factor B). In their 1992 Draft Bull Trout/Dolly Varden Management and Recovery Plan, the Washington Department of Wildlife identified increased fishing pressure as a major contributor to char mortality (WDW 1992) and a factor in the declines of some populations (WDFW 1998). By 1994, all but two river systems in the Puget Sound Region were closed to recreational fishing for bull trout by the Washington Department of Fish and Wildlife (WDFW 1998). This closure has also included marine waters. In addition to the recreational fisheries allowed on the Skagit and Snohomish-Skykomish river systems, the Muckleshoot Tribe has a small subsistence fishery (angling) on the White River. In the past, bull trout (typically referred to as Dolly Varden) have been viewed as an undesirable species, and were often targeted for elimination in many parts of their range, or were given very liberal to no retention limits by fisheries managers (U.S. Fish Commission 1901; Crawford 1907; Bond 1992; Brown 1994; Colpitts 1997; Stuart *et al.* 1997). In the early 1900's, bull trout were caught commercially in central and southern Puget Sound with catches quickly declining in less than 10 years, indicating bull trout were once in much greater abundance in these areas (KCDNR 2000; USACOE in prep).

Although primarily localized in impact, illegal harvest of bull trout persists in some core areas and may have significant impacts to certain local populations. Bull trout in pre-spawning aggregations or on their spawning grounds are especially vulnerable to illegal harvest (Brown 1994; McPhail and Baxter 1996). Regular enforcement of spawning areas is often difficult due to the remoteness and broad distribution of these locations. Areas currently identified with high incidences or potential for illegal bull trout harvest include Excelsior campground and the reach upstream (North Fork Nooksack River); reach downstream of Sylvester’s Falls (South Fork Nooksack River); Money Creek campground (South Fork Skykomish River); Troublesome Creek campground (North Fork Skykomish River); Bear Creek Falls (North Fork Skykomish River); Downey Creek (Suiattle River); upper South Fork Stillaguamish River; upper Bacon Creek and Illabot Creek (Skagit River); Ruby Creek (Ross Lake tributary) near the confluence of Slate and Canyon Creeks; and Silver Springs Creek

Campground on the White River (USFS 1995b; WDFW 1998; G. Lucchetti, King County Department of Natural Resources, pers. comm. 2002; Molesworth, pers. comm. 2003).

Incidental Harvest (Factor B). Recreational, commercial, and Tribal salmon and steelhead harvest and associated incidental mortality of bull trout may have significantly influenced the abundance of bull trout in Puget Sound rivers. For recreational fisheries it is likely that incidental catch of native char occurs during general “trout” and salmon fisheries, and in particular during the early portion of winter steelhead fisheries (WDW 1992). The summer “trout” fisheries in systems such as the South Fork Nooksack River should be evaluated, as foraging or migrating bull trout may already be stressed due to thermal impairment of waters, and in systems such as Ross Lake, where bull trout occupy cold water refugia at tributary outlets during summer months. Although incidental hooking of native char has been documented throughout Puget Sound rivers, Brown (1994) noted that during the mid- to late-summer period of staging, pre-spawning aggregations are especially susceptible to angling mortality. Bull trout are an aggressive apex predator, and they are highly vulnerable to incidental hooking from these and other targeted fisheries. In fact, fish biologists have found one of the most successful tools for sampling bull trout is hook-and-line fishing (Brown 1994). For example, hook-and-line sampling has been used to collect bull trout for research purposes in the Nooksack, Skagit, Snohomish-Skykomish, and Chester Morse systems as well as in marine waters.

The current level of incidental bull trout harvest in other fisheries (gill net and seine) within the Puget Sound Management Unit is not known at this time. Incidental catches of bull trout have been noted in the Puyallup and Nooksack Rivers (B. Smith, Puyallup Tribe, pers. comm. 1998; A. Kamkoff, Lummi Nation, pers. comm. 2000), and likely occur in other river fisheries. Additional or more focused effort on monitoring bull trout catches is needed to determine the level of incidental harvest in other fisheries and ultimately where and when this incidental harvest may significantly impact progress towards bull trout recovery. As additional information is gathered, it is anticipated that harvest management actions developed for other fisheries will integrate measures that minimize negative impacts to bull trout where incidental harvest significantly impedes recovery. Determining the level of incidental harvest in core populations with currently limited adult abundance, such as the Puyallup and Stillaguamish core areas, is critically important.

Habitat (Factor A). Fisheries managers have also been partially responsible for past habitat degradation. Managers from the 1950's to 1970's promoted the removal of large woody debris and log jams from streams because they were perceived to hinder fish migration (Murphy 1995). This practice eliminated or greatly reduced the habitat complexity in many streams.

Nonnative Species (Factor E). A number of nonnative species have been introduced by fisheries managers in the Puget Sound region. Nonnative fish stocking may negatively impact bull trout through competition and/or predation. Westslope cutthroat trout populations have become common in headwater streams below the alpine lakes where they were originally stocked, many overlapping with native char populations. Examples include Higgins Creek, Deer Creek, and upper South Fork Stillaguamish River in the Stillaguamish system; South Fork Sauk River, Illabot Creek, and White Chuck River in the Skagit system; and Goblin Creek in the North Fork of the Skykomish River (Downen, *in litt*. 2003). These populations of cutthroat are resident and develop piscivorous life histories in habitats where bull trout emerge from the gravel, and therefore may constitute a competitive and predatory risk to depressed populations.

Brook trout pose an additional threat to bull trout due to hybridization (Markle 1992) and competition (MBTSG 1996a). Brook trout appear to adapt better to degraded habitats than bull trout (Clancy 1993; MBTSG 1996a). Because elevated water temperatures and sediments are often indicative of degraded habitat conditions, bull trout may be subject to stresses from both interactions with brook trout and degraded habitat (MBTSG 1996a). In laboratory tests, growth rates of brook trout were significantly greater than those for bull trout at higher water temperatures when the two species were tested alone, and growth rates of brook trout were greater than those for bull trout at all water temperatures when the species were tested together (McMahon *et al.* 1998, 1999).

Brook trout have been widely introduced throughout the State of Washington and in 1992 approximately 10 percent of current range of bull trout also contained brook trout (Mongillo and Hallock 1993). Naturalized populations of brook trout within the Nooksack, Upper Skagit, and Puyallup core areas overlap with bull trout spawning and rearing habitat in parts of these watersheds. In the Nooksack core area, brook trout are well established in many areas both upstream of and overlapping with bull trout distributions. They are established upstream of Nooksack Falls, and in Wells and Glacier Creeks (USFS 1995b). Huddle (pers. comm. 2003a) has reported brook trout in numerous areas in the Nooksack system, including a small anadromous tributary adjacent to the North Fork at Excelsior Campground commonly referred to “Excelsior Terrace Tributary,” and “Bottigers Pond” which drains into Cornell Slough. Brook trout are also thought to inhabit Racehorse Creek upstream from the falls, and are known to exist in two lakes within the Kendall Creek drainage, with spawning observed at the Sumas Kendall road crossing. Huddle also notes that brook trout have been stocked in lakes in Canyon Creek upstream from the falls including in Bear Paw Lake, in a small pond in the upper Canyon Lake Creek drainage, and in Bear Lake and “Three Lakes” in the upper South Fork Nooksack River. Hybridization was detected between resident Dolly Varden and brook trout in a sample collected in Canyon Creek upstream from the falls (USFS 1995b). Through the 1970’s the Washington Department of Game released brook trout into beaver ponds in Hutchinson Creek, and brook trout were observed in an inlet channel to Musto Marsh in the 1990’s (WDNR 1998). Snorkel surveys recorded a transition from juvenile bull trout (lower) to brook trout (higher) in Hutchinson Creek downstream from Musto Marsh in 2002 (Ecotrust, *in litt*. 2002). In the Upper Skagit core area, brook trout have been detected in Hozemeen, Silver, Lightning, and Canyon Creeks. Brook trout are also present in Ross Lake (Johnston 1989) and so are presumed to have access to all adfluvial bull trout spawning and rearing tributaries within the Upper Skagit core area. In the upper Skagit River tributary, Nepopekum Creek (British Columbia), mature brook trout have been observed in the same spawning area as Dolly Varden (McPhail and Taylor 1995), which is also accessible to migratory bull trout. In the Puyallup core area, limited surveys have detected brook trout in the mainstem upper Carbon River and its tributaries (Isput, Ranger, and Chenuis Creeks), and they are believed to pose a significant threat to bull trout in this system (USFS 1998;

Samora, *in litt*. 1997; Craig, in *litt*. 2000b). Brook trout have also been detected in bull trout spawning and rearing areas of the upper White River (*e.g.*, Doe Creek and Sunrise Creek), West Fork White River (unnamed tributary, stream catalog no. 0226) and Puyallup River (Mowich River) (MRNP, *in litt*. 2001), as well as in potential spawning and rearing areas in the Greenwater River (Twentyeight Mile Creek and George Creek) of the Puyallup core area (Stagner, pers. comm. 2003). Although hybridization with brook trout has been identified as a significant threat to bull trout in other parts of its range, the full extent that brook trout introductions have impacted Puget Sound populations is currently unknown. Because the replacement of bull trout populations by brook trout has been documented in other parts of their range (MBTSG 1996a), the potential for bull trout displacement by hybridization and competition remains a significant concern in the Puget Sound Management Unit, and should be assessed more closely as soon as possible.

Hatcheries (Factor E). Bull trout have not been extensively cultured in hatcheries in any part of the species' range. The absence of bull trout hatcheries within Washington State has limited the potential biological risks associated with hatcheries (*e.g.*, loss of genetic diversity within and among stocks, interbreeding between hatchery and wild fish, competition with or predation by hatchery fish, disruptive behavior, effects on non-target species, disease, depletion of wild stocks for broodstock, and escapement). For the Puget Sound Management Unit, the use of hatcheries or supplementation in bull trout recovery is believed to be unneeded and is currently not being considered in planning (McPhail and Baxter 1996; MBTSG 1996b). The potential use of hatcheries in bull trout recovery across their range has generally been limited to genetic reserves and restoration stocking in watersheds where a population has been extirpated.

How salmon hatchery operations and the interactions between hatchery-origin salmon have and may continue to affect bull trout have not been closely examined in the management unit, however, the risks to bull trout are likely limited given their life history. Hatchery activities such as weir operations and broodstock collections,may have some impacts to bull trout. It is anticipated that potential risks to bull trout will be assessed and addressed during the ongoing process of reviewing hatchery practices and integrating hatcheries in salmon recovery (*e.g.*, review of Hatchery and Genetic Management Plans (HGMP) developed for take[†] exemptions under the 4(d) rule for Puget Sound Chinook and Hood Canal summer-run chum salmon).

Forage (Prey) Base (Factor E). A number of salmon stocks have declined in abundance in the Puget Sound region. On March 24, 1999, the National Marine Fisheries Service listed the Puget Sound Chinook salmon Evolutionarily Significant Unit as threatened (64 FR 14308), while the Puget Sound-Strait of Georgia coho salmon Evolutionarily Significant Unit remains a species of concern. Declines in these and other salmon stocks threaten bull trout, since juvenile salmonids are a primary food source (Kraemer 1994). These declines are the result of a number of factors which include habitat loss and degradation as well as past fisheries management.

Habitat Fragmentation and Isolation (Factor E)

Improperly installed, sized, or failed culverts have been identified as barriers for fish movement and migration throughout Puget Sound Watersheds (see Forest Management and Transportation Networks sections). The Salmon and Steelhead Habitat Limiting Factors reports for Water Resource Inventory Areas (WSCC 1999a; WSCC 1999b; WSCC 1999c; WSCC 2002a; WSCC 2002b) identify numerous impassible barriers to both resident and migratory fish in the area of the Puget Sound Management Unit. For example, in the Nooksack core area road blockages affect spawning and rearing areas in Hedrick Creek, “Chainup Creek,” “Lookout Creek,” Boyd Creek, a tributary located just downstream of Boulder Creek, Johnson Creek in the Hutchinson Creek drainage, Loomis Creek, and on a tributary to the South Fork which enters near river mile 29.8. There are also a few blocking culverts in the Middle Fork upstream of the diversion dam under the U.S. Forest Service 38 road. There are numerous blockages to foraging habitat in drainages including Anderson Creek (mainstem tributary), Landingstrip Creek, Jones Creek, Kenny Creek, and in tributaries to the Bear Creek Slough complex. The construction of flood control structures, tide gates, and water diversion structures have also contributed to the degradation and fragmentation of migratory corridors, and elimination of historical foraging, migration, and overwintering habitats within the Management Unit.

The construction and operation of dams has also contributed to habitat fragmentation and isolation of bull trout in the Nooksack, Upper Skagit, Lower Skagit, and Puyallup core areas. Facilities in the Puyallup core area have only recently implemented modifications to improve fish passage. Bellingham Diversion on the Middle Fork Nooksack River continues to be a barrier to fish passage. It should be noted that volitional fish passage is currently not feasible for many facilities. Given bull trout's complex migratory behavior at various life stages, assisted passage may limit full expression of this behavior. The significance of this limitation to populations is currently unknown, but likely affects primarily the movements of the subadult life stage.

Reasons for Decline Summary

Chilliwack core area. Habitat within the United States portion of the population is virtually in excellent to pristine condition, with the exception of the agriculturally dominated Sumas River. However, the vast majority of the Chilliwack River system lies within British Columbia, Canada. Most impacts to this core area occur within British Columbia where a number of land management activities have and continue to impact the Chilliwack River basin. Forest practices and agriculture practices have likely had the most widespread and lasting impacts to bull trout habitats within the system. Residential development and urbanization have primarily impacted foraging, migration, and overwintering habitats for bull trout. These factors primarily affect those life history forms that migrate through mainstem river areas, to the Fraser River, and/or to nearshore waters in the Strait of Georgia. Current fisheries management in British Columbia allowing the retention of bull trout does reduce the number of spawners returning to spawning areas in the United States, however the overall impact to the sustainability of the Chilliwack core area is currently unknown.

Nooksack core area. Past forest practices and related road networks and mass wasting have had some of the most significant impacts to bull trout habitat within this core area. These have resulted in the loss or degradation of a number of spawning and rearing areas within local populations, as well as foraging, migration, and overwintering habitats. Bellingham Diversion has significantly reduced if not precluded connectivity of the Upper Middle Fork Nooksack River local population with the rest of the core area. Bellingham Diversion currently prevents most anadromous and fluvial bull trout returning to the Middle Fork Nooksack River from reaching spawning and rearing habitats in the upper watershed. Agriculture practices, residential development, the transportation network and related stream channel and bank modifications have resulted in the loss and degradation of foraging, migration, and overwintering habitats in mainstem reaches of the major forks, as well as in a number of tributaries. Marine foraging habitats for this core area have and continue to be greatly impacted by urbanization along nearshore habitats in Bellingham Bay and Strait of Georgia. The presence of brook trout in many parts of the Nooksack core area and their potential to further increase in distribution is of significant concern given the level of habitat degradation that has occurred within the core area. The detection of brook trout/Dolly Varden hybrids further emphasizes this threat to bull trout. The absence of established spawner index areas or other repeatable means of monitoring bull trout population abundance and distribution within the core area, continues to hinder the identification, conservation, and restoration of remaining spawning and rearing reaches within the core area.

Lower Skagit core area. Large portions of this core area fall within areas under National Park and Wilderness designation, so these areas have generally avoided many of the impacts from more intensive land management. Gorge Dam currently restricts connectivity between the Stetattle Creek local population and the majority of the core area. This has put the Stetattle Creek local population at increased risk, however this break in connectivity may be less significant to the core area as a whole due to the large number of connected local populations that exist below this barrier. The Baker Dams also restrict connectivity between the Baker Lake local population and Sulphur Creek potential local population and the rest of the core area. Operations of the Lower Baker Dam have at times significantly impacted water quantity in the lower Baker and Skagit Rivers. Agriculture practices, residential development, the transportation network and related stream channel and bank modifications have resulted in the loss and degradation of foraging, migration, and overwintering habitats in mainstem reaches of the major forks, as well as in a number of tributaries. Nearshore foraging habitats have and continue to be impacted by agricultural practices and development activities. Bull trout within this system were overharvested in the past, but the implementation of more restrictive regulations in the early 1990's have helped allow the population to increase in abundance from the low levels of the late 1980's. Recent spawning index area counts strongly indicate that this population is rebounding near or to recovered levels.

Upper Skagit core area. Much of the habitat within the United States portion of the population is virtually in excellent to pristine condition. The most significant habitat change resulted from of the formation of Ross Lake, which eliminated the mainstem habitat of the Skagit River. The formation of the lake created access to a number of steep tributaries now used for spawning and rearing, and although uncertain, may have completely compensated for this mainstem habitat loss. In the United States, the majority of the core area falls within National Park, Wilderness designation, and Recreational Area designation, so it has generally avoided impacts from more intensive land management. There are some tributaries (e.g., Hozemeen Creek) which have not yet recovered from past timber harvest activities. Ross Dam currently restricts connectivity between the Thunder Creek local population and the majority of the core area. This has put the Thunder Creek local population at increased risk. However, this break in connectivity may be less significant to the core area as a whole due to the number of local populations that exist above this barrier both in the United States and in Canada. Past and ongoing forest practices have impacted bull trout habitats that lie within British Columbia. Recreational mining activities continue to impact some key local populations. Brook trout are established in a number of tributaries to Ross Lake, which are also used by bull trout for spawning and rearing. In some tributaries (*e.g.*, Hozemeen Creek), brook trout appear to have replaced or displaced bull trout that were likely once dominant in the system.

Stillaguamish core area. Past forest practices and related road networks and mass wasting have had some of the most significant impacts to bull trout habitat within this core area. These have resulted in the degradation of a number of spawning and rearing areas within local populations, as well as foraging, migration, and overwintering habitats. Ongoing mass wasting delivers significant amounts of sediment to this system, resulting in the loss of deep pools and elevated water temperatures. Like most major river systems within the Puget Sound Management Unit, habitat complexity has been significantly reduced in the mainstems and intertidal habitats have been largely eliminated as a result of various land management and development activities. This has resulted in the degradation of foraging, migration, and overwintering habitat and potentially rearing habitat for the anadromous life history form. Past fisheries on bull trout, up until the early 1990s, likely resulted in a significant reduction of the overall core population. Given the low abundance of migratory adults, current legal and illegal fisheries within the Stillaguamish core area may significantly limit the ability of the population to recover. The absence of established spawner index areas or other repeatable means of monitoring bull trout population abundance and distribution within the core area continues to hinder the identification, conservation, and restoration of remaining spawning and rearing reaches within the core area.

Snohomish-Skykomish core area. Many of the key spawning and rearing habitats of local populations within the North Fork of the Skykomish River remain in good to excellent condition. Past and recent timber harvest and associated road building has impacted habitats primarily within the South Fork Skykomish River local population. Like most major river systems within the Puget Sound Management Unit, habitat complexity has been significantly reduced in the mainstems as a result of various land management and development activities. This has resulted in the degradation of foraging, migration, and overwintering habitat and potentially rearing habitat for the anadromous life history form. Nearshore foraging habitats have and continue to be impacted by development activities. Bull trout within this system were overharvested in the past, but the implementation of more restrictive regulations in the early 1990's have helped allow the population to increase in abundance from the low levels of the late 1980's. Recent returns strongly indicate that this population has likely rebounded near or to recovered levels of abundance.

Chester Morse Lake core area. Past forest practices and reservoir management have likely had the most significant impacts to bull trout habitat within the core area. Although the adult spawner abundance appeared to be at extremely low levels in the 1990's, recent returns strongly indicate that this population has likely rebounded near or to recovered levels. Past and current flood events have likely been exacerbated by the existing forest conditions, but are expected to improve over time given current forest management under the City of Seattle's Cedar River Habitat Conservation Plan. A number of actions being conducted under the habitat conservation plan are directed at restoring and protecting bull trout habitats within the core area, managing the reservoir to minimize negative impacts to bull trout, and monitoring the distribution and abundance of the bull trout population.

Puyallup core area. Although significant portions of the known spawning and rearing areas for bull trout remain protected within Mount Rainier National Park lands, past and present timber harvest and related road building continue to impact spawning and rearing areas in the upper Puyallup River system, while agriculture practices continue to impact foraging, migration, and overwintering habitats for bull trout in the lower watershed. Dams and diversions have had some of the most significant impacts to migratory bull trout in the core area. The Electron Diversion Dam had isolated bull trout in the upper Puyallup and Mowich Rivers from the rest of the Puyallup core area for nearly 100 years until passage was recently restored. The facility has drastically reduced the abundance of migratory life history forms in the Puyallup River. Buckley Diversion and Mud Mountain Dam have had some of the most significant impacts to the White River system. In the past, these facilities impeded or precluded adult and juvenile migration, and degraded mainstem foraging, migration, and overwintering habitats. Although improvements have been made, some of these impacts continue today, but to a lesser degree. Urbanization and residential development and the marine port have significantly reduced habitat complexity and quality in the lower mainstem rivers and associated tributaries, and have largely eliminated intact nearshore foraging habitats for anadromous bull trout within Commencement Bay. The presence of brook trout in many parts of the Puyallup core area including National Park waters and their potential to further increase in distribution is considered a significant threat to bull trout. Brook trout in the Upper Puyallup and Mowich Rivers local population is of highest concern given the past isolation and the level of habitat degradation that has occurred within parts of the local population. Past fisheries on bull trout, up until the early 1990's, likely resulted in a significant reduction of the overall core population. Given the low abundance of migratory adults, current legal and illegal fisheries within the Puyallup core area may significantly limit the ability of the population to recover. The absence of established spawner index areas or other repeatable means of monitoring bull trout population abundance and distribution within the core area, continues to hinder the identification, conservation, and restoration of remaining spawning and rearing reaches within the core area.

ONGOING CONSERVATION MEASURES

The overall recovery implementation strategy for the Coastal-Puget Sound Distinct Population Segment is to integrate with ongoing Tribal, State, local, and Federal management and partnership efforts at the watershed or regional scales. This coordination will maximize the opportunity for complementary actions, eliminate redundancy, and make the best use of available resources for bull trout and salmon recovery.

State of Washington

Salmon Recovery Act. The Governor's office in Washington State has developed a statewide strategy that describes how State agencies and local governments will work together to address habitat, harvest, hatcheries, and hydropower as they relate to recovery of listed species of salmonids (WGSRO 1999). The Salmon Recovery Act, passed in 1998 (Engrossed Substitute House Bill 2496), provides the structure for salmonid protection and recovery at the local level (counties, cities, and watershed groups).

The Salmon Recovery Act directs the Washington State Conservation Commission, in consultation with local governments and treaty Tribes, to invite private, Federal, State, Tribal, and local government personnel with appropriate expertise to convene as a technical advisory group for each Water Resource Inventory Area (WRIA) of Washington State. Water Resource Inventory Areas are generally equivalent to the State's major watershed basins. The purpose of the technical advisory group is to develop a report identifying habitat limiting factors for salmonids. This report is based on a combination of existing watershed studies and knowledge of the technical advisory group participants. Limiting factors are defined as "conditions that limit the ability of habitat to fully sustain populations of salmon, including all species of the family Salmonidae."

The bill further clarifies the definition by stating, “These factors are primarily fish passage barriers and degraded estuarine areas, riparian corridors, stream channels, and wetlands.” It is important to note that the responsibilities given to the Conservation Commission do not constitute a full limiting factors analysis.

Salmon Recovery Funding Board. In 1999, the Washington State Legislature created and authorized the Salmon Recovery Funding Board to guide spending of funds targeted for salmon (the term was used broadly to include all species of salmon, trout, char, whitefish, and grayling) recovery activities and projects. The Salmon Recovery Funding Board’s mission is “to support salmon recovery by funding habitat protection and restoration projects, and related programs and activities that produce sustainable and measurable benefit for the fish and their habitat.” The primary role of the Board is to fund the best salmonid habitat projects and activities reflecting local priorities and using the best available science, to protect, preserve, restore and enhance salmonid habitat and watershed functions. Under current funding policies, the Salmon Recovery Funding Board will give the greatest preference to strategies and project lists that benefit salmonid populations that are listed under the Endangered Species Act.

Washington Department of Fish and Wildlife. The Washington Department of Fish and Wildlife has developed a native char management plan that addresses both bull trout and Dolly Varden (WDFW 2000b). The Washington Department of Fish and Wildlife no longer stocks brook trout in streams or lakes connected to bull trout waters. Fishing regulations prohibit harvest of bull trout, except for a few areas where stocks are considered “healthy” by the State of Washington. The Washington Department of Fish and Wildlife is also currently involved in a mapping effort to update bull trout distribution data within the State of Washington, including all known occurrences, spawning and rearing areas, and potential habitats. The salmon and steelhead inventory and assessment program is currently updating their database to include the entire State, which consists of an inventory of stream reaches and associated habitat parameters important for the recovery of salmonid species including bull trout. This database will provide critical baseline habitat and fish distribution information that can be used in a number of conservation efforts.

Harvest for bull trout has been significantly reduced across the species' range. Most recreational fisheries for bull trout in fresh and marine waters in the Coastal-Puget Sound Distinct Population Segment have been closed since 1994. There are only two river systems in western Washington where directed recreational harvest of bull trout is currently allowed by the Washington Department of Fish and Wildlife, the Skagit and Skykomish Rivers. In these two systems, a two fish retention limit with a minimum harvest size of 508 millimeters (20 inches) was established in 1990 to allow all migratory individuals the opportunity to spawn at least once to increase spawner abundance levels. To date, this management action has succeeded in increasing spawner abundance levels in these two systems. As the Coastal-Puget Sound Distinct Population Segment begins to achieve its recovery goal, the Washington Department of Fish and Wildlife and Tribes in coordination with the U.S. Fish and Wildlife Service will determine the location and level of bull trout harvest that continues to support the population characteristics consistent with bull trout recovery.

The Washington Department of Fish and Wildlife's Hydraulic Project Approvals program reviews and permits or denies projects that propose to use, obstruct, divert or change streambeds or flows, or impact nearshore marine waters in the State of Washington. Updates that have been made within the program to help conserve bull trout and their habitat include: revised rules and regulations for mineral prospecting and placer mining to reduce impacts to bull trout and bull trout habitat; revised approved work windows (periods of time for inwater work) that provide greater protection for bull trout life stages during spawning and incubation; and development of marine work windows that help protect important marine forage (prey) fish species for bull trout.

The Washington Department of Fish and Wildlife in conjunction with the Northwest Indian Fisheries Commission have been using Ecosystem Diagnosis and Treatment (EDT) modeling for deriving recovery goals for Puget Sound Chinook salmon in terms of productivity, capacity, and diversity based on properly functioning conditions for habitat. The model is used to analyze environmental information and draw conclusions about the ecosystem as it relates to the life history of Chinook salmon in this case. This approach compares existing conditions with a future condition where conditions are as good as they theoretically can be within the watershed. From this comparison, a “diagnosis” of factors that are preventing achievement of this future condition can be made, and potential actions to achieve goals can be identified. It is anticipated that many of the limiting habitat factors for Chinook salmon identified through this model will be equally or partially applicable to bull trout.

Washington Department of Ecology. The Washington Department of Ecology is involved in a number of programs and actions intended to help provide greater conservation for bull trout and other salmonids by reducing habitat impacts. These include updating the State’s Stormwater Management Manual for construction and development, updating State Shoreline Management regulations, updating the State’s Water Quality Standards, and developing and implementing water cleanup plans, or TMDLs (total maximum daily loads) for impaired waterbodies.

Shoreline Management Act. The goal of the Shoreline Management Act (Revised Code of Washington [RCW] 90.58) is “to prevent the inherent harm in an uncoordinated and piecemeal development of the State’s shorelines.” This act establishes a balance of authority between local and State government. Cities and counties are the primary regulators but the State has authority to review local programs and permit decisions. The Shoreline Management Act gives preference to uses that:

- Protect the quality of water and the natural environment.
- Depend on proximity to the shoreline.
- Preserve and enhance public access or increase recreational opportunities for the public along shorelines.

The Shoreline Management Act also requires extra protection for management of “shorelines of statewide significance.” These shorelines include Pacific Coast, Hood Canal, the Strait of Juan de Fuca, and large rivers (1,000 cubic feet per second or greater for rivers in western Washington) (WDOE 1999).

The National Oceanic and Atmospheric Administration’s Office of Ocean and Coastal Resource Management funds the Shoreline Management Act and is responsible for approving the guidelines and incorporating them into the federally approved Washington Coastal Zone Management Program. As part of the approval process, the Office of Ocean and Coastal Resource Management must comply with the Endangered Species Act, which requires consultation with us and the National Oceanic and Atmospheric Administration (NOAA) Fisheries.

Growth Management Act. The goal of the Growth Management Act is to prevent uncoordinated and unplanned growth that poses a "threat to the environment, sustainable economic development, and the health, safety, and high quality of life enjoyed by residents of this State" (RCW 36.70A.010). Under the Growth Management Act, the State provides broad public access to data and maps describing development opportunities and constraints. The Growth Management Act is widely used as a framework for other State statutes and policies related to land-use practices, environmental protection, and sustainable development (Washington State Department of Community, Trade, and Economic Development, no date). The Growth Management Act requires all cities and counties in the State to:

- Designate and protect wetlands, frequently flooded areas, and other critical areas;
- Designate farm lands, forest lands and other natural resource areas;
- Determine that new residential subdivisions have appropriate provisions for public services and facilities.

Washington Department of Natural Resources. The Washington Department of Natural Resources manages State trust lands for terrestrial, riparian, aquatic, and special habitats under their habitat conservation plan, approved by us in 1997. The Washington Department of Natural Resources manages State trust lands similarly throughout the western Cascade Mountains and southwest Washington. Approximately 540,000 acres within the Puget Sound Management Unit are covered by this habitat conservation plan. The riparian conservation strategy for these lands has two conservation objectives: 1) maintain or restore salmonid freshwater habitat on Washington Department of Natural Resources managed lands, and 2) contribute to the conservation of other aquatic and riparian obligate species.

These two objectives will be achieved by the following activities along Type 1, 2, and 3 Waters (fish bearing waters described in the Washington Administrative Code 222-16-031): 1) the width of the riparian buffer shall be approximately equal to a site potential tree height; 2) no timber harvest shall occur within the first 7.6 meters (25 feet) from the outer margin of the 100 year floodplain primarily to maintain stream bank integrity; 3) the next 22.8 meters (75 feet) of the buffer shall be a minimum harvest area, that may include ecosystem restoration and the selective removal of single trees, to maintain natural levels of stream temperature, sediment load, detrital nutrient load, and instream large woody debris; and 4) the area beyond 30 meters (100 feet) to approximately a site potential tree height from the active channel margin shall be a low harvest area.

The riparian buffer on Type 4 streams will be 30 meters (100 feet) wide measured horizontally from the outer margin of the 100-year floodplain. The zone will be managed similar to the two inner zones described above for Type 1, 2 and 3 streams. Type 5 streams flowing through high risk mass wasting areas will be protected when necessary for water quality, fisheries habitat, stream banks, wildlife, and other important elements of the aquatic system for the first 10 years of the plan, then protected according to a long-term plan incorporating an adaptive management strategy.

In addition to providing riparian buffers to fish bearing and non-fish bearing streams, this habitat conservation plan provides for wind buffers on Types 1, 2, and 3 streams in areas that are prone to windthrow. Wind buffers will be 15 to 30 meters (50 to 100 feet) along the windward side or possibly both sides depending on the intensity and direction of potential windthrow, and the stream size.

The habitat conservation plan strives to minimize adverse impacts to salmonid habitat caused by the road network by developing a comprehensive landscape-based road network management process that will include such elements as: 1) minimization of active road density; 2) a base-line inventory of all roads and stream crossings; 3) prioritization of roads for decommissioning, upgrading, and maintenance; and 4) identification of fish blockages caused by stream crossings and a prioritization of their retrofitting or removal.

The forest management described in the riparian conservation strategy for the Washington Department of Natural Resources Habitat Conservation Plan is expected to result in improved salmonid habitat by developing older conifer forest in the riparian zone, developing greater root strength and hydrologic maturity of young forests on unstable slopes, and ameliorating the adverse impacts of roads through the comprehensive road management plan.

Washington State Forest Practices Rules. In July 2001, the Washington Forest Practices Board adopted new permanent forest practice rules implementing the Forest and Fish Report (FFR 1999; WFPB 2001). The Forest and Fish Report was the result of a document development process that relied on broad stakeholder involvement, including the U.S. Fish and Wildlife Service, the National Marine Fisheries Service (now NOAA Fisheries), and the U.S. Environmental Protection Agency, as well as State agencies, Counties, Tribes, forest industry and environmental groups. Prior to completion of the Forest and Fish Report, the environmental groups withdrew their support and participation in the process. The forest practices rules established new prescriptions to better conserve aquatic and riparian habitat for bull trout and other salmonids, and many provisions of the rules represent improvements over previous regulations. Because there is biological uncertainty associated with some of the prescriptions, the Forest and Fish Report relies on an adaptive management program for assurance that the new rules will meet the conservation needs of bull trout. Research and monitoring being conducted to address areas of uncertainty for bull trout include protocols for detection of bull trout, habitat suitability, forest management effects on groundwater, field methods or models to identify areas influenced by groundwater, and forest practices influencing cold-water temperatures.

Dairy Nutrient Management Act. The Dairy Nutrient Management Act (RCW 90.64), overseen by the Washington Department of Agriculture, and local Manure Management Ordinance require farm plans for dairies but not for other livestock operations. Virtually every dairy farm in Whatcom County is operating under an approved farm plan. These plans are designed to protect ground and surface water quality and include, at a minimum, a grass filter strip on all water courses (G. Boggs, Whatcom County Conservation District, pers. comm. 2003).

Washington State Conservation Reserve Enhancement Program. The national Conservation Reserve Enhancement Program, implemented by the Natural Resources Conservation Service, dedicates $250 million annually for restoration activities on agricultural lands in Washington State. Farmers and landowners receive reimbursements in the form of soil rental rates for taking land out of production to plant riparian buffers, fence livestock out of streams, and restore stream habitat. Whatcom County has the greatest number of sign-ups with 85 contracts (over 405 hectares; 1,000 acres) since the program began in 1998. Whatcom is followed by Skagit County with 60 contracts (nearly 125 hectares; 390 acres), Lewis County with 13 contracts (162 hectares; 400 acres) and Snohomish County with 7 contracts (33 hectares; 83 acres). Approximately 12 to 16 hectares (30 to 40 acres) total are under contract in King, Pierce, and Thurston Counties where agricultural lands are limited. The Conservation Reserve Enhancement Program contracts are 10 to 15-year terms and restored riparian areas are often incorporated into conservation easements to provide permanent protection.

Federal Agencies

U.S. Fish and Wildlife Service. Aside from the Endangered Species Act regulations and guidelines that apply to Federal actions (see Appendix 4), there have been several significant Federal efforts with specific implications for bull trout in the Puget Sound Management Unit. We also have a number of national programs (*e.g.*, Private Stewardship Program, Cooperative Endangered Species Conservation Fund) that can and have provided funds to projects restoring and conserving bull trout habitats in Puget Sound.

We have negotiated several habitat conservation plans within the area of the Puget Sound Management Unit. The Washington Department of Natural Resources Habitat Conservation Plan is discussed above; the other plans are discussed below.

The City of Seattle's Cedar River Watershed Habitat Conservation Plan was implemented in April 2002. This habitat conservation plan addresses Chester Morse reservoir operations and activities associated with restoration planting of about 567 hectares (1,400 acres); restoration thinning of about 4,451 hectares (11,000 acres); ecological thinning of about 809 hectares (2,000 acres); instream habitat restoration projects; removal of approximately 386 kilometers (240 miles) of road over the first 20 years; maintenance of about 836 kilometers (520 miles) of road per year at the start of the habitat conservation plan, diminishing as roads are removed over time to about 611 kilometers (380 miles) per year at year 20; and improvement of about 6.4 to 16.1 kilometers (4 to 10 miles) of road per year. In addition, the habitat conservation plan outlines a number of bull trout research projects in Chester Morse Lake and upper Cedar River system. The results of these projects will help inform and guide future management. The term of the City of Seattle Habitat Conservation Plan and incidental take permit is 50 years.

The Tacoma Water Habitat Conservation Plan was implemented in July 2001. This habitat conservation plan addresses effects to listed species from Tacoma Public Utilities management of 6,070 hectares (15,000 acres) of forest in the upper Green River Watershed, including approximately 177 stream kilometers (110 stream miles), and Tacoma's municipal water withdrawal from Green River at river mile 61.0. Distribution of bull trout in the upper watershed has not been documented and only a few individuals have recently been found in the lower Green River and the Duwamish Waterway (USFWS 2001). The U.S. Fish and Wildlife Service permitted the incidental take of bull trout resulting from water withdrawal activities affecting the middle and lower Green River, even-aged harvest of 1,329 hectares (3,285 acres), uneven-aged harvest of 809 hectares (2,000 acres), and the construction, maintenance, and decommissioning of 181 kilometers (113 miles) of road. This plan also includes the construction of an adult trap and haul facility and juvenile passage facility for anadromous salmonids at the Tacoma Headworks diversion dam. The term of the Tacoma Water Habitat Conservation Plan and permit is 50 years.

The Plum Creek Habitat Conservation Plan was implemented in June 1996. The U.S. Fish and Wildlife Service permitted the incidental take of the spotted owl, marbled murrelet, grizzly bear, and gray wolf, in the course of the otherwise legal forest-management and related land-use activities carried out under the plan in portions of King and Kittitas Counties, Washington. The permit was amended to include the Columbia River population segment of bull trout in

1998, and the Coastal-Puget Sound population segment of bull trout in 2002. The term of the plan and incidental take permit is 50 to 100 years, as some aspects of the plan and permit may terminate at year 50 while others may continue for an additional 50 years. Plum Creek's ownership within the covered area is located both east and west of the Cascade Mountains crest along the Interstate-90 corridor in central Washington. Plum Creek's ownership covered by the plan on the west side of the Cascade crest is approximately 21,450 hectares (53,000 acres), primarily composed of the upper Green River watershed. Recent surveys of the habitat conservation plan lands west of the Cascade crest have not detected bull trout, but surveys are not comprehensive. The Riparian Management Strategy in the habitat conservation plan includes the maintenance and protection of riparian habitat areas. These riparian habitat areas and wetlands total about 1,255 hectares (3,100 acres) in Plum Creek’s lands west of the Cascade Crest. Minimum guidelines in these areas include establishing 60-meter (200-foot) buffers (measured as horizontal distance from the edge of the stream) on each side of all fish-bearing streams. Other measures include some protections for riparian wetlands, west-side (of the Cascade Mountains) nonfish-bearing perennial streams, and seasonal fish-bearing streams.

The West Fork Timber (formerly Murray Pacific) Habitat Conservation Plan was issued in September 1993, and recently amended (June 2002) to include the Coastal-Puget Sound Distinct Population Segment of bull trout. The habitat conservation plan area consists of 21,662 hectares (53,527 acres) of forest land in two contiguous blocks north and northeast of the town of Morton in eastern Lewis County, Washington. The majority of the habitat conservation plan area is managed for timber production, and is currently a mosaic of coniferous forest stands of varying ages. Although approximately 100 kilometers (62 miles) of fish-bearing waters have been identified in the area, historically bull trout presence has never been detected. Similarly, bull trout have not been identified through recent surveys conducted as part of the fish monitoring program under this habitat conservation plan. In order for bull trout to migrate to the area, they would travel along the Cowlitz and Nisqually River systems. Dams on the Cowlitz and Nisqually Rivers effectively prevent the upstream migration of salmonid species. Therefore, the potential for individuals from the lower Nisqually River or other areas of Puget Sound to migrate to the area is low. The most significant measure associated with the habitat conservation plan is the conservation of at least 18 to 20 percent (4,050 hectares; 10,000 acres) of the area as a source of late-successional forest habitat. Most of these reserve areas are located in riparian zones along streams and wetlands which would benefit bull trout should they be detected in this area in the future.

Our Western Washington Fish and Wildlife Office also has a number of restoration programs (*e.g.*, Jobs in the Woods, Partners for Fish and Wildlife, Puget Sound Coastal Program) that provide funding and technical assistance for habitat restoration work in the Puget Sound region. Many of the projects funded through these programs contribute to the recovery of bull trout through habitat enhancements or through the restoration of watershed processes and functions that have been eliminated or impaired by land management activities. These programs also contribute to the restoration of estuarine and nearshore habitats important to the recovery of bull trout and salmon.

The Fisheries Restoration and Irrigation Mitigation Program provides funds for fish screening and for providing fish passage at water diversions. Industrial, municipal, and agricultural diversions are eligible for restoration and mitigation funding.

Our Western Washington Fish and Wildlife Office participates in the Federal Energy Regulatory Commission's hydroelectric project proceedings for both new projects and projects requiring a new operating license. During the license proceeding, we provide the Federal Energy Regulatory Commission with recommended measures to protect and enhance fish and wildlife, including their habitat, and may include mandatory fish passage prescriptions. The recommended measures are transmitted through the Department of the Interior's response on the license application. During project relicensing, we have an opportunity to improve habitat that has been degraded by project operation by persuading the Federal Energy Regulatory Commission to include mitigative measures (*e.g.*, improved flows, sediment and large woody debris transport, etc.) as license conditions. A hydroelectric project operating license typically covers a period of between 25 and 40 years.

U.S. Forest Service. Currently, timber management in the National Forest System within the Puget Sound Management Unit is guided by individual Forest Plans as amended by the Northwest Forest Plan (see Appendix 4). Benefits to aquatic and riparian habitat to date from the Northwest Forest Plan are evident throughout the North Cascades.

The U.S. Forest Service also conducts ongoing aquatic habitat monitoring and fish survey efforts, and continues to be involved in restoration efforts of upland and aquatic habitats on National Forest lands to benefit salmonids and other aquatic species.

North Cascades and Mount Rainier National Parks. Portions of the Lower and Upper Skagit core areas are located within the boundaries of North Cascades National Park, and portions of the Puyallup core area are located within the boundaries of Mount Rainier National Park. This largely undisturbed habitat provides important high quality spawning and rearing habitat for bull trout and other salmonids and protects some of the last undisturbed bull trout habitat in Washington. The two parks are undertaking aquatic habitat monitoring, inventories of fish populations throughout unsurveyed watersheds within the parks, and they are inventorying and replacing or modifying road culverts that will assist bull trout recovery in Puget Sound.

U.S. Environmental Protection Agency. Growing public awareness and concern for controlling water pollution led to the enactment of the Federal Water Pollution Control Act Amendments of 1972. As amended in 1977, this law became commonly known as the Clean Water Act (33 USC 1251 *et seq*.). The Clean Water Act established the basic structure for regulating discharges of pollutants into the waters of the United States. This Act gave the U.S. Environmental Protection Agency the authority to implement pollution control programs such as setting wastewater standards for industry. The Clean Water Act also continued requirements to set water quality standards for all contaminants in surface waters. This Act made it unlawful for any person to discharge any pollutant from a point source into navigable waters, unless a permit was obtained under its provisions. As a requirement of section 303(d) of the Clean Water Act, a list of impaired waters must be prepared by each State and approved by the U.S.

Environmental Protection Agency for all waterbodies that do not fully support their beneficial uses (see, *e.g*., Appendix 2). The Clean Water Act also funded the construction of sewage treatment plants under the construction grants program and recognized the need for planning to address the critical problems posed by nonpoint source pollution.

Under the Clean Water Act, the U.S. Environmental Protection Agency has authority over approval of all State water quality standards. Because many Pacific Northwest salmonid species are listed as threatened or endangered under the Endangered Species Act, the U.S. Environmental Protection Agency must consult with us and NOAA Fisheries to insure that State or Tribal water quality standards are not likely to jeopardize the continued existence of these listed fish. The U.S. Environmental Protection Agency has developed guidance to assist States and Tribes adopt temperature water quality standards that the Environmental Protection Agency can approve consistent with its obligations under the Clean Water Act and Endangered Species Act (USEPA 2003).

Natural Resources Conservation Service. The Natural Resources Conservation Service works to assist private landowners with conserving their soil, water, and other natural resources. Local, State and Federal agencies and policymakers also rely on the expertise of the Natural Resources Conservation Service for technical assistance with best management practices for conserving natural resources. Most work is done with local partners, such as County Conservation Districts. The Wildlife Habitats Incentives Program, Environmental Quality Incentives Program, and other grants assist private landowner riparian habitat protection and management actions. The Environmental Quality Incentives Program is a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. The Wildlife Habitats Incentives Program is also a voluntary program aimed at working with people who want to develop and improve wildlife habitat (including aquatic areas) on private land.

NOAA Fisheries' Recovery Actions for Puget Sound Chinook. In March 1999, NOAA Fisheries listed the Puget Sound Chinook salmon and Hood Canal summer-run chum salmon Evolutionarily Significant Units as threatened under the Endangered Species Act. These two evolutionarily significant units overlap with the Coastal-Puget Sound Distinct Population Segment of bull trout.

As part of the recovery planning process for Chinook salmon, NOAA Fisheries has issued guidance for the technical development of recovery plans (NMFS, *in litt*. 2000). The framework for salmon and steelhead recovery plan development is divided into distinct geographic areas, or domains, which may contain multiple evolutionarily significant units. Recovery plans for listed salmon and steelhead will contain the same basic elements as mandated by the Endangered Species Act, and include: 1) objective, measurable criteria for gauging recovery; 2) a description of site-specific management actions necessary to achieve recovery; and 3) estimates of the cost and time necessary to carry out recovery actions.

In the Puget Sound Region, NOAA Fisheries is developing a Chinook salmon and summer-run chum salmon recovery plan through a collaborative regional approach, the Shared Strategy for Puget Sound (described in detail later in this section). It is anticipated that many of the habitat recovery actions developed for Chinook salmon will provide conservation benefits to bull trout and in some cases possibly meet their conservation needs (*e.g.*, Chinook salmon recovery actions in mainstem river reaches). However, bull trout will require greater habitat protection and restoration measures in some locations due to their cold water requirements, greater sensitivity to habitat degradation, and use of habitats outside of areas occupied by Chinook salmon. As a participant in the Shared Strategy effort, we will coordinate the implementation of the recovery actions identified in the Puget Sound and Olympic Peninsula Management Unit recovery plans with salmon measures to avoid duplication of effort and to maximize the use of available resources, as well as identify actions necessary for bull trout that are above and beyond what maybe necessary for Chinook salmon recovery.

<u>Native American Tribal Activities</u>

The Tribes within the Puget Sound region are fisheries co-managers along with the Washington Department of Fish and Wildlife, and have an active role in managing the fisheries resource, including monitoring abundances and conserving and restoring salmonid habitats. Their efforts include outmigration sampling, adult and juvenile surveys, research, habitat restoration, and biological and physical monitoring of salmonid watersheds. Most Tribal governments in the Puget Sound region have active natural resource or fisheries departments with technical staff working on collaborative projects with Federal, State, and local entities. A number of Puget Sound Tribes participate in ongoing collaborative regional recovery efforts such as general resource protection, the Shared Strategy for Puget Sound, and in more localized watershed efforts such as the Habitat Limiting Factors analyses under State of Washington House Bill 2496.

Shared Strategy for Puget Sound

In October of 1999, over 150 leaders on salmon issues from throughout Puget Sound gathered in Port Ludlow, Washington, to discuss the region's growing salmon crisis. At this meeting a group representing Tribes, Federal, State, and local governments agreed to develop a Shared Strategy to facilitate a coordinated regional approach to salmonid recovery. The strategy includes developing a collaborative recovery plan for the region that is guided by clear goals and meets the broad interests for salmon and bull trout in Puget Sound. The strategy also includes establishing an organizational structure to link recovery efforts, completing a regional recovery plan, guiding its implementation, and identifying and supporting important ongoing near-term efforts to protect Puget Sound salmon and bull trout (Shared Strategy 2002). The Shared Strategy is an effort to engage local citizens, Tribes, technical experts and policymakers to build a practical, cost-effective recovery plan endorsed by the people living and working in the watersheds of the Puget Sound region.

As an ongoing participant and partner in the Shared Strategy, we believe this effort can contribute to the successful implementation of many of the recovery actions identified in the recovery plans for bull trout in the Puget Sound and Olympic Peninsula Management Units. The Puget Sound bull trout recovery team believes the watershed-based planning efforts conducted under the Shared Strategy can help further develop and refine certain site specific recovery actions

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identified for core areas in the Puget Sound Management Unit, and has referred to those efforts in the “recovery measures narrative” where appropriate.

<u>Puget Sound Nearshore Ecosystem Restoration Project</u>

In 2000, a reconnaissance study conducted by the U.S. Army Corps of Engineers concluded that major human modifications along the Puget Sound shoreline have resulted in a significant loss of estuarine and nearshore habitats. The changes in the physical structure of the shorelines have resulted in significant impacts to critical fish and wildlife resources, including habitat that supports all species of salmonids (USACOE and WDFW 2001). The study identified a number of proposed actions that would be key in restoring nearshore habitats to a more natural state. These actions included: providing or improving beach nourishment (accumulation of sand and gravel materials for forming habitat); removing, moving, or modifying artificial structures (*e.g.*, bulkheads, riprap, dikes, tide gates); using alternative shoreline erosion and flooding protection measures that avoid or minimize impacts to natural nearshore processes; and restoring estuaries and nearshore habitats such as eelgrass beds and kelp beds.

With the U.S. Army Corps of Engineers as lead, a cooperative effort to preserve and restore the health of the Puget Sound nearshore has been formed with local sponsors that include State and other Federal agencies, Tribes, local governments, industries, and environmental organizations. This long-term effort is currently in the feasibility study phase, which evaluates the factors that are causing habitat to decline and pollution to accumulate in the Puget Sound Basin; formulates, evaluates, and screens potential solution to these factors; and recommends a series of actions and restoration projects. Currently, restoration project engineering and design is projected to begin by 2006, and project construction is targeted for 2009. A companion Corps of Engineers construction authority, the Puget Sound and Adjacent Waters Initiative, was authorized to receive first year funds in 2003. The initiative is a construction authority for restoration projects in the Puget Sound Basin.

Canadian Government Activities

Bull trout are currently a “Blue Listed” species by the British Columbia government, and as such receive certain protections from land management activities including timber harvest. Fishing regulations were implemented in 1989 that have reduced the retention limit of bull trout from eight per day (with two fish allowed over 500 millimeters (19.7 inches)) to four per day (with 1 fish allowed over 500 millimeters) in the Lower Mainland Region. Evaluation of the need to further reduce retention limits and/or implement gear restrictions (single barbless hook/bait ban) for bull trout in Chilliwack Lake is ongoing (Jesson, pers. comm. 2002a). Researchers in British Columbia are currently working on a collaborative research project with Seattle City Light to improve our understanding of the Upper Skagit River transboundary populations (Connor and Jesson, *in litt*. 2002). The study is investigating migratory movements, defining spawning areas, and assessing population abundance of bull trout within the Upper Skagit core area and the upper Skagit River system in British Columbia.

STRATEGY FOR RECOVERY

Bull trout have specific ecological requirements and depend upon an interconnected network of complex habitats to support multiple life history forms and facilitate the potential for occasional dispersal between local populations to maintain gene flow and genetic variability. In order to effectively address the needs of this wide-ranging species and the varying threats it faces, as well as incorporate the needs and concerns of the numerous local interest groups involved in its recovery, we have subdivided the Coastal-Puget Sound Distinct Population Segment into two management units, the Puget Sound and the Olympic Peninsula. Within each management unit, recovery will be based on the concept of functional “core areas.” A core area represents the combination of both a core population (*i.e.*, one or more local populations of bull trout inhabiting a core habitat) and core habitat (*i.e.*, habitat that could supply all the necessary elements for the long-term security of bull trout, including for both spawning and rearing, as well as for foraging, migrating, and overwintering) and constitutes the basic unit upon which to gauge recovery.

In the Puget Sound Management Unit, the recovery team identified 8 core areas, with a total of 58 local populations and 3 potential local populations distributed among them (Table 6). The number of local populations includes those stream complexes for which the presence of bull trout spawning and rearing is either known or has been determined through professional judgement as highly likely. As more fish distribution and abundance information is collected, the number of local populations identified will likely increase.

The recovery team also identified "potential" local populations for some core areas. A potential local population may be defined as either a local population that likely exists but has not been adequately documented, or as a local population that does not currently exist but is likely to develop in the foreseeable future. The development of a local population is likely to occur if spawning habitat or connectivity is restored in that area or if bull trout recolonize or are reintroduced in the area. Potential local populations identified in this plan are considered necessary for recovery.

Ensuring the long-term persistence of extant local populations, especially those exhibiting the anadromous life history, is key to supporting self-sustaining core areas of bull trout within the Coastal-Puget Sound Distinct Population Segment. In the coterminous United States, anadromous bull trout are found only within this population segment. In addition to their unique life history, anadromous forms are important because they provide an opportunity for core populations to exchange genetic material and hence increase the diversity and stability of the overall distinct population segment. Presumably this diversity reduces the risk of extinction of the distinct population segment. Large anadromous bull trout also have higher fecundity than the resident and fluvial forms and use a greater diversity of spawning and foraging habitats, which further contributes to population diversity and lowers the risk of extinction. All migratory life history forms require intact spawning and rearing habitat connected to adequate foraging, migration, and overwintering habitat. For anadromous bull trout, these required habitats span the whole watershed, from headwater tributaries to the estuary and adjacent marine nearshore habitat, as well as freshwater systems outside their natal watershed.

Table 6. List of bull trout local populations and potential local populations by core area in the Puget Sound Management Unit.

CORE AREA	LOCAL POPULATION	POTENTIAL LOCAL POPULATION
Chilliwack	Little Chilliwack River	
	Upper Chilliwack River	
	Selesia Creek (British Columbia and U.S.)	
	Depot Creek (British Columbia and U.S.?)	
	Airplane Creek (British Columbia)	
	Borden Creek (British Columbia)	
	Centre Creek (British Columbia)	
	Foley Creek (British Columbia)	
	Nesakwatch Creek (British Columbia)	
	Paleface Creek (British Columbia)	
Nooksack	Lower Canyon Creek	
	Glacier Creek	
	Lower Middle Fork Nooksack River	
	Upper Middle Fork Nooksack River	
	Lower North Fork Nooksack River	
	Middle North Fork Nooksack River	
	Upper North Fork Nooksack River	
	Upper South Fork Nooksack River	
	Lower South Fork Nooksack River	
	Wanlick Creek	
Lower Skagit	Bacon Creek	Sulphur Creek (Lake Shannon)
	Baker Lake	Stetattle Creek (Gorge Lake)
	Buck Creek	
	Cascade River	
	South Fork Cascade River	

Table 6. List of bull trout local populations and potential local populations by core area in the Puget Sound Management Unit.

CORE AREA	LOCAL POPULATION	POTENTIAL LOCAL POPULATION
	Downey Creek	
	Goodell Creek	
	Illabot Creek	
	Lime Creek	
	Milk Creek	
	Newhalem Creek	
	Forks of Sauk River	
	Upper South Fork Sauk River	
	Straight Creek	
	Upper Suiattle River	
	Sulphur Creek	
	Tenas Creek	
	Lower White Chuck River	
	Upper White Chuck River	
Upper Skagit	Big Beaver Creek	Deer Creek (Diablo Lake)
	Little Beaver Creek	
	Lightning Creek	
	Panther Creek	
	Pierce Creek	
	Ruby Creek (includes Granite and Canyon Creeks)	
	Silver Creek	
	Thunder Creek (Diablo Lake)	
	Skagit River (British Columbia)	
	East Fork Skagit River (British Columbia)	
	Klesilkwa River (British Columbia)	
	Nepopekum Creek (British Columbia)	

Table 6. List of bull trout local populations and potential local populations by core area in the Puget Sound Management Unit.

CORE AREA	LOCAL POPULATION	POTENTIAL LOCAL POPULATION
	Skaist River (British Columbia)	
	Sumallo River (British Columbia)	
Stillaguamish	Upper Deer Creek	
	South Fork Canyon Creek	
	North Fork Stillaguamish River	
	South Fork Stillaguamish River	
Snohomish-Skykomish	North Fork Skykomish River	
	South Fork Skykomish River	
	Salmon Creek	
	Troublesome Creek	
Chester Morse Lake	Boulder Creek	Shotgun Creek
	Upper Cedar River	
	Rex River	
	Rack Creek	
Puyallup	Carbon River	Clearwater River
	Greenwater River	
	Upper Puyallup and Mowich Rivers	
	Upper White River	
	West Fork White River	

Recovery Goals and Objectives

The goal of the bull trout recovery plan is to **ensure the long-term persistence of self-sustaining, complex, interacting groups of bull trout distributed across the species' native range so that the species can be delisted.** To accomplish the goal, recovery objectives addressing distribution, abundance, habitat and genetics were identified.

The recovery objectives for the Puget Sound Management Unit are as follows:

- Maintain the current distribution of bull trout, particularly anadromous forms, and restore migratory life history forms in some of the previously occupied areas within the Puget Sound Management Unit.

- Maintain stable or increasing trends in abundance of bull trout in the Puget Sound Management Unit.

- Restore and maintain suitable habitat conditions for all bull trout life history stages and strategies, with an emphasis on anadromy.

- Conserve genetic diversity and provide opportunity for genetic exchange to conserve migratory life history forms.

Rieman and McIntyre (1993) and Rieman and Allendorf (2001) evaluated the bull trout population numbers and habitat thresholds necessary for the long-term viability of the species. They identified four key elements, and the characteristics of each of those elements, for consideration when evaluating the viability of bull trout populations. These four elements are: (1) the number of local populations; (2) adult abundance (defined as the number of spawning fish present in a core area in a given year); (3) productivity, or the reproductive rate of the population (as measured by population trend and variability); and (4) connectivity (as represented by the presence of the migratory life history form and functional habitat). For each element, the Puget Sound Recovery Team classified bull trout populations into relative risk categories based on the best available data and the professional judgement of the team.

The Puget Sound Recovery Team evaluated these key elements to produce target levels for each under a potential recovered condition. The evaluation of these elements under a recovered condition assumed that the actions identified within this plan had been implemented. The recovery targets for the Puget Sound Management Unit reflect: (1) the stated objectives for the management unit; (2) the evaluation of each population element under both current and recovered conditions; and (3) consideration of current and recovered habitat characteristics within the management unit. These recovery targets are subject to refinement in the future as more detailed information on bull trout population dynamics becomes available. Given the limited information currently available on bull trout, both the level of adult abundance and the number of local populations needed to lessen the risk of extinction should be viewed as best estimates at this time.

This approach to developing recovery criteria acknowledges that the status of populations in some core areas may remain short of the ideals described by conservation biology theory. Some core areas may be limited by natural attributes or by patch size and may always remain at a relatively high risk of extinction. Because of the limited availability of data for the Puget Sound Management Unit, the recovery team relied heavily on the professional judgement of its members.

Local Populations. Metapopulation theory is important to consider in bull trout recovery. A metapopulation is an interacting network of local populations with varying frequencies of migration and gene flow among them (Meffe and Carroll 1994). The distribution and interconnection of multiple local populations throughout a watershed provide a mechanism for spreading risk from stochastic[†] events and allows for potential recolonization in the event of local extirpations. In part, the distribution of local populations in such a manner is an indicator of a functioning core area. Based in part on guidance from Rieman and McIntyre (1993), bull trout core areas with fewer than 5 local populations are at increased risk of local extirpation, core areas with between 5 and 10 local populations are at intermediate risk, and core areas with more than 10 interconnected local populations are at diminished risk.

In the Lower Skagit core area there are currently 19 known local populations. Not only are the local populations numerous, they are also well distributed throughout the core area. Based on the above guidance, the Lower Skagit core area is at diminished risk of adverse effects from stochastic events. In the Upper Skagit core area there are eight local populations currently identified and these are well distributed within the core area. By including only the local populations within the United States in this risk evaluation, the Upper Skagit core area is considered to be at an intermediate risk. However, there are believed to be at least six additional local populations in British Columbia, which are functionally part of the core area. If these are included in our risk evaluation, the Upper Skagit core area would be at a diminished risk of adverse effects from stochastic events[4]. Two regions within these core areas remain a concern, Diablo Lake (Upper Skagit), which currently supports a single local population, and Gorge Lake (Lower Skagit core area), which has one potential local population. If connectivity cannot be restored to these two lake systems, the establishment of additional local populations should be a high priority for these isolated areas where possible. For Diablo Lake, Deer Creek and other tributaries such as Colonial Creek should be further evaluated as to their potential for supporting a local population. It is currently believed that no additional local populations, other than Stetattle Creek, can likely be established in the Gorge Lake system.

The Chilliwack, Nooksack, and Puyallup core areas are considered to be at intermediate risk given the current number of local populations that have been identified. Although generally well distributed, they each support fewer than 10 local populations. There are only three local populations identified for the

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The degree of risk was evaluated separately for the United States portion of this core area, since from an administrative standpoint our jurisdiction technically extends only to those local populations within the United States border. From a biological standpoint, however, these populations are functionally interconnected with the populations in Canada, so the true biological risk is diminished when considered at the level of the core area as a whole. The Chilliwack core area, also shared with Canada, was evaluated in a similar manner.

Chilliwack core area; however, by including the seven local populations identified in British Columbia in our risk evaluation, this core area would functionally be at diminished risk from stochastic events. In the Nooksack core area, the known spawning areas within identified local populations appear to be small in size and dispersed. In the Puyallup core area, the known spawning areas within identified local populations are few in number and not widespread. The Clearwater River system should be further evaluated as to its potential for supporting an additional local population within this system.

The Stillaguamish, Snohomish-Skykomish, and Chester Morse Lake core areas are considered to be at an increased risk of adverse effects from stochastic events. The local populations are generally well distributed throughout these three core areas, however, currently identified local populations have few known spawning areas. The majority of migratory individuals spawn in one local population (North Fork Skykomish River) in the Snohomish-Skykomish core area, placing it in a much more vulnerable state. Recent establishment of the population above Sunset Falls on the South Fork Skykomish River has greatly increased the spawning distribution within the core area, reducing the overall risk. Chester Morse Lake is the smallest core area within the management unit, with the majority of spawning occurring in two local populations. Spawning distribution is generally concentrated within a short river reach in these two local populations, increasing their vulnerability to stochastic events. Recent monitoring efforts for these two local populations suggest they are relatively resilient to stochastic pressures (*e.g.*, major flood events). However, the much smaller local populations identified within the Chester Morse Lake core area need to be maintained and the establishment of additional local populations should be assessed to reduce the overall risk to the core area.

Adult Abundance. The recovered abundance levels in the Puget Sound Management Unit were determined by considering theoretical estimates of effective population size[†], historical census information, and the professional judgement of recovery team members. In general terms, the effective population size is the functional size of the population, from a genetic standpoint, based on the numbers of individuals that successfully breed and the distribution of offspring among individuals. The effective population size may be substantially smaller than the census population size. Effective population size is an important theoretical construct in conservation biology, since genetic variability may be lost from a population with high numbers of individuals if the effective population size is low (Kimura and Crow 1963; Franklin 1980). The concept of effective population size allows us to predict potential future losses of genetic variation within a population due to small population sizes and genetic drift (see Appendix 3).

For the purposes of recovery planning, we used the number of adult bull trout that successfully spawn annually as a measure of effective population size. Based on standardized theoretical equations (Crow and Kimura 1970), guidelines have been established for maintaining minimum effective population sizes for conservation purposes. Effective population sizes of greater than 50 adults are necessary to prevent inbreeding depression and a potential decrease in viability or reproductive fitness of a population (Franklin 1980). To minimize the loss of genetic variation due to genetic drift and to maintain constant genetic variance within a population, an effective population size of at least 500 is recommended (Franklin 1980; Soulé 1980; Lande 1988). Effective population sizes required to maintain long-term genetic variation that can serve as a reservoir for future adaptations in response to natural selection and changing environmental conditions are discussed in Appendix 3.

For bull trout, Rieman and Allendorf (2001) estimated that a minimum number of 50 to 100 spawners per year is needed to minimize potential inbreeding effects within a local population. In addition, a minimum population size of between 500 and 1,000 adults is needed to minimize the deleterious effects of genetic drift at the level of a core area.

For the purposes of bull trout recovery planning, abundance levels were conservatively evaluated at the local population and core area levels. Local populations containing fewer than 100 spawning adults per year were classified as at risk from inbreeding depression. Bull trout core areas containing fewer than 1,000 spawning adults per year were classified as at risk from genetic drift.

Detailed abundance estimates for the Puget Sound Management Unit are currently not available due to limited and nonrepresentative data. Similarly, detailed abundance estimates are not always available at the local population scale. However, the recovery team has provided recovered abundance targets for each core area, based on available data sets, habitat considerations, the population guidance discussed above, and best professional judgement.

The recovery team believes the Lower Skagit core area has the greatest abundance of bull trout within the management unit. The adult abundance of bull trout in the Lower Skagit core area is thought to exceed several thousand individuals based on the number of local populations, estimates of abundance in local populations, and redd counts in the South Fork Sauk River spawner index reach. This core area is currently not considered at risk from genetic drift. Although some local populations within the Lower Skagit core area are believed to support fewer than 100 adults and therefore may be at risk from inbreeding depression, the majority of local populations within the core area are at or above this level.

In the Upper Skagit core area, including those portions of the drainage within British Columbia that are functionally part of the core area, the adult abundance likely exceeds 1,000 spawners. This core area is currently not considered to be at risk from genetic drift. There are likely at least 100 adult spawners in both the Ruby Creek and Lightning Creek local populations based on observations of staging adults and the amount of intact spawning habitat presumed available in these systems. Adult abundance in the remaining local populations within the core area are currently unknown, so the risk from inbreeding for these areas is currently undetermined.

In the Chilliwack core area, including those portions of the drainage within British Columbia that are functionally part of the core area, the adult abundance likely exceeds 1,000 spawners. The core area is currently not considered to be at risk from genetic drift. Adult abundance in the Chilliwack River local population is likely near or in excess of 100 spawners based on preliminary angler catch data in Chilliwack Lake and the near pristine habitat available in North Cascades National Park. Adult abundance in the remaining local populations within the core area are currently unknown, so the risk from inbreeding for these areas is currently undetermined.

Currently the adult abundance of bull trout in each of the Nooksack, Stillaguamish, and Puyallup core areas is likely fewer than 1,000 spawners. Although current adult abundance estimates are lacking for most local populations within these core areas, the majority of local populations likely have fewer than 100 adults each based on the relatively low numbers of migratory adults observed returning to these core areas. In the Nooksack core area, the Glacier Creek local population is likely near or in excess of 100 adult spawners based on incidental redd counts and available spawning habitats. It is possible that 100 adult spawners may also currently exist within the Upper North Fork Nooksack River local population based on the number of persistent small numbers of spawning adults observed in tributaries and the available side channel habitat in this section of the North Fork. Although the glacial nature of this system limits comprehensive adult counts, bull trout spawning has been documented in some of these side channel habitats. In the Stillaguamish core area, only the North Fork Stillaguamish River local population likely meets or exceeds 100 adult spawners based on preliminary adult counts. In the Puyallup core area, current abundance estimates are not available for most local populations. Local populations in the White River system are all likely below 100 adult spawners based on adult counts at the Buckley fish trap. We recognize that these counts may not adequately account for fluvial migrants that might not migrate below the facility, but these counts show that there are few anadromous bull trout returning to local populations in the White River system.

The Snohomish-Skykomish and Chester Morse Lake core areas both likely support between 500 and 1,000 adult spawners, based on the recent redd counts in the North Fork Skykomish River spawning index reach and in the upper Cedar River watershed, respectively. In the Snohomish-Skykomish River core area, the current abundance of the Salmon Creek local population is likely fewer than 100 spawning adults, potentially putting it at an increased risk from inbreeding depression. Although the South Fork Skykomish River local population is currently just below 100 adults, escapement is steadily increasing. In the Chester Morse Lake core area, estimated adult abundance in Boulder Creek and Rack Creek local populations is below 100 adults, potentially placing these local populations at an increased risk from inbreeding depression.

Abundance target levels. To develop recovered abundance targets for core areas, the Puget Sound Recovery Team considered and modified the population guidance presented above. To address inbreeding concerns, the team chose to base local population abundance using the higher value from the 50 to 100 spawners needed to avoid inbreeding depression. The team further recommends that individual minimum local population abundance be set at 200 spawning adults in the Puget Sound Management Unit, given recent information from the Lower Skagit core area indicating that only 50 percent of the adult spawning population are first time spawners (Kraemer, *in litt*. 2003). This minimum abundance provides a buffer against stochastic events, helps ensure diverse age structure among spawners, and helps ensure the expression of diverse life histories within core areas. Available information indicates that many if not most local populations can achieve this abundance, provided adequate habitat conditions are maintained or restored. The team acknowledged that some local populations may not be able to achieve this ideal minimum abundance, while others will likely reach much higher abundances due to natural differences in habitat capacity among the local populations. However, we believe 200 spawners should be the current basis for setting recovered abundance targets for each core area.

To develop a recovered abundance target for each core area, two factors were considered. The first factor was the minimum number of adult spawners needed to avoid the deleterious effects from genetic drift. The team selected 1,000 spawning adults as that minimum number, based on the high value of the suggested range from 500 to 1,000 spawning adults. In addition, the total number of local populations in the core area was considered. Since each local population minimum was set at 200 spawning adults, the recovered abundance target number of spawning adults should be at least 200 times the number of local populations within the core area. The team recommended that the recovered abundance target for each core area be set at either the product of the number of local populations in the core area and the minimum local population abundance of at least 200 spawning adults (number of local populations × 200), or a simple minimum of

1,000 spawning adults, whichever is greater. Thus core areas with more than five local populations would have recovered abundance target levels of more than 1,000 spawning adults, while those with fewer local populations would have an abundance target set at the minimum level of 1,000 spawning adults (Table 7).

Table 7. Number of current local populations, including those with greater than 100 spawning adults (considered not at risk of inbreeding depression), and summary of target abundance levels of spawning adults necessary to recover migratory bull trout in core areas of the Puget Sound Management Unit (see text for derivation of abundance targets).

Core Area	Estimated Existing Number of Local Populations (United States)	Estimated Existing Number of Local Populations with >100 adults (United States)	Recovered Minimum Number of Local Populations with >100 adults (United States)	Recovered Minimum Core Area Adult Abundance Targets
Chilliwack	3	1	3	600 [b]
Nooksack	10	1	9	2,000
Lower Skagit	19	14	14	3,800
Upper Skagit	7[a]	2	5	1,400 [b]
Stillaguamish	4	1	4	1,000
Snohomish-Skykomish	3[a]	1	3	500[c]
Chester Morse Lake	4	2	2	500[c]
Puyallup	5	1	5	1,000

a. Number does not include local populations with primarily resident forms.
b. Target does not include those local populations occurring entirely within British Columbia.
c. Target adjusted to reflect natural habitat limitations.

In the Chilliwack core area, the abundance target reflects only those local populations within the United States portion of this river system. Based on the number of local populations identified within British Columbia, the abundance target for the complete Chilliwack River system would be at least

1,200 adult spawners. In the Snohomish-Skykomish and Chester Morse Lake core areas, some downward adjustment was applied to the recovered minimum number, since these core areas historically had habitats that were unlikely to consistently support as many as 1,000 adult spawners annually. It should be noted, however, that recent redd counts in these 2 core areas indicate that the number of spawners likely approaches or exceeds 1,000 adults in some years.

Productivity. A stable or increasing population is a key criterion for recovery. Measures of the trend of a population (the tendency to increase, decrease, or remain stable) include population growth rate or productivity. Estimates of population growth rate (*i.e.*, productivity over the entire life cycle) that indicate a population is consistently failing to replace itself ($\lambda < 1.0$) indicate an increased risk of extinction. Therefore, the reproductive rate should indicate that the population is at least replacing itself, or growing ($\lambda \geq 1.0$) to be considered recovered.

Since estimates of the total population size are rarely available, the productivity or population growth rate is usually estimated from temporal trends in indices of abundance at a particular life stage. For example, redd counts are often used as an index of a spawning adult population. The direction and magnitude of a trend in the index can be used as a surrogate for the growth rate of the entire population. For instance, a downward trend in an abundance indicator may signal the need for increased protection, regardless of the actual size of the population. A population that is below recovered abundance levels, but that is moving toward recovery, would be expected to exhibit an increasing trend in the indicator.

The population growth rate is an indicator of probability of extinction. This probability cannot be measured directly, but it can be estimated as the consequence of the population growth rate and the variability in that rate. For a population to be considered viable, its natural productivity should be sufficient for the population to replace itself from generation to generation. Evaluations of population status will also have to take into account uncertainty in estimates of population growth rate or productivity. For a population to contribute to recovery, its growth rate must indicate that the population is stable or increasing for a period of time. Because the trend status is unknown due to lack of data, bull trout populations in the Chilliwack, Nooksack, Upper Skagit, Stillaguamish, Chester Morse Lake, and Puyallup core areas are considered at an increased risk until sufficient information is collected to properly assess their productivity. Significant increases in abundance for the past three years in the Chester Morse Lake core area, suggest that this core area is at a lower risk. However, additional years of trend data are needed to confirm this. In contrast, bull trout in the Lower Skagit and the Snohomish-Skykomish core areas are at a diminished threat due to long-term redd counts that indicate increasing population trends.

Connectivity. The presence of the migratory life history form within the Puget Sound Management Unit was used as an indicator of the functional connectivity of the unit. If the migratory life form was absent, or if the migratory form is present but local populations lack connectivity, the core area was considered to be at increased risk. If the migratory life form persists in at least some local populations, with partial ability to connect with other local populations, the core area was judged to be at intermediate risk. Finally, if the migratory life form was present in all or nearly all local populations, and had the ability to connect with other local populations, the core area was considered to be at diminished risk.

Migratory bull trout likely persist in most local populations in the Chilliwack, Lower Skagit, Upper Skagit, Stillaguamish, Snohomish-Skykomish, and Chester Morse Lake core areas, so these areas are considered to be at a diminished risk. Although the Lower and Upper Skagit core areas are generally considered to be at diminished risk, there are three areas within the Skagit River that have very poor connectivity with other local populations and remain a concern. These are Diablo Lake (Upper Skagit) which supports a single local population of migratory bull trout, and Gorge Lake (Lower Skagit core area) which has one potential local population. If connectivity between the Diablo Lake system and the rest of the Upper Skagit core area cannot be adequately restored at Ross Dam, the establishment of additional local populations will likely be needed to help ensure that the Diablo Lake system can persist as an independent core area. Bull trout within the Gorge Lake system are generally isolated from other local populations except for potential one way migration during spill events. If connectivity cannot be adequately restored at Gorge Dam, establishment of the Stetattle Creek potential local population will be critical if these bull trout are determined to be genetically unique. Current connectivity of the Baker Lake local population with the rest of the Lower Skagit core area is also a concern. To ensure persistence of this local population, and to maintain overall distribution within the core area, further evaluation of providing improved connectivity (two-way fish passage) at the Baker Lake Hydroelectric complex is required. In the Nooksack core area, there is connectivity among most local populations, with the exception of the Middle Fork Nooksack River (City of Bellingham Diversion). Based on poor fish passage in the Middle Fork Nooksack River and the presence of road culvert barriers in several local populations, this core area is believed to be at intermediate risk with respect to connectivity. Although migratory bull trout may persist in some local populations in the Puyallup core area, and although connectivity between the upper Puyallup and Mowich Rivers local population with other local populations has been recently improved, there have been very low numbers of migratory fish passing at the Buckley Diversion, placing this core area at an intermediate risk. The low abundance of the migratory life history forms limits the possibility for genetic exchange and local population reestablishment.

Recovery Targets for the Puget Sound Management Unit

As noted in Part I of this plan, recovery and delisting can only occur at the level of the listed entity. Consideration of delisting will depend upon attainment of the recovery criteria for bull trout across their range within the coterminous United States, as currently listed, or at the level of the distinct population segment as a whole should that population segment be found to meet the definition of a distinct population segment under a formal regulatory rulemaking process. For the purposes of recovery planning, we have defined recovery criteria for the delisting of the Coastal-Puget Sound Distinct Population Segment as currently delineated. Although this population segment has been divided into two management units, these units are not eligible to be considered separately for delisting (a management unit is not a listed entity). We have therefore set recovery targets for each of the management units within the Coastal-Puget Sound Distinct Population Segment. These recovery targets reflect the recovery criteria measurement parameters identified for the entire distinct population segment, and reflect our best estimation as to how the recovery criteria can be met, working on recovery at the level of the management unit. We recognize that different configurations may be feasible and we welcome suggestions on alternative targets which can achieve recovery at the level of the distinct population segment.

This recovery plan presents recovery targets for the Puget Sound Management Unit only; recovery targets for the Olympia Peninsula Management Unit are presented separately in Volume II of the recovery plan for the Coastal-Puget Sound Distinct Population Segment of bull trout.

Recovery targets for the Puget Sound Management Unit:

1. **Maintain or expand the current distribution of bull trout in the eight identified core areas[5].** The 57 currently identified local populations (Chilliwack (3), Nooksack (10), Lower Skagit (19), Upper Skagit (8), Stillaguamish (4), Snohomish-Skykomish (4), Chester Morse Lake (4), and Puyallup (5)) will be used as a measure of broadly distributed spawning and rearing habitat within these core areas. In addition, distribution within the five identified potential local populations should be confirmed or restored.

   As noted above, the migratory life history form currently comprises the majority of bull trout in these core areas.

   For recovery to occur, the distribution of these migratory local populations should be maintained, while abundance is increased. However, it should be noted that the number and location of existing local populations is used here as a rough surrogate to reflect what the overall distribution in a core area should look like in the future. In accordance with metapopulation dynamics, it is possible that there may be natural shifts in the numbers or locations of local populations that contribute to the

[5]This criterion applies only to United States waters within this management unit.

function of the metapopulation as a whole. We anticipate that some local populations could be extirpated, others could be established, others could be subdivided with new genetics information, and the distinction between others could fade as barriers to movement are addressed. This criterion must therefore be applied with enough flexibility to allow for adaptive changes in the list of local populations (both additions and subtractions), based on best available science, as additional information concerning population and genetic inventory is gathered. The designation of local populations is based on survey data and the professional judgement of Puget Sound Recovery Team members. Further genetic studies are needed in order to more accurately delineate local populations and quantify spawning site fidelity and straying rates. Additional local populations may be added to this total as additional information is gathered in areas outside the currently designated core areas for this management unit, or if new data indicates currently identified local populations should be further subdivided.

We recognize that stochastic events or deterministic processes already occurring could negatively affect distribution in some cases. The significance of such losses in distribution in ultimately determining whether or not distribution criteria have been met needs to be judged on a case-by-case basis. Maintaining the distribution of bull trout in the British Columbia portion of the Chilliwack (seven local populations) and Upper Skagit core areas (seven local populations) is equally essential, although not covered under the jurisdiction of this plan.

2. **Achieve minimum estimated abundance of at least 10,800 adult bull trout spawners among all core areas in the Puget Sound Management Unit. In each of the core areas, the total adult bull trout abundance, distributed among local populations, typically must exceed 1,000 fish.** Recovered abundance targets for the Chilliwack (600), Nooksack (2,000), Lower Skagit (3,800), Upper Skagit (1,400), Stillaguamish (1,000), Snohomish-Skykomish (500), Chester Morse Lake (500), and Puyallup

(1,000) core areas were derived using a combination of available data sets, the population guidance discussed earlier, the professional judgement of the recovery team, and estimation of the productive capacity of identified local populations. Resident life history forms are not included in this estimate, but are considered a research need. As more data is collected, recovered population estimates will be revised to more accurately reflect both the migratory and resident life history components. The recovery team has initially set abundance targets conservatively if there was limited available information. These will likely be revised as new information becomes available.

3. **Restore adult bull trout to exhibit stable or increasing trends in abundance at or above the recovered abundance target level within the core areas in the Puget Sound Management Unit, based on 10 to 15 years (representing at least 2 bull trout generations) of monitoring data. (Note: generation time varies with demographic variables such as age at maturity, fecundity, frequency of spawning, and longevity, but typically falls in the range of 5 to 8 years for a single bull trout generation).** Productivity criteria are met when adult bull trout exhibit a stable or increasing trend for at least two generations at or above the recovered abundance target level within the Chilliwack, Nooksack, Lower Skagit, Upper Skagit, Stillaguamish, Snohomish-Skykomish, Chester Morse, and Puyallup Core Areas. The development of a standardized monitoring and evaluation program which would accurately describe trends in bull trout abundance is identified as a priority research need. As part of the overall recovery effort, we will take the lead in addressing this research need by forming a multi-agency technical team to develop protocols necessary to evaluate trends in bull trout populations.

4. **Restore connectivity by identifying and addressing specific existing and potential barriers to bull trout movement in the Puget Sound Management Unit.** Connectivity criteria will be met when intact migratory corridors are present among all local populations within each core area, thus providing opportunity for genetic exchange and life history diversity. Several man-made barriers to bull trout migration exist within

the management unit, and this recovery plan recommends actions to identify, assess, and reduce barriers to bull trout passage. Although achieving criteria 1 through 3 is expected to depend on providing passage at barriers (including barriers due to physical obstructions, unsuitable habitat, and water quality) throughout all core areas in the management unit, the intent of this criterion is to note specific barriers to correct or actions that must be performed to achieve recovery.

Known passage barriers include the Bellingham Diversion (Nooksack core area), Gorge Dam (Lower Skagit core area), and Ross Dam (Upper Skagit core area). Connectivity must be restored above the Bellingham Diversion to allow the Upper Middle Fork Nooksack River local population to fully express the fluvial and/or anadromous migratory life histories and to provide access to primary foraging, migration, and overwintering habitats (both freshwater and marine). Connectivity is also necessary to reduce the risk of local extirpation and allow potential genetic exchange with the rest of the Nooksack core area. The need for passage must be evaluated at Gorge and Ross Dams. Should passage be determined unfeasible at Gorge and Ross Dams, additional recovery measures may be needed to maintain persistence of the local population (Thunder Creek in Diablo Lake) and potential local population (Stetattle Creek in Gorge Lake) isolated by these facilities. Passage improvement must be addressed at the Baker River dams (Lower Skagit core area), and at the Electron and Buckley Diversions (Puyallup core area). Assess effectiveness of passage for bull trout at the Tacoma Headworks diversion dam and Howard Hansen Dam (Lower Green River foraging, migration, and overwintering habitat) once fish passage facilities are completed at both dams, as part of evaluating the potential to establish or reestablish an additional core area in south Puget Sound. An additional core area in this region would help secure distribution in the southern part of the management unit. In the management unit as a whole, any proposed hydropower facilities or diversions must provide adequate two-way fish passage for all impacted bull trout life stages.

The development of criteria and specific actions necessary for remaining connectivity needs will be implemented as the necessary information becomes available. Actions that will be needed following the identification and assessment of specific problem areas include eliminating or minimizing entrainment at diversions and ditches (actions 1.2.1), providing adequate fish passage around diversions and dams (1.2.2), eliminating culvert barriers (action 1.2.3), and improving instream flows (1.1.11 and 1.4.2). Substantial gains in reconnecting fragmented habitat may be achieved in Nooksack, Lower Skagit, Stillaguamish, Snohomish-Skykomish, and Puyallup core areas by restoring passage over or around many types of barriers that are typically located on smaller streams, including road crossings, culverts, and water diversions.

The known barriers are listed above and in the Recovery Measures Narrative section of this plan, but many (*e.g.*, culverts) have not yet been identified or have not yet been addressed. However, they are collectively important to recovery. Actions to identify and assess barriers to bull trout passage are recommended in this recovery plan and appropriate actions must be implemented. A list of all such artificial barriers should be prepared in the first 5 years of implementation, and prioritized so that highest priority is directed towards providing access to potential spawning and rearing habitat in local populations, followed by providing access to additional foraging habitats. Substantial progress must be made in providing passage at a significant number of these sites to meet the bull trout recovery targets for connectivity.

Recovery targets for the Puget Sound Management Unit were established to assess whether recovery actions are resulting in the recovery of bull trout. The Puget Sound Recovery Team expects that the recovery process will be dynamic and will be refined as more information becomes available.

Research Needs

Based on the best scientific information available, the Puget Sound Recovery Team has identified recovery targets and actions necessary for recovery of bull trout within the management unit. However, the recovery team recognizes that uncertainties exist regarding bull trout population abundance, distribution, and actions needed to achieve recovery. The recovery team feels that if effective management and recovery are to occur, the recovery plan for the Puget Sound Management Unit must be viewed as a "living" document, which will be updated as new information becomes available. The recovery team will rely on adaptive management to guide recovery implementation. Adaptive management is a continuing process of planning, monitoring, evaluating management actions, and research. Adaptive management will involve a broad spectrum of user groups and will lay the framework for decision-making relative to recovery implementation and ultimately the possible revision of recovery targets in this management unit. As a part of this adaptive management approach, the recovery team has identified research needs that are essential within the management unit. The research needs are listed by priority and, where applicable, in order of sequence.

Population Structure. The Puget Sound Recovery Team recommends that studies be initiated to more precisely describe the genetic makeup of bull trout within management unit core areas. This information would be essential for a more complete understanding of bull trout interactions and population dynamics within the management unit. Additional information on population structure would greatly assist in further refining or revising (confirming, splitting, or combining) the currently identified local populations within core areas, and potentially the core areas themselves. This will require a comprehensive and coordinated sampling effort within all identified local populations.

Distribution, Abundance, and Productivity in Core Areas. A high priority goal for the Puget Sound Management Unit is to acquire more complete information on the current distribution and abundance of bull trout within each core area. This effort will require the application of a scientifically accepted protocol such as that described in the draft Protocol for Determining Bull Trout Presence (Peterson *et al.* 2002), which is currently being evaluated by the Western Division of the American Fisheries Society. The American Fisheries Society protocol consists of standardized and statistically rigorous methods for determining the distribution of juvenile bull trout. Other bull trout or fish survey protocols are available and may be considered in this effort. The Washington Department of Fish and Wildlife developed an earlier guide for sampling the distribution and abundance of bull trout (Bonar *et al.* 1997). These or similar protocols will likely require modification for some areas of the Puget Sound Management Unit due to the physical characteristics of some bull trout spawning streams (*e.g.*, larger stream width and depth, high levels of glacial turbidity).

It is critical that representative spawning index reaches or other appropriate surrogates are developed soon for all core areas to adequately monitor changes in population abundance and productivity. Index reaches have only been established for the Lower Skagit, Snohomish-Skykomish, and Chester Morse core areas.

Key Habitat Features Requiring Protection, Restoration, and Enhancement. Additional research is needed to identify key habitat features and limiting factors with greater precision for bull trout in both freshwater and marine habitats to ensure that habitat protection, restoration, and enhancement activities address critical limiting factors. Priorities include identification of key groundwater sources, hyporheic† areas, and other cold water refugia; better information on the rates and locations of exposure to and sublethal effects of various environmental contaminants; identification of required water temperature regimes in river reaches used for foraging and migration; and identification of key habitat features in mainstem migratory corridors and overwintering areas.

Marine and Estuarine Habitat Use. Bull trout's complete use of estuarine and marine waters are unknown. The marine and estuarine residency period for bull trout is poorly understood, as are complete habitat preferences and complete foraging requirements. Our current understanding of bull trout estuarine and marine use is based on limited observational data, ongoing research projects, and inferences drawn from work conducted on similar species outside the management unit (*e.g.* Dolly Varden). To adequately protect, conserve, and restore estuarine and marine habitats that can support bull trout, research is needed to determine the species' full range of habitat preferences (*e.g.*, depth, salinity, bottom types, foraging habitats). Available information indicates bull trout use primarily nearshore waters, however this use may be biased due to the limitations of sampling in deeper more offshore locations. Based on a limited amount of diet analysis, we do know that in addition to juvenile salmonids, a number of small marine forage fish species are critical to bull trout in estuarine and marine waters (*i.e.*, surf smelt, sandlance, Pacific herring) (WDFW *et al*. 1997), making the protection of key forage fish habitats critical to the recovery of bull trout. It is critical to determine if there are other species, such as specific invertebrates or other estuarine and marine fish, that are also important forage items either in certain feeding areas or to particular bull trout life stages. It is also crucial to better understand the relationship between these essential prey resources and the habitats which support their production and distribution. The processes which build and sustain nearshore habitats are highly susceptible to human impacts, such as bulkheads and other shoreline armoring, which separate beaches from the bluffs which feed them.

Impacts of Fisheries on Bull Trout. Additional information is needed regarding the extent of incidental mortality of bull trout in State recreational and commercial fisheries and Tribal fisheries. These fisheries may impact the largest fish, and core areas with popular recreational fisheries or important Tribal salmon fisheries may be experiencing significant incidental bull trout mortalities.

Monitoring fishing effort and catch is needed from a representative sample of rivers and marine areas throughout the management unit area. Better estimates of bull trout catches are also needed throughout the year. Catch rates for bull trout may be highest during the summer months, but there is substantially more fishing effort on rivers during the fall and winter salmon and steelhead fisheries.

It is unclear whether there is an impact by recreational anglers during the bull trout spawning period. Many spawning areas are high upstream in watersheds, and access may be difficult during the late fall and winter when conditions are poor for hiking. Staging and spawning areas and the timing of these events should be identified to determine what impact recreational fishing could have on bull trout staging and spawning.

Additional information is needed to assess hooking and handling mortality when bull trout are caught and released. While there is considerable information in the literature regarding catch-and-release mortality for trout, there is very little comparable data for bull trout or Dolly Varden. Mortality rates for bull trout caught and released are needed by gear types (barbed versus barbless hooks, single versus treble hooks, and hook size), water temperatures, and bait versus artificial lures. Differences in handling stress and mortality are also needed for bull trout caught in lakes, especially those caught and released by trolling. In addition, specific mortality rates are needed by life stage (juveniles, prespawners, and postspawners).

Monitoring non-Tribal commercial and Tribal gill-net harvest impacts to bull trout is needed to determine the level of impact on bull trout populations. In addition, research may be needed to develop alternative methods for salmon gill-net fisheries, such as adjusting net mesh sizes and/or duration and placement of nets to minimize accidental capture and incidental mortality of bull trout.

Migratory Timing and Patterns of Anadromous Life History Form. Based primarily on Kraemer's (1994) Skagit River work, it is believed that bull trout juveniles generally migrate to the estuary from March to August with most migration occurring between late April through early June (Lummi Nation, *in litt*. 2003; WDFW, *in litt*. 2003) and then re-enter the river from August through November. Subadults.(fish that are not sexually mature but have already entered marine waters) are thought to move between the lower river and estuary throughout the year, but primarily overwinter in freshwater. Most adult fish are believed to enter the estuary in February and March and leave the estuary between May and June to migrate upstream to their spawning grounds. Although the rough timing of migrations to and from marine waters is known, additional research is needed to more precisely understand peak migration timing of various life stages, determine if this timing is the same for all core areas, and determine migration patterns and migratory routes. Additional efforts are needed to help clarify the extent of marine foraging migrations throughout Puget Sound. Most efforts to date have focused on eastern Puget Sound shorelines, which have helped increase our knowledge of marine distribution of bull trout in parts of this area; however, there are significant gaps in our current understanding of the level and frequency of use along the west and south Puget Sound shorelines, and various island shorelines (*e.g.*, Vashon, Whidbey, San Juans). Although bull trout have been documented moving between major river basins via marine waters, the patterns and extent of these migrations are not well known. Recent efforts in the

Snohomish River have begun to study this behavior more closely (USACOE, *in litt.* 2002). Research should focus on elucidating the marine movements of bull trout from each of the core areas, between core areas, and potential movement to and from areas outside of the Puget Sound Management Unit. It is likely that anadromous populations close to the Canadian border make migrations to coastal streams in British Columbia to forage, but this has not been confirmed. Additional research efforts should be conducted to determine if movements occur between the Puget Sound and Olympic Peninsula Management Units.

Monitoring and Assessment Program. This draft recovery plan is the first step in the planning process for bull trout recovery in the Puget Sound Management Unit. The recovery team identified the need to develop a standardized monitoring and assessment program to more accurately describe the current status of bull trout within the management unit, as well as to identify sampling protocols to allow monitoring of recovery action effectiveness. We will take the lead in developing a comprehensive monitoring approach that will provide guidance and consistency in evaluating bull trout populations. Evaluating implementation and monitoring effectiveness of recommended actions will be an important component in the application of adaptive management in recovery implementation. Monitoring and evaluation of population levels and distribution will be an important component of any adaptive management approach.

Potential Use of the Nisqually and Green Rivers. Although historical accounts indicate a much greater use of the Nisqually and Green River watersheds by bull trout in the past, current use appears to be very limited. Today, low numbers of bull trout appear to use these systems primarily for foraging and potentially overwintering. Given that current abundance and distribution are very limited in the southern portion of the Puget Sound Management Unit, the establishment of an additional spawning population in this area would significantly help reduce the risk of local extirpation and loss in distribution. Although the upper Green River was historically accessible to migratory bull trout, there is no information regarding past bull trout use of the upper watershed. An evaluation of water temperature regime will be critical to determine if bull trout spawning and incubation would be successful in this part of the watershed if passage were restored. Although historical access to the upper Nisqually River watershed remains uncertain, stream temperatures in the upper part of the watershed have a high likelihood of being adequate for successful bull trout spawning and rearing due to their glacial nature. It is currently undetermined whether a small remnant population may still exist somewhere in the upper (and/or perhaps lower) watershed, since stream conditions make fish surveys in this area difficult.

RECOVERY ACTIONS

Structure of the Recovery Measures Narrative Outline

The recovery measures narrative outline consists of a hierarchical listing of actions needed to achieve the recovery of bull trout in the Puget Sound Management Unit. The first tier entries represent general recovery actions under which specific (*e.g.*, second and third tier) actions appear as appropriate. Second tier entries represent general recovery actions under which more specific actions may appear. Second tier actions that do not include specific third tier actions are usually programmatic activities that are not specific to this management unit, but that have been identified as applicable across the species' range; they appear in *italic type*. These actions may or may not have third tier actions associated with them. Third tier entries are actions specific to the Puget Sound Management Unit. These third tier entries appear in the implementation schedule that follows this section and are identified in the narrative outline by three levels of numerals separated by periods (*e.g*., 2.1.1)

The Puget Sound Management Unit volume of the recovery plan should be updated or revised as recovery actions are accomplished, or revised as environmental conditions change, and monitoring results or additional information become available. Revisions to the Puget Sound Management Unit recovery plan will likely focus on priority streams or stream segments within core areas where restoration activities have taken place and habitat or bull trout populations have shown a positive response. The Puget Sound Recovery Team should meet annually to prioritize recovery activities, review annual monitoring reports and summaries, and make recommendations to us.

Working with Federal, State, Tribal, and private entities, and in coordination with local governments, we need to secure quality habitat conditions for bull trout. These efforts should be coordinated with ongoing NOAA Fisheries and other salmon recovery actions to avoid duplication in planning and implementation.

In the Coastal-Puget Sound Distinct Population Segment, the Puget Sound and Olympic Peninsula Recovery Teams developed specific actions to remove the threats to bull trout in their respective management units. While there is general overlap for some actions between the two management units, other actions are specific to each management unit.

Appendix 2 provides a summary table linking the actions (third tier actions) needed for recovery with the reasons for decline (threat categories).

Recovery Actions Narrative Outline

1. Protect, restore, and maintain suitable habitat conditions for bull trout.

    1.1 Maintain or improve water quality in bull trout core areas or potential core habitat.

        1.1.1 Identify and improve or remove unstable or problem roads causing sediment delivery. Use existing information from State, Tribal, and U.S. Forest Service surveys and watershed analyses, Water Resource Inventory Area's habitat limiting factors analyses, Washington Department of Natural Resources' slope stability prediction model, local subbasin road inventories and assessments, and Water Resource Inventory Area's Ecosystem Diagnostic Treatment modeling to identify problem roads (*e.g.*, roads with deep fills and undersized cross drains, inadequate cross drain spacing, and sidecast with potential to deliver or route sediment to streams). Stabilize roads, crossings, and other road-related sources of sediment delivery to streams, with a primary focus on bull trout spawning and rearing areas (local populations). Secondary focus would be on foraging, migration, and overwintering areas. Reduce forest road density. Known priority areas include North, Middle and South Forks Nooksack River, especially roads in drainages with history of debris flows (Nooksack core area); Illabot Creek, South Fork Sauk River (Lower Skagit core area); North and South Forks Skykomish River (Snohomish-Skykomish core area); Canyon Creek, Deer Creek, Upper South and North Fork Stillaguamish River, and Boulder River (Stillaguamish core area); Upper Cedar River (Chester Morse Lake core area); Upper Puyallup and Carbon River drainages (Puyallup core area). Secondary priority areas include the Pilchuck, Wallace, Tolt and Snoqualmie drainages (Snohomish-Skykomish core area).

1.1.2 Improve routine road maintenance practices affecting water quality. Some road maintenance practices have been identified as adversely affecting bull trout habitat where maintenance occurs on roads next to or near streams. Implement improved road maintenance protocols on all Federal, State, County, private, and city managed roads throughout Puget Sound core areas to avoid and minimize, sediment and contaminant input (*e.g.*, oil and grease, heavy metals, pesticides), riparian damage, and identify and correct fish passage barriers. Focus on inspecting roads and cross drains annually and during storm events, particularly those that have a history of sedimentation problems, those adjacent to streams, and all roads within drainages that have spawning and rearing habitat in core areas. High priority areas to initially focus efforts include Monte Cristo Road (Lower Skagit core area); South Fork Stillaguamish Sunrise Mine Road (Stillaguamish core area); Carbon River Road (Puyallup core area); and all forest roads in local populations.

1.1.3 Implement measures to restore natural thermal regime. Assess and eliminate or attempt to mitigate thermal effects on bull trout from temperature increases (non-point sources) that negatively impact receiving waters in spawning and rearing areas and in migratory corridors and foraging areas. Use Water Resource Inventory Area's habitat limiting factors analyses, Washington Department of Ecology's 303(d) lists, and Water Resource Inventory Area's Ecosystem Diagnostic Treatment modeling to help prioritize areas. Primary focus is on the following local population areas: Lower South Fork Nooksack River and spawning and rearing tributaries to it, non-glacial spawning and rearing tributaries to North and Middle Fork Nooksack Rivers (Nooksack core area); North and South Forks of Stillaguamish River, Deer Creek (Stillaguamish core area); North and South Forks Skykomish River (Snohomish-Skykomish core area); and Greenwater and Clearwater Rivers (Puyallup core area). Efforts should also focus on foraging, migration and overwintering habitats, including the lower South Fork Nooksack River and tributaries, mainstem Nooksack River and tributaries, and Lower North Fork tributaries (Nooksack core area); Pilchuck, Wallace, Tolt and Snoqualmie drainages (Snohomish-Skykomish core area); Samammish and Lower Cedar Rivers (Lake Washington foraging, migration, and overwintering habitat); and Green River (Lower Green River foraging migration and overwintering habitat).

1.1.4 Reduce anthropogenic nutrient input. Reduce anthropogenic related nutrient delivery throughout the Puget Sound basin by improving sewage treatment and disposal, agriculture practices (*e.g.*, manure spreading, fertilizing), and silvicultural fertilizing practices. Develop ways to reduce negative impacts from the residential use of fertilizers.

1.1.5 Encourage the uptake of marine-derived nutrients from salmon carcasses into the freshwater ecosystem. This needs to be a basinwide effort with focus on the physical process to trap and cycle the nutrients into the freshwater environment, including riparian zones. This is facilitated by two processes: 1) the hauling of carcasses up into the riparian zone by animals (mammals and birds), and 2) the reestablishment of complex stream channels (braided channels or side channels, large woody debris incorporated into the channel structure, etc.) to trap and retain the carcasses. Explore the potential to modify salmon harvest management (see action 3.1.3) to assure a more consistent and large spawning escapement[†] of salmon to all core areas with anadromous bull trout populations, especially pink and chum salmon which seem to provide the largest benefit to char. Also conduct hatchery salmon carcass deployment efforts where appropriate.

1.1.6 Monitor water quality and meet water quality standards for temperature, nutrient loading, dissolved oxygen, and contaminants. Implement additional water temperature monitoring on State, Federal, Tribal, County, City, and private lands. Identify and correct causes of temperature exceedences (*e.g.*, riparian changes, hydrologic changes, debris flows) in bull trout spawning, rearing, foraging and migratory habitat. Evaluate current minimum forest practice regulations for sufficiency in maintaining adequate riparian shading for maintaining water quality standards. Increase monitoring and enforcement of water quality standards and implement the Total Maximum Daily Load program. Water quality is an acute problem in many of the lower basin tributaries of most core areas, and in some mainstem areas including South Fork and Middle Fork Nooksack Rivers, mainstem Nooksack River, Cornell, Gallop, Boulder, Racehorse, Canyon Lake, Howard, Clearwater, Anderson, Tenmile, Deer, Fishtrap, Bertrand, and Kamm Creeks, and Double and Duffner Ditches (Nooksack core area); North Fork Stillaguamish and Deer Creek (Stillaguamish core area); French and Allen Creeks (Snohomish-Skykomish core area); Greenwater, Clearwater, and White Rivers (Puyallup core area).

1.1.7 Identify, restore, and protect groundwater and hyporheic sources. Identify, restore, and protect groundwater and hyporheic sources and cold water refugia in local populations and in migratory and foraging habitats. Where forward looking infrared flights have occurred, protect identified refugia areas from ground or surface water withdrawals, and prioritize these areas for instream habitat improvements. Highest priorities for protection are those sources located in local and potential local populations and in critical migratory corridors and foraging areas, especially those that currently exceed water quality standards or have acute, chronic temperature problems. These include: South Fork, Middle Fork, and Lower Nooksack River (Nooksack core area); Stillaguamish River (Stillaguamish core area); Green River (Lower Green River foraging, migration, and overwintering habitat); White River, Clearwater and Greenwater River (Puyallup core area); and Nisqually River (Lower Nisqually foraging, migration, and overwintering habitat).

1.1.8 Reduce anthropogenic sediment and contaminant sources generated from agriculture practices. Identify and reduce fine sediment and contaminant sources (pesticides) from agriculture practices in watersheds of the Puget Sound Management Unit. Monitor effectiveness of sediment reduction projects. Highest priority areas include where agriculture exists above or adjacent to spawning and juvenile rearing habitats within core areas. Secondary priorities include mainstems and associated tributaries that provide foraging, migration, and postdispersal rearing. The Nooksack, Lower Skagit, Stillaguamish, Snohomish-Skykomish, and Puyallup core areas all have substantial agricultural use in lowland settings.

1.1.9 Reduce anthropogenic sediment sources generated from forest management. Identify and reduce coarse and fine sediment sources from forest management practices in watersheds of the Puget Sound Management Unit. Protect unstable slopes from timber harvest where there is potential for sediment delivery to downstream bull trout waters. Ensure that landslide frequencies and magnitudes approach natural background levels. Monitor effectiveness of sediment reduction projects. Where unstable slopes have the potential to deliver large woody debris to bull trout waters and adjacent riparian areas, leave trees to provide future sources of large wood and to attenuate sediment delivery. Priorities include timber management areas above or adjacent to core area spawning and rearing areas, particularly those that are inherently geologically unstable including areas in the Nooksack core area; Illabot Creek, Lower Cascade River, White Chuck River, Lower Bacon Creek in the Lower Skagit core area; Deer Creek, Canyon Creek, and South Fork Stillaguamish River in the Stillaguamish core area; Upper Mowich and Puyallup Rivers in the Puyallup core area.

1.1.10 Reduce anthropogenic sediment and contaminant sources generated from residential development and urbanization. Identify and reduce fine sediment and contaminant sources (including stormwater runoff, non-point source pollutants, and wastewater discharges) from residential and urban developments in watersheds of the Puget Sound Management Unit. Monitor effectiveness of sediment and contaminant reduction projects. Highest priority is where development and urbanization occur above or adjacent to spawning and rearing areas, and where it occurs adjacent to critical foraging, migration, and overwintering habitats. Most sources are currently adjacent to or upstream of mainstem rivers, estuaries, nearshore habitats and foraging tributaries. A reduction in sediment and contaminant sources within these waters is important due to potential sublethal effects on migratory and foraging bull trout, and potential lethal and sublethal impacts on bull trout prey species.

1.1.11 Maintain and improve instream flows. Ensure that minimum instream flows as established by Washington Department of Ecology or those required by other agreements or licenses, whichever is higher, are maintained. Locate and terminate unpermitted water withdrawals to restore adequate instream flows and prevent potential entrainment of juvenile bull trout. Increase compliance monitoring and enforcement of unauthorized withdrawals and enforcement action. Identify stream reaches where decreased instream flows limit bull trout spawning, rearing, foraging, migration, or overwintering and work to improve instream flows to more fully support these uses. Long-term efforts must included addressing overallocated basins or tributaries through water conservation, voluntary purchase or retirement of water rights, education, incentives, and enforcement.

1.2 Identify barriers or sites of entrainment for bull trout and implement actions to provide passage and eliminate entrainment.

1.2.1 Eliminate or minimize entrainment at diversions and ditches. Identify all diversions and artificial (completely manmade) ditches that have the potential to entrain bull trout. Screen all identified diversions and artificial ditches to meet State and Federal fish screen requirements where determined to have significant adverse impacts. Current identified priorities include the Bellingham Diversion, and potentially Excelsior powerhouse outfall/Nooksack Falls (Nooksack core area); Electron Diversion power canal (Puyallup core area); and Masonary Dam intakes (Chester Morse Lake core area).

1.2.2 Provide adequate fish passage around diversions and dams. Provide fish passage around diversions that have reduced population connectivity within watersheds. Diversions and dams currently reduce connectivity among local populations, and block access to potential spawning and juvenile/subadult rearing and foraging habitats. When upstream volitional passage is not feasible, establish protocols for determining when and where to relocate captured fish. Priority areas for restoring or improving local population connectivity include City of Bellingham Diversion (Nooksack core area); Gorge Dam and Baker River Dams (Lower Skagit core area); Ross Dam (Upper Skagit core area) and Buckley Diversion (Puyallup core area). Priority areas for restoring or improving connectivity to juvenile/subadult rearing and foraging habitats include: French Creek, Marshland pumping station, and the diversion dam on the Pilchuck River (Snohomish-Skykomish core area); and Howard Hansen Dam (Lower Green foraging, overwintering, and migration habitat).

1.2.3 Identify and eliminate culvert barriers. Inventory road crossings for blockages to upstream fish passage, and where beneficial to bull trout and other native fish, remove, replace or improve existing culverts that impede passage. Use existing inventories from State, Tribal, County, and

U.S. Forest Service surveys and watershed analyses, Water Resource Inventory Area's habitat limiting factors analyses, and Water Resource Inventory Area's Ecosystem Diagnostic Treatment modeling, and conduct additional inventories where needed to identify key problem culverts. Develop a prioritized program with schedules for barrier culvert removal, replacement, or modification to improve fish passage. Highest priorities for removal, replacement, or modification are in local populations (*e.g.*, Upper North Fork Nooksack [Hedrick, "Powerhouse," "Chainup," Lookout, Boyd, Kenny Creeks]; Upper Middle Fork [Loomis Creek], Lower South Fork [Johnson Creek]; and Upper Puyallup and Mowich River), while secondary priorities are tributaries to foraging, migration, and overwintering habitats.

1.2.4 <u>Identify and eliminate or modify tide gates, pump stations, and flood gates blocking access to bull trout habitat</u>. Inventory all tide gates, pump stations, and flood gates and evaluate the habitat blocked by each structure. Remove or modify those structures that block access to significant rearing and foraging habitats. Priority areas include lower river mainstems in core areas, and estuary and nearshore areas (Skagit, Lummi, Samish, Bellingham Bays) near rivers supporting core populations.

1.2.5 <u>Inform the public about the impacts of recreational barriers to migrating bull trout</u>. Inform the public about the impacts of recreational barriers (rock weirs) to bull trout spawners trying to access spawning grounds. Signs and educational material should be developed, stressing the deconstruction of these structures after their use, to ensure upstream passage of adult bull trout. High priority areas include spawning and rearing areas within proximity to recreational use sites. Known problem areas include South Fork Sauk

(Lower Skagit core area) and North Fork Skykomish River (Snohomish-Skykomish core area).

1.3 Identify impaired stream channel and riparian areas and implement actions to restore their appropriate functions.

1.3.1 Restore and protect riparian areas. Identify impaired riparian areas and restore vegetative cover to provide shade, canopy, riparian cover, and native vegetation. Use results from State, Tribal, and U.S. Forest Service surveys and watershed analyses, basin riparian assessment reports, Water Resource Inventory Area's habitat limiting factors analyses, and Water Resource Inventory Area's Ecosystem Diagnostic Treatment modeling to help identify priority areas. Develop and implement a public awareness campaign regarding the effectiveness and necessity of maintaining and improving riparian areas for supporting salmonids. Focus on how to restore and protect riparian areas. Emphasize restoration of riparian areas by planting native species appropriate to provide shade and functional large woody debris to form and maintain stream habitat. Highest priorities for restoration include impaired riparian areas along streams in identified local populations. Secondary priorities for restoration include riparian areas along tributaries to mainstem migratory, foraging, and overwintering habitats, and riparian areas along lake shorelines. Priority areas for protection include: developing rural areas within identified local populations; and foraging and migration, and overwintering areas with existing high quality habitat or habitat on a trajectory towards recovery.

1.3.2 Identify, evaluate, and restore overwintering habitat in the mainstem rivers and tributaries. In all core areas identify specific overwintering areas used by bull trout in the mainstem rivers and estuaries and classify general overwintering habitat for use, current condition, and restoration potential. Determine where overwintering habitat areas are degraded by factors such as sediment accumulation, bedload movement, or low flows in all core areas. Implement necessary restoration activities as described throughout this section to improve overwintering habitat.

1.3.3 Identify and restore foraging waters with high restoration benefit. Use Water Resource Inventory Area's habitat limiting factors analyses, and Water Resource Inventory Area's Ecosystem Diagnostic Treatment modeling, or conduct additional inventories where needed to select specific areas where restoration of known or potential foraging areas will contribute the most to bull trout recovery. Highest priorities are mainstems downstream of local populations used by anadromous life histories to reach marine habitats. These serve not only for adult migration, but also for subadult and adult foraging, overwintering and holding, and smolt migration. Secondary priorities are larger tributaries to mainstem reaches that now have or have potential for high salmon use.

1.3.4 Reduce stream channel degradation and increase channel complexity. Where feasible remove existing and prevent future bank armoring (bulkheads and riprap) and channel constrictions (*e.g.*, dikes and levees) associated with development and agriculture. Restore connectivity to floodplain. Recreate lost off-channel habitat, and opportunities for off-channel habitat formation through time by protecting channel migration areas from encroachment during new construction or reconstruction of these structures. Priority areas include most lower mainstem rivers in all core areas. Results from completed Water Resource Inventory Area Ecosystem Diagnostic Treatment modeling for Chinook salmon should help establish priorities.

1.3.5 Practice non-intrusive flood control and flood repair activities. Provide technical assistance to Counties, Cities, and private landowners to develop options for fish friendly flood control methods and repair techniques. Ensure that negative effects to bull trout habitat from ongoing flood control activities (*e.g.*, dredging, woody debris removal, channel clearing, hardened bank stabilization, and riparian removal from dikes and levees) are avoided or minimized. Alternatives should emphasize restoration of floodplain connectivity and the elimination or setback of existing armored banks, dikes and levees to restore habitat forming processes. Focus is on the Nooksack, Lower Skagit, Stillaguamish, Snohomish-Skykomish, and Puyallup core areas.

1.3.6 Reduce development impacts on streams, floodplains, and lake shores. Avoid and minimize further development that will constrict or constrain stream channels, degrade riparian areas, negatively impact ground water and surface water interactions, or in any other way degrade stream channel functions. Reduce impacts within floodplains and lake shores through development and implementation of appropriate zoning restrictions, restoration, and targeted acquisition (by Counties, land trusts, etc.) of prioritized lands.

1.3.7 Reduce transportation corridor impacts on streams. Reduce impacts from the legacy of road and railroad encroachment (*e.g.*, sedimentation, channel straightening, channel relocation, channel constriction, and undersized bridges).

Avoid future bank armoring (bulkheads and riprap) and channel constrictions (*e.g.*, dikes, levees, undersized bridges) associated with transportation corridor construction and maintenance and, where necessary and feasible, remove existing bank armoring and channel constrictions to allow natural channel migration and formation of off-channel habitats. Avoid placing roads and bridges on alluvial fans, where channel migration naturally occurs over time. Results from completed Water Resource Inventory Area Ecosystem Diagnostic Treatment modeling for Chinook salmon and available Washington State Department of Transportation Corridor Analyses should help in establishing priorities. Priority areas for action are transportation corridors along most mainstem rivers in core areas, and some areas within local populations. Examples of roads within local populations include: State Route 542 which has impacted Canyon Creek, Glacier Creek, Boulder Creek, and the North Fork Nooksack (Nooksack core area); State Route 20 which has impacted Ruby Creek and Granite Creek (Upper Skagit core area); and State Route 530 which has impacted the North Fork Stillaguamish River (Stillaguamish core area).

1.3.8 Improve grazing practices. Develop, implement, and adaptively manage livestock grazing plans which include actions (*e.g.*, riparian fencing, revegetation, off-channel watering) and performance standards and targets for floodplains, riparian vegetation, and streambanks that protect bull trout habitat and water quality. Focus efforts on the Nooksack, Lower Skagit, Stillaguamish, and Snohomish-Skykomish core areas.

1.3.9 Restore natural stream channel morphology[†]. Conduct stream channel restoration activities if they are likely to be beneficial to bull trout and other native fish, and only where similar results cannot be achieved by other less costly and intrusive means. Current identified priorities in spawning and rearing areas include: Boulder Creek (Chester Morse Lake core area); Canyon, Boulder, Hutchinson Creeks (Nooksack core area); Deer Creek (Stillaguamish core area); and Upper North Fork Skykomish (Snohomish-Skykomish core area). Priorities in foraging, migration, and overwintering areas include "straightened" mainstem river reaches and tributary streams entering mainstem rivers (*e.g.*, South Fork Nooksack River and Fishtrap Creek [Nooksack core area]).

1.3.10 <u>Enhance and restore instream habitat</u>. Increase or enhance instream habitat by restoring habitat diversity. Projects should focus on the enhancement of habitat elements such as large woody debris, log jams, and complex channels in the short-term, and the restoration of processes that support these habitat elements in the long-term. High priorities are mainstem areas identified by the Water Resource Inventory Area's habitat limiting factors analyses, Water Resource Inventory Area's Ecosystem Diagnostic Treatment modeling, and other instream habitat assessments.

1.3.11 <u>Protect riparian and stream channel habitat at managed and unmanaged campgrounds, trail systems, and recreational sites</u>. Develop riparian and stream channel management plans to protect migration, spawning, and rearing habitat adjacent to trail systems (hiking, off- road vehicle, horse), camping, and recreation sites. Relocate campgrounds and trail systems out of riparian areas when necessary to avoid impacts to bull trout habitat. Inventory, close, and restore areas impacted by unauthorized off-road vehicle trails in or adjacent to riparian areas, and close unauthorized stream fords in all core areas. Restore and protect riparian and stream channel habitat along heavily used trails and trail heads, and locate new trails outside of riparian areas.

Currently identified priority campgrounds and trails include: Excelsior Campground (Nooksack core area); Monte Cristo recreational area, Downey Creek Trail (Lower Skagit core area); Sunrise Mine recreational area (Stillaguamish core area); and Troublesome Creek (Snohomish-Skykomish). Currently identified areas for reducing off-road vehicle impacts include Bear Creek Slough complex, Hutchinson, and Racehorse Creeks (Nooksack core area); North Fork Skykomish River (Snohomish-Skykomish core area); and South Fork Sauk River (Lower Skagit core area).

1.4 Operate dams to minimize negative effects on bull trout in reservoirs and downstream.

1.4.1 Reduce reservoir operation impacts. Review dam operation plans (*e.g.*, South Fork Tolt, Baker River, and Spada Dams) for potential impacts on bull trout and their forage base. Continue to evaluate reservoir operational concerns in Chester Morse Lake, and provide operating recommendations if necessary (Chester Morse Lake core area). Evaluate temperature and attraction flow concerns at the Deringer tailrace outlet below Lake Tapps (Puyallup core area).

1.4.2 Provide sufficient instream flow downstream from dams and diversions. Ensure existing instream flows (timing and quantity) are sufficient to support all affected bull trout life stages. Address ramping rates, access, and utilization by bull trout, and changes to benthic invertebrate communities. Priorities for evaluation and modification are Bellingham Diversion (Nooksack core area); Baker River Dams and Gorge Dam (Lower Skagit core area); Diablo and Ross Dams (Upper Skagit core area); and Buckley Diversion and Electron Diversion (Puyallup core area). Ensure instream flows for proposed hydropower projects in bull trout streams are based on migratory bull trout life history rather than life histories of resident cutthroat or rainbow trout. If obsolete facilities are restarted, ensure that improvements are made as needed to prevent entrainment, provide adequate instream flows to support all affected life stages, provide appropriate ramping, and provide tailrace protection (*e.g.*, Excelsior/Nooksack Falls facility).

1.5 Identify upland conditions negatively affecting bull trout habitats and implement actions to restore appropriate functions.

1.5.1 <u>Update and/or review local Forest Service or other watershed analyses</u>. Review management activities and short- and long-term goals for compatibility with bull trout recovery in North Fork Nooksack River, Canyon Creek, Sauk River and Sauk River Forks, South Fork Stillaguamish, Deer Creek, and Carbon River. Review prescriptions in State watershed analyses to ensure they are consistent with bull trout recovery, and reconvene prescription teams as needed to revise them.

1.5.2 <u>Upgrade or decommission existing and potential problem roads</u>. Continue the upgrading or decommissioning of problem roads that adversely affect or have potential to adversely affect bull trout streams. Inventory and decommission orphan road systems. Use road maintenance and abandonment plans required under State forest practices, Water Resource Inventory Area's habitat limiting factors analyses, and results from Water Resource Inventory Area's Ecosystem Diagnostic Treatment modeling to help determine priority roads or segments for decommissioning within each core area. High priorities are orphaned and other roads with demonstrated problems that continue to pose a threat to downstream spawning and rearing areas within local populations. Strive to reduce overall road densities within local populations.

1.5.3 Minimize levels of effective impervious surface from development. Minimize the effects of impervious surfaces by protecting hydrologically mature forest cover† to the maximum extent feasible, and by implementing other low impact development measures. Alternatively, if lacking such forest condition, protect the opportunity to reestablish forest cover by minimizing amount of clearing, buildings, and infrastructure. If reestablishment of forest cover is not possible due to existing high intensity development (*e.g.*, already built-out areas of cities and unincorporated urban growth areas), then require highest levels of stormwater engineering and integrate low impact development measures (*e.g.*, impervious surface removal, roof top gardens) where possible. For rural areas (*i.e.*, lands not in cities or not within unincorporated areas with existing high density development) draining to bull trout foraging, migration and overwintering areas, maintain at least (but preferably more than) 65 percent hydrologically mature forest cover and no more (and preferably much less) than 10 percent effective impervious area. For cities and unincorporated areas with existing high density development, require the highest level of stormwater engineering available. For catchments draining to areas that are used for spawning and early rearing areas, developments should strive for zero percent effective impervious surfaces (*i.e.*, all stormwater should be treated on site to match predevelopment peaks, duration and quality) and at least (but preferably much more than) 65 percent forest cover. Generally, protected forest cover should be contiguous with riparian areas, steep slopes, aquifer recharge areas and wetlands. Accomplish these protections through appropriate zoning and development standards.

1.6 Identify impaired estuarine and nearshore marine habitats and implement actions to restore their appropriate functions.

1.6.1 Identify and remediate contaminant sites in estuarine and nearshore marine areas. Identify estuarine and nearshore marine sites with contaminated sediments and structures (*e.g.*, treated wood piles) that pose a significant exposure risk to bull trout or their forage species, and address contaminant exposure by site capping or other remediation. High priority sites include those in close proximity to known and potential marine forage fish spawning areas and bull trout subadult and adult foraging habitats. High priority locations include Commencement Bay, Lower Duwamish and Elliott Bay, and Bellingham Bay.

1.6.2 Reduce impacts of development and transportation corridors along estuarine and marine shorelines. Reduce impacts along estuarine and marine shorelines by developing appropriate zoning restrictions and through acquisition of lands by Counties, land trusts, etc. Where feasible remove or reduce existing bank armoring (bulkheads and riprap), dikes, in-water and over-water structures (*e.g.*, pilings, docks) to restore or enhance altered shorelines and adjacent riparian areas. Avoid further development that will interfere with natural bluff and beach erosion processes, degrade vegetated intertidal habitats and forage fish spawning areas, or degrade nearshore riparian areas. Ensure measures are in place at all shoreline facilities that will avoid potential release of contaminants into marine waters. Highest priority areas for restoration include those in or in close proximity to known and potential marine forage fish spawning areas and bull trout subadult and adult foraging habitats, especially those directly linked to known core areas. Other high priority areas include nearshore habitats linking core habitats and foraging, migration, and overwintering habitats.

1.6.3 Restore or recreate intertidal foraging habitats in key areas. Restore or recreate intertidal habitat that has been previously altered or destroyed in estuaries and nearshore areas associated with core areas. Priority areas include Bellingham Bay, Lummi Bay, Samish Bay, Skagit Bay, Shilshole Bay, Elliott Bay, and Commencement Bay. Secondary priorities include estuarine areas or mouths of small anadromous salmon streams outside of core areas discharging into Puget Sound.

2. Prevent and reduce negative effects of nonnative fishes and other nonnative taxa on bull trout.

2.1 Develop, implement, and enforce public and private fish stocking policies to reduce stocking of nonnative fish that potentially affect bull trout.

2.1.1 Review and analyze effectiveness of current fish stocking policies. Ensure planting of nonnative fish does not occur in areas that drain into bull trout habitat within core areas. Recommend actions that will prevent or reduce negative impacts to bull trout from nonnative fish stocking, and monitor for increased fishing pressure, alterations to prey base, predation, and competition.

2.2 Evaluate policies for preventing illegal transport and introduction of nonnative fishes.

2.2.1 Review existing enforcement of current policies for preventing illegal transport and introduction of nonnative fishes. Review existing policies for their effectiveness and make changes necessary for improved enforcement.

2.3 Provide information to the public about ecosystem concerns of illegal introductions of nonnative fishes.

2.3.1 Discourage unauthorized fish introductions. Focus an intensive public outreach campaign on the Puget Sound basin to reduce the potential spread of illegally introduced nonnative fish species, especially brook trout and lake trout. Outreach should emphasize ecological consequences of spreading nonnative fish species.

2.4 Evaluate biological, economic, and social effects of control of nonnative fishes.

2.4.1 Review existing protocols for eradicating, suppressing, or managing nonnative fish populations and implement protocols where needed. Conduct research and analysis of existing protocols to determine the most effective methods for suppressing or eradicating nonnative fishes (especially brook trout) where they overlap with bull trout distributions and are negatively impacting bull trout. Evaluate the impact of existing and proposed liberal brook trout limits in the Puget Sound Management Unit on reducing populations and limiting expansion of brook trout.

2.5 Implement control of nonnative fishes where found to be feasible and appropriate.

2.5.1 Determine distribution and abundance of nonnative fish (brook trout and westslope cutthroat trout) and identify overlap with bull trout. Identify distributional overlap using existing stream and fish survey data, conduct surveys in unsurveyed areas, and monitor changes in distribution. Map known brook trout distributions for all core areas. Prioritize local population areas where spawning and rearing has been documented, followed by potential local population areas. Current priorities for brook trout include the Nooksack, Upper Skagit, Snohomish-Skykomish (Foss River), and Puyallup core areas. Current priorities for westslope cutthroat trout include the Lower Skagit (Upper

Baker River and tributaries to Baker Lake) and Stillaguamish core areas (South Fork Stillaguamish and Deer Creek).

2.5.2 Evaluate brook trout impacts to migratory bull trout populations. Evaluate to what extent resident brook trout adversely impact migratory populations of bull trout in the Puget Sound Management Unit. Focus for these efforts should be on the Nooksack, Upper Skagit, and Puyallup core areas.

2.5.3 Experimentally remove established brook trout populations from priority streams. Evaluate opportunities for experimental removal of brook trout in areas where there is a potential problem of competition with bull trout, and in areas where there is a reasonable likelihood for future dispersal into bull trout streams. Where brook trout appear to be expanding in distribution in areas that offer suitable habitat for bull trout, eradication may be required. Efforts should be focused on streams such as Hutchinson Creek, fire pond draining to Upper Howard and Skookum Creeks (Nooksack core area); Hozomeen Creek (Upper Skagit core area); and Upper Carbon River tributaries (Puyallup core area).

2.6 Develop actions to reduce negative effects of nonnative taxa on bull trout.

2.6.1 Remove invasive nonnative plants that are limiting the effectiveness of riparian areas and restore with native vegetation. Remove nonnative plants (*e.g.*, reed canary grass, Japanese knotweed) that are limiting the effectiveness of riparian areas and altering channel conditions along bull trout streams. Develop and implement measures to prevent their spread into other areas. Identified priorities include Nooksack, Lower Skagit, and Stillaguamish core areas.

2.6.2 Continue control of *Spartina* in estuarine and nearshore areas. Continue ongoing *Spartina* (cord grass) control in estuarine and nearshore areas. Ensure methods are compatible with bull trout recovery. High priorities include Padilla Bay, Skagit Bay, Port Susan Bay, and Camano Island and Whidbey Island nearshore areas.

3. Establish fisheries management goals and objectives for compatibility with bull trout recovery, and implement practices to achieve goals.

3.1 Develop and implement State and Tribal native fish management plans integrating adaptive research.

3.1.1 Integrate research and monitoring results into native fish management plans and related information resources. Update native fish management plans [*e.g.*, bull trout/Dolly Varden Management Plan (WDFW 2000b), Salmonid Stock Inventory (SaSI) appendix for bull trout and Dolly Varden (WDFW 1998), Wild Salmonid Policy (WDFW 1997), Washington Department of Fish and Wildlife's spawn survey database] with the latest results from bull trout research and monitoring including distribution and population status. Develop and implement native fish management plans that emphasize timely integration of research results into management programs.

3.1.2 Protect remaining bull trout strongholds and native species complexes. Protect integrity of areas with intact native species assemblages *(e.g.*, upper Skagit River, upper North Fork Skykomish River, upper Cedar River). Identify and maintain these complexes with appropriate management and methods. Management actions that protect intact anadromous salmon complexes will benefit bull trout by maintaining the prey base and preserving habitat for cold water salmonids. Large abundances of pink and chum salmon are of particular benefit to bull trout. These salmon species not only supply nutrients to the freshwater environment, but they also supply loose eggs (dislodged during mass spawning) in the fall and large abundances of fry in the spring that are direct food sources for bull trout.

3.1.3 Provide increased forage opportunities in freshwater. Establish improved forage opportunities by managing for increased salmon escapement complimentary to related habitat improvements to increase salmon productivity and abundance. Priority watersheds include the Nooksack, Stillaguamish, and Puyallup core areas.

3.1.4 Increase biomass of marine forage base. Improve marine prey base (*e.g.*, surf smelt, sandlance, herring) known to be important to bull trout through appropriate forage fish habitat protection and management measures.

3.2 Evaluate and prevent overharvest and incidental angling mortality of bull trout.

3.2.1 Evaluate the impacts of harvest on bull trout populations. Track changes in population characteristics (abundance, life histories, age structure, etc.) to assess the impacts of angling mortality from recreational bull trout fisheries in the Lower Skagit and Snohomish-Skykomish core areas. Ensure recovery objectives for individual core areas are not compromised by current harvest strategies. Maintain repeat spawning levels (measured as the percent of adult migratory spawners over 508 millimeters [20 inches]) at 50 percent or more annually. Assess impacts of the Tribal bull trout fishery in the Puyallup core area. Work with Tribes to ensure harvest is at levels that will support recovery objectives for the core area.

3.2.2 Evaluate and minimize incidental mortality of bull trout in other fisheries. Determine level of incidental catch and related mortality in other fisheries. Review and modify State, National Park, and Tribal fisheries management plans, guidelines, and policies to insure that incidental mortality of bull trout is minimized. Fisheries intercepting adult bull trout are the highest priority for review. Work with Washington Department of Fish and Wildlife, Tribes, National Park Service, and NOAA Fisheries to develop and implement regulations that modify the timing and methods (*e.g.*, selective gear, no-bait, mesh size) in these fisheries to reduce incidental catches and mortalities of bull trout.

3.2.3 Increase enforcement efforts with special emphasis on bull trout spawning and staging areas to eliminate illegal harvest. Increase enforcement and posting of "closed waters" and bull trout informational signs in all readily accessible staging and spawning areas, and in areas with known history of illegal harvest. Priority areas include all known staging and spawning areas for bull trout, especially Sylvester Falls (South Fork Nooksack River); downstream of Nooksack Falls (North Fork Nooksack River); Downey Creek and Buck Creek (Suiattle River); Sauk River above Elliott Creek (Skagit River); tributary mouths to Ross Lake; the North Fork Skykomish River between Bear Creek Falls and Deer Falls; and Masonry Pool (Chester Morse Lake).

3.2.4 Expand angler and public awareness efforts. Develop an outreach program to provide information to the general public and key contacts such as anglers, outfitters, and guides about bull trout identification, fishing regulations, management issues, and the importance of bull trout and their habitats. Evaluate combining bull trout outreach with other fish conservation efforts. Develop information signs for key habitat areas, increase informational exposure in areas such as agency web sites (*e.g.*, Montana Fish Wildlife and Parks bull trout identification and education website, <http://www.fwp.state.mt.us/bulltroutid/default.htm>), and develop a program for presenting fish conservation information to key area schools.

3.2.5 Coordinate with British Columbia on harvest management strategies. Coordinate and work closely with British Columbia Ministry of Water, Land, and Air Protection to carefully monitor the potential effects of regulated bull trout harvest in British Columbia waters (Chilliwack Lake, Ross Lake, Upper Skagit River) on recovery in the United States.

3.3 Evaluate potential effects of introduced fishes and associated sport fisheries on bull trout recovery and implement actions to minimize negative effects on bull trout.

3.3.1 Monitor and evaluate effects of planted hatchery fish on bull trout, especially effects related to increased competition, disease, and predation. Continue to monitor and evaluate effects of stocking hatchery salmon smolts and trout on bull trout populations. Review fish stocking programs to assure those programs are not contributing to significant levels of increased competition, disease, or predation that could interfere with bull trout recovery. Ensure that lake and pond releases of planted trout will not compete with or prey upon bull trout in or downstream of these areas.

3.4 Evaluate effects of existing and proposed fishing regulations on bull trout.

3.4.1 Continue to monitor and evaluate the effects of the current minimum size limit on existing recreational bull trout fisheries. Monitor for changes in age structure and size of spawners in current bull trout fisheries. Evaluate application of alternative harvest size limit (*e.g.*, slot limit, larger minimum harvest size) to bull trout fisheries.

3.4.2 Identify important bull trout spawning and staging areas that may require special regulations. Where populations are depressed or fishing pressures are heavy in bull trout spawning and staging locations, special regulations may need to be adopted to minimize fishing impacts.

4. Characterize, conserve, and monitor genetic diversity and gene flow among local populations of bull trout.

4.1 Incorporate conservation of genetic and phenotypic[†] attributes of bull trout into recovery and management plans.

4.1.1 Develop and implement a genetics study plan for future collection and analysis of genetic samples from local populations. Use genetic molecular analysis to delineate and describe the genetic population structure within the Puget Sound Management Unit. Complete analyses of backlogged tissue samples (*e.g.*, Snohomish-Skykomish core area) and recently collected tissue samples (*e.g.*, Chester Morse Lake core area) so results can be incorporated into a comprehensive genetics study plan for the Coastal Puget Sound Distinct Population Segment.

4.1.2 Determine level of interaction between bull trout and Dolly Varden populations. Evaluate the level of interaction between sympatric (co-occurring) bull trout and Dolly Varden populations within core areas and incorporate results in the management of both species. Focus efforts on Upper Skagit and Nooksack core areas with known populations of Dolly Varden, and in the Chilliwack core area with suspected populations.

4.2 Maintain existing opportunities for gene flow among bull trout populations.

4.2.1 Evaluate level of gene flow among core areas. Determine the level (frequency and amount) of gene flow among and within core areas that are linked by marine waters. Design and implement research efforts to determine full extent of anadromous bull trout migration patterns and use between core areas; foraging, migration, and overwintering habitats; and marine areas.

4.3 *Develop genetic management plans and guidelines for appropriate use of transplantation and artificial propagation*[†] .

It will be necessary to establish genetic reserve protocols and standards for initiating, conducting, and evaluating captive propagation programs. It may also be necessary to artificially propagate bull trout to preserve fish that are likely to be extirpated or to conduct research. Protocols will be needed to standardize the process and prevent detrimental effects on the donor population and captive fish, for determining when transplantation and artificial propagation is necessary, how to conduct these activities, and how to evaluate their effectiveness.

*Transplantation and artificial propagation of bull trout is not proposed for the Puget Sound Management Unit at this time.

5. Conduct research and monitoring to implement and evaluate bull trout recovery activities, consistent with an adaptive management approach using feedback from implemented, site-specific recovery actions.

5.1 Design and implement a standardized monitoring program to assess the effectiveness of recovery efforts affecting bull trout and their habitats.

5.1.1 Design and implement a population monitoring strategy for the Puget Sound Management Unit. Design and implement a monitoring strategy taking into account the unique conditions (*e.g.*, glacial turbidity, larger spawning and rearing tributaries, anadromous life history forms, remoteness of spawning sites) in the Puget Sound Management Unit, and revise the strategy as necessary under the principles of adaptive management. Develop a range of alternative methods for assessing population abundance. Add a monitoring component for foraging, migration, and overwintering habitats (*e.g.*, lower Green River, lower Nisqually River) that are identified as essential for recovery.

5.1.2 Evaluate existing recovery measures over time. Conduct an ongoing evaluation of existing recovery measures established for each core area to determine whether these require revision as new information is collected through research. A standardized monitoring and assessment program needs to be developed and implemented to evaluate recovery criteria, assess and improve management actions, and ensure a coordinated strategy for the future. The program should include a protocol to reliably estimate bull trout abundance and population structure over time. Coordinate these efforts with the Washington State Comprehensive Monitoring Strategy being develop for measuring success in recovering salmon and maintaining watershed health.

5.2 Conduct research evaluating relationships among bull trout distribution and abundance, bull trout habitat, and recovery actions.

5.2.1 Determine complete distribution of anadromous, fluvial, adfluvial, and resident bull trout and habitats used by each life stage. Continue implementation of existing bull trout population abundance and distribution studies and initiate new studies. Highest priority is to identify and map all spawning and rearing areas within core areas. Efforts should initially focus on the Nooksack, Stillaguamish, and Puyallup core areas. For anadromous, fluvial bull trout, continue to determine full extent of foraging, migration, and overwintering habitat.

5.2.2 Determine migratory pathways, patterns, and habitat preferences of anadromous bull trout in the Puget Sound Management Unit. Design and implement research efforts to determine full extent of anadromous bull trout migration patterns and use between core areas, foraging, migration and overwintering habitat areas (*e.g.*, Samish, lower Green), and within marine areas. Evaluate depth and other habitat preferences in estuarine and marine areas.

5.2.3 Conduct migrational studies for the Puget Sound Management Unit and coordinate with the Olympic Peninsula Management Unit and British Columbia. Information collected from these efforts will provide a more complete understanding of adult bull trout habitat requirements and the interrelationship of anadromous populations between the two management units and British Columbia. Efforts in the Chilliwack and Upper Skagit core areas will provide us critical information about the watershed-scale habitat requirements of bull trout populations in these transboundary systems.

5.2.4 Identify and assess complete estuarine and marine forage base for bull trout. Conduct research to identify complete forage base utilized by bull trout in estuarine and marine habitats. Assess current condition of this forage base and evaluate its long-term role in recovery. This includes identifying forage species of greatest importance for various life stages, adequate distribution of these forage species for bull trout, and necessary abundance levels of forage fish species to support recovery.

5.2.5 Determine extent of effects from contaminant exposure. Evaluate the significance of contaminant (*e.g.*, herbicides, pesticides, heavy metals, polyaromatic hydrocarbons, estrogenic compounds) exposure to bull trout in freshwater, estuarine, and marine habitats. Assess contaminant levels within individuals across age classes, evaluate lethal and sublethal effects and pathways of exposure, and assess potential overall effect to individual core areas. Also evaluate significance of contaminant exposure on their prey base, such as Cherry Point herring population. Current high priority areas include Bellingham Bay, Snohomish River estuary, Commencement Bay, and Duwamish River/Elliott Bay.

5.2.6 Evaluate importance of streams with only incidental bull trout presence. Evaluate the importance and contribution of core area tributaries or independent streams (*e.g.*, Whatcom Creek) directly flowing into Puget Sound currently assumed to have only limited incidental bull trout use (*i.e.*, for foraging or refuge). Determine which of these tributaries and independent streams are most likely necessary for supporting population expansion and/or long-term persistence in core areas.

5.2.7 Identify key habitat features within freshwater and marine habitats. Additional research is necessary to identify key habitat features in both freshwater and marine habitats to ensure habitat protection, restoration, and enhancement activities address critical limiting factors. Priorities include identification of key groundwater sources, hyporheic areas, and other cold water refugia; identification of desired water temperature regimes in river and tributary reaches used for foraging and migration; and identification of key habitat features required to support bull trout in migratory corridors and overwintering areas.

5.2.8 Monitor additional local populations to provide more accurate abundance estimates for each core area. Establish an appropriate number of representative spawning index areas for each core area. Highest priority is in core areas inconsistently or not currently monitored (*i.e.*, Chilliwack, Nooksack, Upper Skagit, Stillaguamish, and Puyallup core areas).

5.2.9 Determine actions necessary to restore spawning and rearing in potential local populations. Identify and evaluate actions that will be required to reestablish a sufficient level of spawning and rearing within currently identified potential local populations.

5.3 Conduct evaluations of the adequacy and effectiveness of current and past best management practices in maintaining or achieving conditions conducive to bull trout recovery.

5.3.1 Develop a sediment monitoring program. Develop a sediment monitoring program and focus collection of periodic sediment samples in bull trout spawning tributaries to determine impact of management actions on delivery of fine sediments. Monitor all core areas where management activities may potentially release sediment into spawning, rearing, and migratory areas.

5.3.2 Develop a temperature monitoring program. Develop a temperature monitoring program and focus collection of periodic temperature samples in bull trout spawning tributaries to determine impact of management actions on stream temperatures. Monitor all core areas where management activities may potentially increase temperature in spawning, rearing, and migratory areas.

5.3.3 Evaluate and improve existing forestry best management practices. Evaluate and improve existing forestry best management practices to ensure they provide for conditions (biological functions) necessary for bull trout recovery. Implement and expand monitoring of compliance and effectiveness of current Washington Forest Practices as described by the Forest and Fish Report (FFR 1999), including effectiveness of riparian protection measures on non-fishbearing streams in maintaining adequate temperatures in downstream bull trout waters. Implement adaptive management to ensure forest practices provide adequate protection to bull trout on private lands.

5.3.4 Evaluate and improve existing agricultural conservation practices. Evaluate and improve existing agricultural conservation practices to ensure they provide for conditions (biological functions) necessary for bull trout recovery. Continue and expand monitoring of compliance and effectiveness of mandatory conservation practices (Clean Water Act, Water Pollution Control Act and Dairy Nutrient Management Act) and effectiveness of voluntary conservation practices. Recommend adjustments to and revise conservation practices to correct any documented deficiencies where those practices are ineffective in supporting adequate habitat conditions for bull trout on private lands. Provide farmers with information about the functions and importance of functional riparian areas, and develop incentives for improving riparian conditions in agricultural settings.

5.3.5 Evaluate and improve existing and proposed development best management practices. Evaluate and improve existing and proposed development best management practices (including stormwater management and treatment practices) to ensure they provide for conditions (biological functions) necessary for bull trout recovery. Monitor compliance and effectiveness of State and local best management practices for development. Recommend adjustments to and revise best management practices to correct any documented deficiencies where those practices are ineffective in supporting adequate habitat conditions for bull trout.

5.4 Evaluate effects of disease and parasites on bull trout, and develop and implement strategies to minimize negative effects.

*Evaluating the effects of disease and parasites on bull trout is not an action proposed for the Puget Sound Management Unit at this time; although these factors may pose threats to bull trout in other parts of their range, to our knowledge they do not currently pose any significant threat to bull trout in this area.

5.5 Implement research and monitoring studies to improve information concerning the distribution and status of bull trout.

5.5.1 <u>Develop a predictive model of suitable habitat used by juvenile and resident bull trout</u>. Development of a suitable habitat model for bull trout in the Puget Sound Management Unit would help to refine prioritization of areas for surveys intended to detect new spawning or juvenile rearing sites. A suitable habitat model would also help to prioritize areas for recovery efforts.

5.5.2 <u>Investigate potential use of the upper Green River by bull trout, and investigate habitat suitability</u>. Conduct additional surveys to determine presence of remnant bull trout population in the upper Green River basin. Evaluate habitat suitability in the upper Green River for expanding current foraging, migration, and overwintering habitat, and evaluate habitat suitability for spawning and rearing in the upper Green River basin for possible establishment of an additional core area.

5.5.3 Investigate potential use of the upper Nisqually River by bull trout. Conduct additional surveys to determine presence of remnant bull trout population(s) in the upper Nisqually River basin.

5.6 Identify evaluations needed to improve understanding of relationships among genetic characteristics, phenotypic traits, and local populations of bull trout.

5.6.1 Determine the life history requirements and interactions of overlapping resident and migratory bull trout populations. The Puget Sound Management Unit has a number of local populations containing both resident and migratory (anadromous, adfluvial, and fluvial) forms. An understanding of specific habitat requirements and interrelationship between resident and migratory forms will assist with monitoring and evaluating the recovery status of bull trout.

6. Use all available conservation programs and regulations to protect and conserve bull trout and bull trout habitat.

6.1 Use partnerships and collaborative processes to protect, maintain, and restore functioning core areas for bull trout.

6.1.1 Coordinate bull trout recovery with other listed salmonid species recovery efforts. The Puget Sound Recovery Team will coordinate the implementation of bull trout recovery actions with Puget Sound Chinook salmon recovery measures and other general salmon recovery efforts to avoid duplication of effort and maximize the use of available resources.

6.1.2 Ensure protection of the highest quality spawning and rearing habitats remaining within each core area through measures including conservation land purchases and easements. Use partnerships to develop habitat conservation plans, conservation land purchases, and easements within local populations. Maintain and promote State, Federal, and non-governmental land management programs that protect the best remaining spawning and rearing habitat within the management unit. Examples include Federal wilderness, Wild and Scenic Rivers, State and Federal parks, and land trusts.

6.2 Use existing Federal authorities to conserve and restore bull trout.

6.2.1 Ensure adequate protection for bull trout at all life stages under Washington State Water Quality Standards. Ensure that new and existing water quality criteria are protective of all bull trout life stages and their prey base. Support development of research directed at evaluating exposure to contaminants and their effects on bull trout. Determine optimal temperature requirements for subadult and adult life stages and develop appropriate water quality standards to protect these life stages in the areas where they occur (*i.e.*, mainstem corridors, core area tributaries with anadromous use downstream of local populations, and independent tributaries used or potentially used by subadult and adult bull trout for foraging, migration, and holding).

6.3 Enforce existing Federal, State, and Tribal habitat protection standards and regulations and evaluate their effectiveness for bull trout conservation.

6.3.1 Ensure restrictions on recreational mineral prospecting and placer mining in bull trout habitat are effective. Evaluate compliance with and effectiveness of restrictions in protecting bull trout habitat as described by the State's rules and regulations for mineral prospecting and placer mining ("Gold and Fish" pamphlet; WDFW 1999). Modify to improve effectiveness if necessary. Priority areas for evaluation include South Fork of the Sauk River (Lower Skagit core area), and Ruby Creek drainage (Upper Skagit core area).

7. Assess the implementation of bull trout recovery by management units and revise management unit plans based on evaluations.

7.1 Convene annual meetings of each management unit recovery team to review progress on recovery plan implementation.

7.1.1 Generate progress reports on implementation of the bull trout recovery plan. Annual reviews are necessary to track progress in implementing the recovery plan. Annual reports can be used to identify successful approaches for implementing recovery actions and direct where efforts should be placed within management units.

7.2 Develop and implement a standardized monitoring program to evaluate the effectiveness of recovery efforts.

7.2.1 Develop and implement a standardized monitoring program to evaluate the effectiveness of recovery efforts (coordinate with recovery action 5.1). A standardized monitoring program is needed to evaluate achievement of recovery objectives and provide information to adaptively manage and improve recovery efforts.

7.3 Revise scope of recovery as suggested by new information.

7.3.1 Periodically assess progress toward recovery goals and assess recovery action priorities. Annually review progress toward population and abundance criteria and recommend changes, as needed, to the Puget Sound Management Unit recovery plan. In addition, review actions, action priorities, completed actions, budget, time frames, particular successes, and feasibility.

IMPLEMENTATION SCHEDULE

Implementation schedules describe recovery action priorities, action numbers, action descriptions, duration of actions, potential or participating responsible parties, total estimated costs for the duration of the action, cost estimates for the next five years, and comments. Those actions, when accomplished, will lead to recovery of bull trout in the Puget Sound Management Unit, and ultimately to recovery of bull trout in the coterminous United States.

Parties with the authority, responsibility, or expressed interest to implement a specific recovery action are identified in the implementation schedule. Listing a responsible party does not imply that prior approval has been given, nor does it require that party to participate or expend funds. However, willing participants will benefit by demonstrating that their budget submission or funding request is for a recovery action identified in an approved recovery plan, and is therefore part of a coordinated effort to recover bull trout. In addition, section 7(a)(1) of the Endangered Species Act directs all Federal agencies to use their authorities to further the purposes of the Act by implementing programs for the conservation of threatened or endangered species.

In compliance with our Endangered and Threatened Species Listing and Recovery Priority Guidelines, Recovery Plan Preparation and Implementation Priorities (48 FR 43103), we have considered and adopted priorities and subpriorities that represent recovery goals for bull trout across their native range as well as those reflected in the individual recovery plans. We have also considered established conservation plans and the ongoing local, State and Federal planning processes to maintain consistency and integration with those efforts. Assigning priorities does not imply that some recovery actions are of low importance, as all recovery actions are important to achieve the recovery objectives. We further recognize lower priority actions may be implemented ahead of higher priority actions because of the integration of bull trout recovery efforts with these existing plans and processes, and/or the availability of funding opportunities. All recovery actions will have assigned priorities based on the following:

- Priority 1: All actions that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

- Priority 2: All actions that must be taken to prevent a significant decline in species population or habitat quality or to prevent some other significant negative effect short of extinction.

- Priority 3: All other actions necessary to provide for full recovery.

Action Number and Action Description: Recovery actions as numbered in the recovery outline. Refer to the recovery action narrative outline for descriptions.

Action Duration: Expected number of years to complete the corresponding action. Study designs can incorporate more than one action, which when combined can reduce the time needed for action completion.

Responsible or Participating Parties: The following organizations are those with the responsibility or capability to fund, authorize, or carry out the corresponding action. Within the implementation schedule, bold type indicates the agency or agencies that have the lead role for action implementation and coordination, though not necessarily sole responsibility. Additional identified agencies or parties are considered cooperators in conservation efforts. Identified parties include the following:

Federal Agencies

ACOE	Army Corps of Engineers
EPA	Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
FHWA	Federal Highway Administration
NMFS	National Marine Fisheries Service (NOAA Fisheries)
NPS	National Park Service
NRCS	Natural Resources Conservation Service
USFWS	U.S. Fish and Wildlife Service
USFS	U.S. Forest Service
USGS	U.S. Geological Survey, Biological Resources Division

State Agencies

WDOA	Washington State Department of Agriculture
WDOE	Washington State Department of Ecology
WDFW	Washington State Department of Fish and Wildlife
WDNR	Washington State Department of Natural Resources
WDOT	Washington State Department of Transportation

Other Governments and Participating Parties

BCM	British Columbia Ministry of Water, Land and Air Protection
BNR	Burlington Northern Railway
Cities	Cities
C	Counties
NGO	Non-governmental organizations (*e.g.*, University of Washington, People for Puget Sound, Washington Trout, Regional Salmon Enhancement Groups, The Nature Conservancy, The Trust for Public Land)
NWIFC	Northwest Indian Fisheries Commission
PSE	Puget Sound Energy
Ports	Ports (*e.g.*, Port of Seattle, Port of Tacoma, Port of Bellingham)
SRFB	Salmon Recovery Funding Board
SSPS	Shared Strategy for Puget Sound Watershed Groups
SCL	Seattle City Light
SPU	Seattle Public Utilities
TG	Tribal Governments

Cost Estimates: Cost estimates are rough approximations and are provided only for general guidance. Total costs are estimated for the duration of the action, are itemized annually for the next 5 years, and include estimates of expenditures by local, Tribal, State, and Federal governments and by private business and individuals.

An asterisk (*) in the total cost column indicates ongoing actions that are currently being implemented as part of normal agency responsibilities under existing authorities. Because these actions are not being done specifically or solely for bull trout conservation, they are not included in the cost estimates. Some of these efforts may be occurring at reduced funding levels and/or in only a small portion of the watershed.

“TBD” in the total cost column indicates that estimated costs for these actions are not determinable at this time. Input is requested to help develop reasonable cost estimates for these actions.

The symbol “‡” indicates costs are combined with or embedded within other related actions.

Implementation schedule for the bull trout recovery plan: Puget Sound Management Unit

Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
1	1.1.1	Identify and improve or remove unstable or problem roads causing fine sediment delivery	25	**C**, **NPS**, **Private land owners**, SRFB, TG, **USFS**, USFWS, **WDNR**, WDFW	TBD						Costs will be partially covered by ongoing actions
1	3.2.3	Increase enforcement efforts with special emphasis on bull trout spawning and pre-spawning staging areas to eliminate illegal harvest	25	**WDFW**, TG, USFS, **USFWS**	*						
1	6.1.2	Ensure protection of the highest quality spawning and rearing habitats remaining within each core area through measures including conservation land purchases and easements	25	C, NGO, SRFB, SSPS, TG, **USFS**, **USFWS**, WDFW, **WDNR**	TBD						
2	1.1.2	Improve routine road maintenance practices affecting water quality	25	**C**, **Cities**, FHWA, **WDOT**	*						

* Ongoing actions currently being implemented as part of normal agency responsibilities; these actions are not included in the cost estimates since they are not being done specifically for bull trout conservation.
TBD Costs not determinable at this time; input is requested to help develop reasonable cost estimates for these actions.
‡ Costs are combined with or embedded within other related actions and are not itemized separately here.

Implementation schedule for the bull trout recovery plan: Puget Sound Management Unit												
Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
2	1.1.3	Implement measures to restore natural thermal regime	25	EPA, **FERC**, **WDOE**	TBD						Costs will be partially covered by ongoing actions
2	1.1.5	Encourage the uptake of marine derived nutrients from salmon carcasses into the freshwater ecosystem	25	C, SSPS, **TG**, **USFS**, USFWS, **WDFW**	‡						Cost embedded in habitat actions and action 3.1.3
2	1.1.6	Monitor water quality and meet water quality standards for temperature, nutrient loading, dissolved oxygen, and contaminants	25	C, **EPA**, FERC, TG, USFS, **WDOE**	*						
2	1.1.7	Identify, restore, and protect groundwater and hyporheic sources	25	FERC, NGO, NRCS, TG, USGS, **WDOE**, WDFW, WDNR	TBD						

* Ongoing actions currently being implemented as part of normal agency responsibilities; these actions are not included in the cost estimates since they are not being done specifically for bull trout conservation.

TBD Costs not determinable at this time; input is requested to help develop reasonable cost estimates for these actions.

‡ Costs are combined with or embedded within other related actions and are not itemized separately here.

Implementation schedule for the bull trout recovery plan: Puget Sound Management Unit											
Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
2	1.1.8	Reduce anthropogenic sediment and contaminant sources generated from agriculture practices	25	**C**, **NRCS**, USGS, **WDOA**, WDOE	TBD						
2	1.1.9	Reduce anthropogenic sediment sources generated from forest management	25	C, **USFS**, **WDNR**	TBD						Costs will be partially covered by ongoing actions
2	1.1.10	Reduce anthropogenic sediment and contaminant sources generated from residential development and urbanization	25	**C**, **Cities**, EPA, **WDOE**	TBD						
2	1.1.11	Maintain and improve instream flows	25	C, **Cities**, EPA, **FERC**, **WDOE**	*						
2	1.2.2	Provide adequate fish passage around diversions and dams	15	**ACOE**, FERC, **City of Bellingham**, NMFS, **PSE**, **SCL**, WDFW, USFWS	55,500	3700	3700	3700	3700	3700	Costs shared with salmon recovery

* Ongoing actions currently being implemented as part of normal agency responsibilities; these actions are not included in the cost estimates since they are not being done specifically for bull trout conservation.

TBD Costs not determinable at this time; input is requested to help develop reasonable cost estimates for these actions.

‡ Costs are combined with or embedded within other related actions and are not itemized separately here.

Implementation schedule for the bull trout recovery plan: Puget Sound Management Unit											
Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
2	1.2.3	Identify and eliminate culvert barriers	25	**C**, **Cities**, FHWA, SRFB, **TG**, WDFW, **WDNR**, **WDOT**, **USFS**, USFWS	TBD						Total cost depends on number of culverts identified and type of action necessary
2	1.3.1	Protect and restore riparian areas	25	ACOE, **C**, **Cities**, **NRCS**, SRFB, **SSPS**, TG, **USFS**, USFWS, WDFW, **WDNR**	TBD						Costs will be partially covered by ongoing actions
2	1.3.2	Identify, evaluate, and restore overwintering habitat in mainstem rivers and tributaries	25	**ACOE, C**, **Cities**, **NRCS**, SRFB, **SSPS**, TG, USFS, USFWS, WDFW, **WDNR**	TBD						Costs will be partially covered by ongoing actions for salmon
2	1.3.3	Identify and restore foraging waters with high restoration benefit	25	**ACOE**, **C**, **Cities**, **NRCS**, SRFB, **SSPS**, **TG**, **USFS**, **USFWS**, **WDFW**, **WDNR**	TBD						Costs will be partially covered by ongoing actions for salmon

* Ongoing actions currently being implemented as part of normal agency responsibilities; these actions are not included in the cost estimates since they are not being done specifically for bull trout conservation.

TBD Costs not determinable at this time; input is requested to help develop reasonable cost estimates for these actions.

‡ Costs are combined with or embedded within other related actions and are not itemized separately here.

Implementation schedule for the bull trout recovery plan: Puget Sound Management Unit												
Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
2	1.3.4	Reduce stream channel degradation and increase channel complexity	25	**ACOE**, **C**, Cities, FERC, **NRCS**, SRFB, SSPS, TG, **USFS**, USFWS, WDFW, WDNR,	TBD						
2	1.3.5	Practice non-intrusive flood control and flood repair activities	25	**ACOE**, **NRCS**, **C**, Cities	TBD						
2	1.3.6	Reduce development impacts on streams, floodplains, and lake shores	25	ACOE, **C**, **Cities**, SSPS	TBD						
2	1.3.9	Restore natural stream channel morphology	25	**ACOE**, **C**, Cities, FERC, **NRCS**, SSPS, TG, USFS, WDFW, WDNR,	TBD						
2	1.3.11	Protect riparian and stream channel habitat at managed and unmanaged campgrounds, trail systems, and recreational sites	25	**C**, **NPS**, **USFS**, **WDNR**	*						

* Ongoing actions currently being implemented as part of normal agency responsibilities; these actions are not included in the cost estimates since they are not being done specifically for bull trout conservation.
TBD Costs not determinable at this time; input is requested to help develop reasonable cost estimates for these actions.
‡ Costs are combined with or embedded within other related actions and are not itemized separately here.

Implementation schedule for the bull trout recovery plan: Puget Sound Management Unit											
Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
2	1.4.1	Reduce reservoir operation impacts	25	ACOE, FERC, **PSE**, **SCL**, **SPU**	TBD						
2	1.4.2	Provide sufficient instream flow downstream from dams and diversions	25	**City of Bellingham**, ACOE, **FERC**, **PSE**, **SCL**	TBD						
2	1.5.2	Upgrade or decommission existing and potential problem roads	15	**C**, **NPS**, SRFB, TG, **USFS**, USFWS **WDNR**, WDFW,	TBD						Costs will be partially covered by ongoing actions
2	1.5.3	Minimize levels of effective impervious surface from development	25	**C**, **Cities**, FHWA, WDOE, **WDOT**	TBD						
2	1.6.2	Reduce impacts of development and transportation corridors along estuarine and marine shorelines	25	**ACOE**, **BNR**, C, Cities, FHWA, **Ports**, TG, WDOT	TBD						

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Implementation schedule for the bull trout recovery plan: Puget Sound Management Unit											
Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
2	1.6.3	Restore or recreate intertidal foraging habitats in key areas	25	**ACOE**, **C**, Cities, FHWA, **NMFS**, **NRCS**, **Ports**, SRFB, SSPS, **TG**, **USFWS**, **WDFW**, **WDNR**, **WDOT**	TBD						
2	2.4.1	Review existing protocols for eradicating, suppressing, or managing nonnative fish populations and implement protocols where needed	2	**NPS**, USFWS, **WDFW**	*						
2	2.5.1	Determine distribution and abundance of nonnative fish (brook trout and westslope cutthroat trout) and identify overlap with bull trout	5	NGO, **NPS**, TG, **USFS**, USFWS, **WDFW**	100	20	20	20	20	20	
2	2.5.2	Evaluate brook trout impacts to migratory bull trout populations	5	**NGO**, USFWS, **USGS**, WDFW	50	10	10	10	10	10	
2	2.5.3	Experimentally remove established brook trout populations from priority streams	5	NGO, **NPS**, **USFS**, USGS, USFWS, **WDFW**	25	5	5	5	5	5	

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Implementation schedule for the bull trout recovery plan: Puget Sound Management Unit											
Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
2	3.1.2	Protect remaining bull trout strongholds and native species complexes	25	**NPS**, **SPU**, **USFS**, WDFW, WDNR	0						
2	3.1.3	Provide increased forage opportunities in freshwater.	25	NMFS, **TG**, **WDFW**	TBD						
2	3.1.4	Increase biomass of marine forage base	25	**C**, NMFS, **Ports**, **TG**, **WDFW**, **WDNR**, WDOT	*						
2	3.2.1	Evaluate the impacts of harvest on bull trout populations	25	**TG**, USFWS, **WDFW**	*						
2	3.2.2	Evaluate and minimize incidental mortality of bull trout in other fisheries	25	NMFS, **NPS**, NWIFC, **TG**, USFWS, **WDFW**	TBD						
2	3.2.5	Coordinate with British Columbia on harvest management strategies	10	**BCM**, **NPS**, USFWS, **WDFW**	*						
2	3.3.1	Monitor effects of planted hatchery fish on bull trout, especially effects related to increased competition, disease, and predation	25	NGO, NMFS, **TG**, **USFWS**, USGS, **WDFW**	*						

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Implementation schedule for the bull trout recovery plan: Puget Sound Management Unit											
Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
2	3.4.1	Continue to monitor and evaluate the effects of the current minimum size limit on existing recreational bull trout fisheries	25	**WDFW**, USFWS	‡						Associated with other population monitoring actions
2	3.4.2	Identify important bull trout spawning and staging areas that may require special regulations	25	**TG**, **NPS**, **USFS**, USFWS, **WDFW**	‡						Total cost will depend on 5.2.1
2	4.1.2	Determine level of interaction between bull trout and Dolly Varden populations	5	**BCM**, NGO, **NPS**, **USFWS**, USGS, SCL, **WDFW**	100	20	20	20	20	20	
2	4.2.1	Evaluate level of gene flow among core areas	5	NGO, **USFWS**, USFS, USGS, **WDFW**	TBD						Some costs embedded within other research and monitoring actions
2	5.1.1	Design and implement a population monitoring strategy for the Puget Sound Management Unit	5	BCM, NPS, TG, USFS, **USFWS**, **WDFW**	TBD						

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Implementation schedule for the bull trout recovery plan: Puget Sound Management Unit											
Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
2	5.2.1	Determine complete distribution of anadromous, fluvial, and resident bull trout and habitats used by each life stage	5	BCM, NGO, **NPS**, **TG**, **USFS**, USFWS, **WDFW**	1250	250	250	250	250	250	
2	5.2.2	Determine migratory pathways and patterns, and habitat preferences of anadromous bull trout in the Puget Sound Management Unit	5	ACOE, NGO, TG, **USFWS**, USGS, **WDFW**	750	150	150	150	150	150	A study is currently being conducted in north Puget Sound by ACOE
2	5.2.5	Determine extent of effects from contaminant exposure	10	**EPA**, NMFS, **USFWS**, USGS, **WDOE**	1000	100	100	100	100	100	
2	5.2.7	Identify key habitat features within freshwater and marine habitats	10	**NGO**, NMFS, TG, **USFWS**, **USGS**, **WDOE**, WDFW	TBD						
2	5.2.8	Monitor additional local populations to provide more accurate abundance estimates for each core area	25	**NPS**, **TG**, **USFS**, **USFWS**, **WDFW**	4500	180	180	180	180	180	Assumes two index areas per core area, cost does not include existing index areas

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Implementation schedule for the bull trout recovery plan: Puget Sound Management Unit											
Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
2	5.5.1	Develop a predictive model of suitable habitat used by juvenile and resident bull trout	4	USFS, **USFWS**	180		30	75	75		Costs shared with Olympic Peninsula Management Unit
2	6.2.1	Ensure adequate protection for bull trout at all life stages under Washington State Water Quality Standards	25	**EPA**, USFWS, **WDOE**, WDFW	*						
2	6.3.1	Ensure restrictions on recreational mineral prospecting and placer mining in bull trout habitat are effective	25	**USFS**, **WDFW**	*						
3	1.1.4	Reduce anthropogenic nutrient input	25	**C**, **NRCS**, USGS, **WDOA**, WDOE, WDNR	TBD						
3	1.2.1	Eliminate or minimize entrainment at diversions and ditches	10	C, Cities, **FERC**, **NRCS**, **PSE**, **SPU**, WDFW	4,000	400	400	400	400	400	Costs shared with salmon recovery
3	1.2.4	Identify and eliminate or modify tide gates, pump stations, and flood gates blocking access to bull trout habitat	15	**ACOE**, **C**, Cities, **NRCS**, TG, WDOA, WDFW, **WDOT**	TBD						

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Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
3	1.2.5	Inform the public about the impacts of recreational barriers to migrating bull trout	2	**USFS**, **WDFW**	10	5	5				Development and distribution of educational information
3	1.3.7	Reduce transportation corridor impacts on streams	25	ACOE, **BNR**, **C**, Cities, FHWA, **USFS**, WDNR, **WDOT**	TBD						
3	1.3.8	Improve grazing practices	10	**C**, **NRCS**, **WDOA**	*						
3	1.3.10	Enhance and restore instream habitat	25	**ACOE**, **C**, Cities, FERC, NGO, NRCS, SRFB, SSPS, TG, **USFS**, **USFWS**, **WDFW**, **WDNR**	TBD						
3	1.5.1	Update and/or review local Forest Service or other watershed analyses	25	**USFS**, **WDNR**	*						

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Implementation schedule for the bull trout recovery plan: Puget Sound Management Unit

Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
3	1.6.1	Identify and remediate contaminant sites in estuarine and nearshore marine areas	25	ACOE, **C**, **Cities**, EPA, **Ports**, **WDNR**, WDFW, **WDOE**	TBD						
3	2.1.1	Review and analyze effectiveness of current fish stocking polices	2	NMFS, **TG**, USFWS, **WDFW**	*						
3	2.2.1	Review existing enforcement of current policies for preventing illegal transport and introduction of nonnative fishes	5	**TG, WDFW**	*						
3	2.3.1	Discourage unauthorized fish introductions	25	**NPS**, **TG, USFS**, **USFWS**, **WDFW**	*						Likely requires additional funding
3	2.6.1	Remove invasive nonnative plants limiting the effectiveness of riparian areas and restore with native vegetation	25	**C**, **NGO**, **NRCS**, TG, **USFS**, USFWS, WDFW, **WDNR**	TBD						
3	2.6.2	Continue control of spartina in estuarine and nearshore areas	25	**C**, **WDFW**, USFWS,	TBD						
3	3.1.1	Integrate research and monitoring results into native fish management plans and related information resources	25	**NPS**, TG, **USFS**, USFWS, **WDFW**	‡						

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Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
3	3.2.4	Expand angler and public education efforts	25	NGO, **NPS**, **TG**, **USFWS**, **WDFW**	100	20	20	20	20	20	
3	4.1.1	Conduct a genetic inventory	5	NPS, TG, USFS, **USFWS**, USGS, WDFW	150	30	30	30	30	30	Study plan currently being developed by USFS
3	5.1.2	Evaluate existing recovery measures over time	25	SSPS, TG, **USFWS**, WDFW	TBD						
3	5.2.3	Conduct migrational studies for the Puget Sound Management Unit and coordinate with the Olympic Peninsula Management Unit and British Columbia	5	**BCM**, **NPS**, **SCL**, **USFWS**, USGS, WDFW	TBD						Ongoing study occurring in the Upper Skagit core area by SCL and BCM
3	5.2.4	Identify and assess complete estuarine and marine forage base for bull trout	2	**NGO**, **TG**, **USFWS**, **USGS**, **WDFW**	200	100	100				
3	5.2.6	Evaluate importance of streams with only incidental bull trout presence	5	**NGO**, **USFWS**, **USGS**, **WDFW**	TBD						
3	5.2.9	Determine actions necessary to restore spawning and rearing in potential local populations	5	NGO, **NPS**, **SPU**, **USFWS**, USGS, **WDFW**	TBD						

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Implementation schedule for the bull trout recovery plan: Puget Sound Management Unit

Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
3	5.3.1	Develop a sediment monitoring program	25	**TG**, **USFS**, **USFWS**, **WDNR**	*						
3	5.3.2	Develop a temperature monitoring program	25	**EPA,** NPS, USFWS, USFS, WDNR, **WDOE**	*						
3	5.3.3	Evaluate and improve existing forestry best management practices	25	NGO, **USFS**, TG WDFW, **WDNR**	TBD						
3	5.3.4	Evaluate and improve existing agricultural conservation practices	25	C, NGO, **NRCS**, **WDOA**, WDOE, WDFW	TBD						
3	5.3.5	Evaluate and improve existing and proposed development best management practices	25	**C**, Cities, NGO, **WDOE**, WDFW	TBD						
3	5.5.2	Investigate potential use of the upper Green River by bull trout, and investigate habitat suitability	5	**ACOE**, NGO, TG, **USFWS**, USGS, WDFW	TBD						
3	5.5.3	Investigate potential use of the upper Nisqually River by bull trout	5	NGO, **NPS**, **USFS**, USGS, **USFWS**, WDFW	TBD						

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Action priority	Action number	Action description	Action duration (years)	Responsible parties (Alphabetical)	Cost estimates ($1,000)						Comments
					Total cost	Year 1	Year 2	Year 3	Year 4	Year 5	
3	5.6.1	Determine the life history requirements and interactions of overlapping resident and migratory bull trout populations	5	NGO, TG, **USFWS**, USGS, **WDFW**	200	40	40	40	40	40	
3	6.1.1	Coordinate bull trout recovery with other listed salmonid species recovery efforts	25	NMFS, **SSPS**, TG, **USFWS**, WDFW	*						
3	7.1.1	Generate progress reports on implementation of the bull trout recovery plan	25	NPS, SSPS, TG, USFS, **USFWS**, WDFW, WDNR	*						
3	7.3.1	Periodically assess progress toward recovery goals and assess recovery action priorities	25	NRCS, **Puget Sound Recovery Team**, SSPS, TG, USFS, **USFWS**, WDFW, WDNR, WDOE	*						
			TOTAL ESTIMATED COST		68,115						

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APPENDIX 1.

State of Washington's 1998 303(d) List for the Puget Sound Management Unit (as per section 303(d) of the Clean Water Act, 33 USC 1251 *et seq*.).

(Based on the Washington Department of Ecology 303(d) List website: http://www.ecy.wa.gov/programs/wq/303d/1998/1998_by_wrias.html)

Within a Local Population?	Waterbody Name	Pollutant(s) or Parameter(s) Not Meeting Standards
Chilliwack Core Area		
No	Sumas River	Fecal coliform
Nooksack Core Area		
No	Anderson Creek	Fine sediment, temperature
No	Bertrand Creek	Ammonia, dissolved oxygen, fecal coliform, instream flow
Yes	Boulder Creek	Temperature
Yes	Canyon (Lake) Creek	Temperature
Yes	Canyon Creek	Temperature
Yes	Cavanaugh Creek	Temperature
Yes	Cornell Creek	Temperature
No	Deer Creek	Ammonia, dissolved oxygen, fecal coliform, pH
No	Fishtrap Creek	Dissolved oxygen, fecal coliform, instream flow
Yes	Gallop Creek	Temperature
Yes	Howard Creek	Fine sediment, temperature
No	Johnson Creek	Dissolved oxygen
No	Nooksack River	Fecal coliform, fine sediment

Within a Local Population?	Waterbody Name	Pollutant(s) or Parameter(s) Not Meeting Standards
Yes	Nooksack River, Middle Fork	Temperature
No	Nooksack River, South Fork.	Instream flow, temperature
Yes	Nooksack River, South Fork	Fine sediment, temperature
No	Racehorse Creek	Fine sediment, temperature
Yes	Roaring Creek	Temperature
No	Silver Creek	Dissolved oxygen, fecal coliform
Lower Skagit Core Area		
No	Day Creek	Temperature
No	Hansen Creek	Fecal coliform, fish habitat, temperature
No	Jones Creek	Temperature
No	Nookachamps Creek	Fecal coliform, temperature
No	Skagit River	Fecal coliform
No	Wiseman Creek	Temperature
No	Finney Creek	Temperature
No	Grandy Creek	Temperature
No	Jackman Creek	Temperature
Stillaguamish Core Area		
Yes	Deer Creek	Temperature
Yes	Higgins Creek	Temperature
No	Jim Creek	Fecal coliform
No	Jorgenson Slough (Church Creek)	Fecal coliform

Within a Local Population?	Waterbody Name	Pollutant(s) or Parameter(s) Not Meeting Standards
Yes	Little Deer Creek	Temperature
No	Pilchuck Creek	Dissolved oxygen, temperature
No	Portage Creek	Dissolved oxygen, fecal coliform, turbidity
No	Stillaguamish River	Ammonia, arsenic, metals (copper, lead, nickel), dissolved oxygen, fecal coliform, temperature
No	Stillaguamish River, North Fork	Fecal coliform
Yes	Stillaguamish River, North Fork	Temperature
No	Stillaguamish River, South Fork	Dissolved oxygen, fecal coliform, pH, temperature
Snohomish-Skykomish Core Area		
No	Allen Creek	Dissolved oxygen, fecal coliform
No	Ebey Slough	pH, fecal coliform
No	French Creek	Dissolved oxygen, fecal coliform
No	Pilchuck River	Fecal coliform, temperature
No	Quilceda Creek	Dissolved oxygen, fecal coliform
No	Skykomish River	Metals (copper, lead, silver), fecal coliform, temperature
No	Snohomish River	Various contaminants, arsenic, copper, mercury, dissolved oxygen, fecal coliform, temperature
No	Snoqualmie River	Temperature
No	Wallace River	Temperature
No	Woods Creek	Fecal coliform

Within a Local Population?	Waterbody Name	Pollutant(s) or Parameter(s) Not Meeting Standards
Puyallup Core Area		
No	Boise Creek	Temperature
No	Clarks Creek	Fecal coliform, pH
No	Clear Creek	Fecal coliform
Yes (potential)	Clearwater River	Temperature
Yes	Greenwater River	Temperature
No	Puyallup River	Arsenic, fecal coliform, instream flow
No	Scatter Creek	Temperature
No	South Prairie Creek	Fecal coliform, temperature
No	Voight Creek	Temperature
No	White River	Copper, mercury, fecal coliform, instream flow, pH, temperature
No	Wilkenson Creek	Copper, temperature
Samish River foraging, migration, overwintering habitat		
No	Friday Creek	Fecal coliform
No	Samish River	Fecal coliform
Lake Washington foraging, migration, overwintering habitat		
No	Bear-Evans Creeks	Fecal coliform
No	Cedar River	Fecal coliform
No	Coal Creek	Fecal coliform
No	Issaquah Creek	Fecal coliform, temperature
No	Juanita Creek	Fecal coliform
No	Kelsey Creek	Pesticides, fecal coliform
No	Laughing Jacob’s Creek	Fecal coliform

Within a Local Population?	Waterbody Name	Pollutant(s) or Parameter(s) Not Meeting Standards
No	Little Bear Creek	Fecal coliform
No	May Creek	Copper, lead, zinc, fecal coliform, temperature
No	McAleer Creek	Fecal coliform
No	North Creek	Dissolved oxygen, fecal coliform
No	Sammamish Lake	Fecal coliform
No	Sammamish River	Dissolved oxygen, fecal coliform, pH, temperature
No	Swamp Creek	Dissolved oxygen, fecal coliform
No	Thorton Creek	fecal coliform
No	Tibbetts Creek	fecal coliform
No	Union Lake/Lake Washington Ship Canal	Pesticide (dieldrin)
No	Lake Washington	Fecal coliform
Lower Green River foraging, migration, overwintering habitat		
No	Duwamish Waterway and River	Various contaminants, arsenic, metals (cadmium, chromium, copper, lead, mercury, silver, zinc), PAHs, PCBs, dissolved oxygen, fecal coliform, pH
No	Green River	Fecal coliform, metals (chromium, mercury), temperature
No	Mullen Slough	Dissolved oxygen, temperature
No	Newaukum Creek	Dissolved oxygen, fecal coliform
No	Soos Creek	Fecal coliform, temperature
No	Springbrook (Mill) Creek	Dissolved oxygen, metals (cadmium, chromium, copper, mercury, zinc), fecal coliform, temperature

Within a Local Population?	Waterbody Name	Pollutant(s) or Parameter(s) Not Meeting Standards
Lower Nisqually River foraging, migration, overwintering habitat		
No	McAllister Creek	Dissolved oxygen, fecal coliform
No	Ohop Creek	Fecal coliform
Puget Sound marine foraging, migration, overwintering habitat		
No	Bellingham Bay (inner) and Whatcom Water Way	Numerous contaminants, copper, lead, mercury, zinc, PCBs
No	Bellingham Bay (outer)	Fecal coliform, pH
No	Lummi Bay and Hale Passage	Fecal coliform
No	Strait of Georgia	Various contaminants, cadmium, PCBs
No	Indian Slough	Dissolved oxygen, fecal coliform, temperature
No	Padilla Bay, Fidalgo Bay, and Guemes Channel	PCBs
No	Samish Bay	Fecal coliform
No	Skagit Bay and Similk Bay	Dissolved oxygen, fecal coliform
No	Port Susan	Fecal coliform
No	Penn Cove	Dissolved oxygen
No	Port Gardner and Inner Everett Harbor	Numerous contaminants, mercury, zinc, PCBs
No	Possession Sound	Numerous contaminants, metals (cadmium, copper, lead, mercury, zinc), dissolved oxygen
No	Puget Sound (central)	Various contaminants, mercury, PCBs

Within a Local Population?	Waterbody Name	Pollutant(s) or Parameter(s) Not Meeting Standards
No	Elliott Bay	Various contaminants, arsenic, metals (cadmium, chromium, copper, lead, mercury, silver, zinc), PCBs
No	Puget Sound (South Central) and East Passage	Fecal coliform
No	Commencement Bay (inner)	Various contaminants, metals (lead, mercury, zinc), PCBs
No	Commencement Bay (outer)	Various contaminants, arsenic, metals (cadmium, copper, lead, mercury, silver, zinc), PCBs
No	Thea Foss Waterway	PCBs
No	Nisqually Reach	Fecal coliform

APPENDIX 2.

Table linking Recovery Actions and Reasons for Decline in the Puget Sound Management Unit.

Action Number	Recovery Target Number(s)	Reasons for Decline							
		Dams	Forest Management Practices	Agricultural Practices	Transportation Networks	Residential Development and Urbanization	Mining	Fisheries Management	Habitat Fragmentation and Isolation
1.1.1	1,2,3		X		X	X			X
1.1.2	1,2,3		X		X	X			
1.1.3	1,2,3		X	X	X	X			
1.1.4	1,2,3			X		X			
1.1.5	1,2,3			X	X	X		X	
1.1.6	1,2,3	X	X	X	X	X			
1.1.7	1,2,3		X	X	X	X			
1.1.8	1,2,3			X					
1.1.9	1,2,3		X		X				
1.1.10	1,2,3				X	X			
1.1.11	1,2,3	X		X		X			
1.2.1	4	X		X					X
1.2.2	4	X							X
1.2.3	4		X		X				X
1.2.4	4					X			X
1.2.5	4			X		X			X
1.2.6	4							X	X

Action Number	Recovery Target Number(s)	Reasons for Decline							
		Dams	Forest Management Practices	Agricultural Practices	Transportation Networks	Residential Development and Urbanization	Mining	Fisheries Management	Habitat Fragmentation and Isolation
1.3.1	1,2,3		X	X	X	X			X
1.3.2									
1.3.3	1,2,3		X	X	X	X			X
1.3.4	1,2,3			X	X	X			
1.3.5	1,2,3			X	X	X			
1.3.6	1,2,3				X	X			
1.3.7	1,2,3				X	X			
1.3.8	1,2,3			X					
1.3.9	1,2,3		X	X	X	X			
1.3.10	1,2,3		X	X	X	X			
1.3.11	1,2,3		X						
1.4.1	1,2,3,4	X							
1.4.2	1,2,3	X							
1.5.1	1,2,3		X						
1.5.2	1,2,3		X						
1.5.3	1,2,3				X	X			
1.6.1	1,2,3				X	X			
1.6.2	1,2,3				X	X			
1.6.3	1,2,3,4			X	X	X			
2.1.1	1,2,3							X	

Action Number	Recovery Target Number(s)	Reasons for Decline							
		Dams	Forest Management Practices	Agricultural Practices	Transportation Networks	Residential Development and Urbanization	Mining	Fisheries Management	Habitat Fragmentation and Isolation
2.2.1	1,2,3							X	
2.3.1	1,2,3							X	
2.4.1	1,2,3							X	
2.5.1	1,2,3							X	
2.5.2	1,2,3							X	
2.5.3	1,2,3							X	
2.6.1	1,2,3			X		X			
2.6.2	1,2,3			X		X			
3.1.1	1,2,3							X	
3.1.2	1,2,3		X	X			X	X	
3.1.3	1,2,3							X	
3.1.4	1,2,3							X	
3.2.1	1,2,3							X	
3.2.2	1,2,3							X	
3.2.3	1,2,3							X	
3.2.4	1,2,3							X	
3.2.5	1,2,3							X	
3.3.1	1,2,3							X	
3.4.1	1,2,3							X	
3.4.2	1,2,3							X	

Action Number	Recovery Target Number(s)	Reasons for Decline							
		Dams	Forest Management Practices	Agricultural Practices	Transportation Networks	Residential Development and Urbanization	Mining	Fisheries Management	Habitat Fragmentation and Isolation
4.1.1	1,2,3,4							X	
4.1.2	1,2,3							X	
4.2.1	1,2,3,4							X	X
5.1.1	1,2,3							X	
5.1.2	1,2,3	X	X	X	X	X		X	X
5.2.1	1,2,3,4							X	
5.2.2	1,2,3,4							X	
5.2.3	1,2,3,4							X	X
5.2.4	1,2,3							X	X
5.2.5	1,2,3		X	X	X	X			
5.2.6	1,2,3							X	
5.2.7	1,2,3	X	X	X	X	X		X	
5.2.8	1,2,3							X	
5.2.9	1,2,3		X			X	X	X	
5.3.1	1,2,3		X	X	X	X	X		
5.3.2	1,2,3	X	X	X					X
5.3.3	1,2,3		X						
5.3.4	1,2,3			X					
5.3.5	1,2,3				X	X			
5.5.1	1,2,3		X					X	

Action Number	Recovery Target Number(s)	Reasons for Decline							
		Dams	Forest Management Practices	Agricultural Practices	Transportation Networks	Residential Development and Urbanization	Mining	Fisheries Management	Habitat Fragmentation and Isolation
5.5.2	1,2,3	X							X
5.5.3	1,2,3	X							X
5.6.1	1,2,3							X	
6.1.1	1,2,3	X	X	X	X	X		X	X
6.1.2	1,2,3		X		X	X	X		X
6.2.1	1,2,3,4	X	X	X	X	X	X		X
6.3.1	1,2,3,4						X		
7.1.1	1,2,3,4	X	X	X	X	X	X	X	X
7.3.1	1,2,3,4	X	X	X	X	X	X	X	X

APPENDIX 3.

Effective Population Size and Recovery Planning

Effective population size provides a standardized measure of the amount of genetic variation that is likely to be transmitted between generations within a population. Effective population size is a theoretical concept that allows one to predict potential future losses of genetic variation within a population due to small population size and genetic drift. Individuals within populations with very small effective population sizes are also subject to *inbreeding depression* because most individuals within small populations share one or more immediate ancestors (parents, grandparents, etc.) after only a few generations and will be closely related.

A number of factors affect the effective population size of a species. For example, unequal sex ratios can significantly affect effective population size because male and female adults of the parent generation must each contribute 50 percent of the genes to the progeny generation regardless of their relative numbers. Hence, effective population size will be lower than the summed census number of both sexes, and will also be less than four times as large as the number of adults of the less common sex. For example, a population derived from one male and three females would have an effective population size of three; a population derived from one male and an infinite number of females would have an effective population size of four (Crow and Kimura 1970). The latter population would experience the same amount of genetic drift as a population derived from only two males and two females. Similarly, populations with high fluctuations in abundance over time (or generations) will have an effective population size that is approximated by the harmonic mean of the effective population sizes of each generation. This harmonic mean will be influenced significantly by the generation with the lowest effective population size because that generation represents the "bottleneck" through which all genetic variation in future generations must pass.

It is relatively easy to relate effective population size to theoretical losses of genetic variation in future generations and, thus, provide conservation guidelines for effective population size. Based on standardized theoretical equations (Crow and Kimura 1970), the following guidelines have been established for maintaining minimum effective population sizes for conservation purposes:

- Effective Population Size > 50 to prevent inbreeding depression and a potential decrease in viability or reproductive fitness of a population (Franklin 1980);

- Effective Population Size > 500 to minimize loss of genetic variation due to genetic drift and maintain constant genetic variance within a population resulting from a balance between loss of variance due to genetic drift and an increase in variance due to new mutations or gene migration (Franklin 1980; Soulé 1980; Lande 1988);

- Effective Population Size > 5,000 to maintain constant variance for quasi-neutral, genetic variation that can serve as a reservoir for future adaptations in response to natural selection and changing environmental conditions (Lande 1995). The rationale here is that the effective population size needs to be large enough to minimize genetic drift and the potential loss of genetic material that may confer a slight, selective advantage under existing or future environmental conditions.

In contrast to establishing conservation guidelines for effective population size, it is much more difficult to quantitatively relate the breeding structure of a species and census numbers of populations to effective population size so that the 50/500/5000 guidelines can be applied at the appropriate scale. The longevity, life histories, and structure of individual breeding units (*i.e.*, *local populations*) must be understood sufficiently to relate the number of observed adults within a particular population (and in a particular generation) to a genetic *effective number of breeders*. Conceptually, this latter quantity will be similar to effective population size in the classical, textbook sense. Second, it is necessary to understand the amount of gene flow among geographically adjacent breeding units (*e.g.*, bull trout reproducing in adjacent tributaries to a river) so that, over multiple-generation time-scales, effective breeding numbers at the local population level can be considered part of a larger *metapopulation* with respect to applying the 50/500/5000 guidelines. For example, very small amounts of gene flow may not be sufficient to increase the effective number of breeders within a given local population above effective population equal to 50. However, in a combination of such populations that experience gene flow between them, effective breeding numbers for the metapopulation may be greater than 500. In this latter situation, one would predict significant genetic variation among breeding units and comparatively small amounts of genetic variation within individual breeding units, but the combination (or metapopulation) as a whole could potentially retain significant amounts of genetic variation over time. The key to understanding the evolutionary and conservation implications of such a breeding structure is knowing whether the individual breeding units, or local populations, are completely isolated reproductively or whether some gene flow does indeed occur, thus allowing genetic material to be reintroduced if lost from a particular population.

The effective population size > 5,000 rule derived by Lande (1995) relates largely to future evolutionary potential. Hence, the scale for its application are expected, in most cases, to be much larger than the spatial and temporal scales at which one applies the “50/500" rules. For example, the effective population size > 50 and effective population size > 500 guidelines may be most applicable on time scales encompassing 1 to 5 and 5 to 50 generations, respectively: at least 2 generations are necessary to produce “inbred” individuals after a population has gone through a major population bottleneck (*i.e.*, effective population size < 50), and a substantially greater number of generations are usually necessary for genetic drift to be significant (*i.e.*, when effective population size < 500). On the other hand, the effective population size > 5,000 guideline relates to the evolutionary persistence of a species over some defined geographic area such that, if extinction does occur, recolonization from elsewhere is precluded geographically or is unlikely to occur over microevolutionary time scales (*e.g.*, 50 or more generations).

Rieman and Allendorf (2001) have performed computer simulations of bull trout populations to understand the relationship between the observed number of adults, or spawners, within a local population and effective population size. Their best estimate of effective population size is 0.5 to 1.0 times the mean number of adult fish spawning annually. This translates into maintaining between 50 and 100 spawners per year to minimize potential inbreeding effects within local populations. The spatial scale for such a local population would encompass all adult fish with approximately equal probability of interbreeding amongst themselves within a single year or generation. One would expect such a population to include very few immigrants from another population or breeding unit. Between 500 and 1,000 spawners per year would be needed to maintain genetic variation and minimize the deleterious effects of drift. The appropriate spatial for maintaining genetic variation for bull trout would be most frequently applied at the core area level.

APPENDIX 4.

Federal Legislation, Activities and Guidelines Affecting Bull Trout Recovery

Endangered Species Act. Bull trout in the coterminous United States occur on lands administered by the Federal Government (*e.g.*, Bureau of Land Management, Forest Service, and National Park Service), various State-owned properties, and private and Tribal lands. The majority of bull trout spawning and rearing habitat occurs on Federal lands. Federal agency actions that occur on Federal lands or elsewhere with Federal funds or authorization may require consultation under the Endangered Species Act (16 USC 1531 *et seq*.). These actions include U.S. Army Corps of Engineers involvement in projects such as the construction of roads and bridges, the permitting of wetland filling and dredging projects subject to section 404 of the Clean Water Act (33 USC 1251 *et seq*.), construction, maintenance, and operation of dams and hydroelectric plants; Federal Energy Regulatory Commission-licensed hydropower projects authorized under the Federal Power Act (16 USC 791a *et seq*.); Forest Service and Bureau of Land Management timber, grazing, and recreation management activities; Environmental Protection Agency-authorized discharges under the National Pollutant Discharge Elimination System of the Clean Water Act; U.S. Housing and Urban Development projects; U.S. Bureau of Reclamation projects; and National Park Service activities. Because there are various policies, directives, and regulations providing management direction to Federal agencies and opportunities to conserve bull trout, *e.g.*, roadless area conservation on Forest Service lands (66 FR 3244), we provide the following types of activities as examples.

Bull Trout Interim Conservation Guidance. The purpose of the Bull Trout Interim Conservation Guidance is to provide U.S. Fish and Wildlife Service biologists with a tool that is useful in conducting Endangered Species Act activities, including section 7 consultations, negotiating Habitat Conservation Plans that culminate in the issuance of section 10(a)(1)(B)-incidental take permits (see section 10(a)(1) discussion below), issuing recovery permits, and providing technical assistance in forest practice rule development and other interagency bull trout conservation and recovery efforts. This document is not intended to supersede any biological opinion that has been completed for Federal agency actions. Rather, it should be used as another tool to assist in consultation on those actions.

PACFISH/INFISH. Land management plans for the Bureau of Land Management and Forest Service lands within the range of bull trout have been amended by the Interim Strategy for Managing Anadromous Fish-producing Watersheds in Eastern Oregon and Washington, Idaho, and Portions of California (PACFISH; USDA and USDI 1995a) and the Interim Strategy for Managing Fish-producing Watersheds in Eastern Oregon and Washington, Idaho, Western Montana and Portions of Nevada (INFISH; USDA and USDI 1995b). PACFISH, developed by the Bureau of Land Management and Forest Service, is intended to be an ecosystem-based, aquatic habitat and riparian-area management strategy for Pacific salmon, steelhead, and sea-run cutthroat trout habitat on lands administered by the two agencies that are outside the area subject to the Northwest Forest Plan. INFISH was developed by the Forest Service to provide an interim strategy for inland native fish in areas outside those where PACFISH and the Northwest Forest Plan apply. We issued a programmatic non-jeopardy biological opinion on land and resource management plans of the Bureau of Land Management and Forest Service, as amended by PACFISH and INFISH, for the Klamath and Columbia River population segments of bull trout that endorsed implementation of additional commitments made by the two agencies (USFWS 1998a). The commitments included habitat restoration and improvement; standards and guidelines of PACFISH and INFISH; evaluation of key and priority watershed networks; completion of watershed analysis and monitoring; establishing goals for long-term conservation and recovery; and conducting section 7 consultation at the watershed level. The biological opinion also identified additional actions to help ensure conservation of bull trout. Consultations for site-specific actions are continuing, as are consultations for land and resource management plans in other bull trout population segments.

In December, 1998, the regional executives for the U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Forest Service and Bureau of

Land Management chartered The Interagency Implementation Team. This Team is integral to the implementation of PACFISH and INFISH, under the direction of the regional executives, and is responsible for coordinating implementation of the biological opinions on the effects of the aquatic conservation strategies on listed salmon, steelhead and bull trout. The Team has directed the development of a PACFISH/INFISH Monitoring Task Team to develop a monitoring program for tracking implementation and effectiveness of PACFISH/INFISH.

Northwest Forest Plan. On April 13, 1994, the Secretaries of the Department of Agriculture and the Department of the Interior adopted the Northwest Forest Plan for management of late-successional forests within the range of the northern spotted owl (USDA 1994a, b). This plan contains objectives, standards, and guidelines to provide for a functional late-successional and old-growth forest ecosystem. Included in the plan is an Aquatic Conservation Strategy involving riparian reserves, key watersheds, watershed analysis, and habitat restoration. We issued a programmatic non-jeopardy biological opinion on the plan for the Coastal-Puget Sound, Columbia River, and Klamath River population segments of bull trout (USFWS 2000). The biological opinion also identified additional actions to be taken by the Federal land managers to help ensure conservation of bull trout. These actions included clearly documenting that proposed actions are consistent with the aquatic conservation strategy objectives, developing and implementing guidance for reducing effects of road management programs on bull trout, and responding quickly to mining notices on lands administered by the Bureau of Land Management in order to advise operators how to prevent adverse effects to bull trout. Consultations for site-specific actions are ongoing.

Section 10(a)(1) Permits. Permits, authorized under section 10(a)(1) of the Endangered Species Act, may be issued to carry out otherwise prohibited activities involving endangered and threatened wildlife under certain circumstances. Permits are available for scientific purposes to enhance the propagation or survival of a species and for incidental "take" (harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect a listed species) in connection with otherwise lawful activities. Private landowners seeking permits for incidental take offer a means of protecting bull trout habitat through the voluntary development of Habitat Conservation Plans and Safe Harbor Agreements.

Habitat Conservation Plans. Incidental take permits are required when non-Federal activities will result in "take" of threatened or endangered species. A habitat conservation plan must accompany an application for an incidental take permit. The purpose of the Habitat Conservation Planning process is to ensure there is adequate minimization and mitigation of effects from the authorized incidental take. The purpose of the incidental take permit is to authorize the incidental take of a listed species.

As one example, the Plum Creek Timber Company developed a Habitat Conservation Plan with us addressing bull trout and other native salmonids occurring on over 688,500 hectares (1.7 million acres) of corporate lands, primarily in the Columbia River basin. The majority of the land under consideration occurs in Montana (87 percent) with the remainder in Idaho and Washington. Because silvicultural activities, logging road construction and maintenance, and open range cattle grazing by the Plum Creek Timber Company may result in harm to bull trout, seven categories of conservation commitments were included in the Habitat Conservation Plan. The seven categories are: (1) road management, (2) riparian management, (3) livestock grazing, (4) land-use planning, (5) legacy management and other restoration opportunities, (6) administration and implementation measures, and (7) monitoring and adaptive management. The conservation benefits of activities in the seven categories include reducing sediment delivery to streams from roads and grazing, increasing canopy cover in riparian areas, restoring stream bank integrity and overall habitat complexity, and providing fish passage at road culverts and water diversion structures.

In Washington, the Washington Department of Natural Resources developed a Habitat Conservation Plan that was adopted on January 1, 1999. The plan covers the approximately 647,500 hectares (1.6 million acres) of forested State trust lands that lie within the range of the northern spotted owl. The Habitat

Conservation Plan contains riparian conservation strategies that were designed to protect salmonid and riparian species for lands west of the Cascade Mountains crest. It includes a streamside no-harvest buffer strategy, a minimal-harvest area for ecosystem restoration, and a low-harvest area for selective removal of single trees or groups of trees and thinning and salvage operations. In addition to riparian buffers, road management standards were developed to ensure that mass-wasting (erosion and landslides) is not artificially accelerated and that sediment delivery remains near natural levels. The Habitat Conservation Plan also includes monitoring and adaptive management components. The minimization and mitigation actions of the plan will address habitat requirements of bull trout and cumulatively will reduce the adverse effects to bull trout in comparison to previous forest management practices (USFWS 1998b).

Safe Harbor Agreements. Safe Harbor Agreements between the U.S. Fish and Wildlife Service and non-Federal landowners are another voluntary mechanism to encourage conservation of listed species and authorize incidental take permits. In general, these agreements provide (1) conservation benefits for listed species that would otherwise not occur except for the agreement, and (2) Endangered Species Act regulatory assurances to the landowner through a section 10 permit. Safe Harbor Agreements are intended for landowners who have few or no listed species (or listed species' suitable habitat) on their property, but who would be willing to manage their property in such a way that listed species may increase on their lands, as long as they are able to conduct their intended land-use activities. An example of how Safe Harbor Agreements may be used to further bull trout conservation can be found with fish passage barriers in streams. If a landowner owns a stream with a fish passage barrier that prevents access to their property by bull trout, they may be unwilling to remove the barrier, and thereby allow access by bull trout, for fear of the "take" prohibitions under section 9 of the Endangered Species Act and potential restrictions on land-use activities. Under a Safe Harbor Agreement, the landowner would agree to removal of the barrier, allow bull trout access to their property, and the landowner and U.S. Fish and Wildlife Service would negotiate other conservation measures necessary to ensure suitable bull trout habitat conditions are maintained on the property while allowing the landowner's land-use activities to occur. The landowner would receive a section 10 permit authorizing incidental take of bull trout consistent with the agreed upon conservation measures in the Safe Harbor Agreement. Safe Harbor Agreements for bull trout may be developed in the future.

Clean Water Act. The Clean Water Act (33 USC 1251 *et seq*.) provides some regulatory mechanisms for protection and restoration of water quality in waters that support bull trout. Under sections 303 and 304, states or the Environmental Protection Agency set water quality standards, which combine designated beneficial uses and criteria established to protect uses. States or the Environmental Protection Agency designate water bodies that are failing water quality standards as water quality limited under section 303(d) (*e.g.*, Appendix 1), and are required to develop management plans. Management plans include total maximum daily loads with implementation plans that define site-specific actions and timelines for meeting water quality goals (65 FR 43586). The total maximum daily loads assess and allocate all the point and nonpoint sources of pollutants within a watershed. Best management practices are used with total maximum daily loads to address nonpoint sources of pollution, such as mining, forestry, and agriculture. Regulatory authority to enforce the best management practices, however, varies among the states. The U.S. Environmental Protection Agency requests that states give higher priority to polluted waters that are sources of drinking water or support listed species, when developing total maximum daily loads and implementation plans (65 FR 43586).

In accordance with section 319 of the Clean Water Act, states also develop programs to address nonpoint sources of pollution such as agriculture, forestry, and mining. The effectiveness of controlling water pollution from these activities has been mixed. The State of Washington monitored the effectiveness of riparian prescriptions under past forest practices regulations in meeting water quality temperature criteria for streams on forest lands and concluded that regulations for stream shading were inadequate to meet criteria (Sullivan *et al.* 1990).

Northwest Power Planning Council Fish and Wildlife Program. Congress, through the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (16 USC 839), directed the Northwest Power Planning Council to develop a Fish and Wildlife Program. The program is intended to give the citizens of Idaho, Montana, Oregon, and Washington a stronger voice in the future of electricity generated by the Federal hydropower dams in the Columbia River basin and fish and wildlife affected by the dams and their operation.

One of the Northwest Power Planning Council's major responsibilities is to develop a program to protect and rebuild fish and wildlife populations affected by hydropower development in the Columbia River basin. State, Tribal, and local governments often work closely with the Northwest Power Planning Council as it develops power and fish and wildlife plans. The Bonneville Power Administration provides funding for implementation of the Council's Fish and Wildlife Program. In 2000, the Council amended its Fish and Wildlife Program to include development of subbasin plans. Subbasin planning, beginning in 2002, is a means for identifying projects that will be funded to protect, mitigate, and enhance the Columbia River basin’s fish and wildlife resources. These plans are viewed as crucial efforts for implementing the Endangered Species Act responsibilities of the Bonneville Power Administration, U.S. Army Corps of Engineers, and the Bureau of Reclamation in the Columbia River basin.

The primary objective of subbasin planning is to develop a unifying element for implementation of the Northwest Power Planning Council's Fish and Wildlife Program. It will also assist in the implementation of Endangered Species Act recovery activities. One of the goals of the subbasin planning process is to provide specific products that can be integrated directly into the Endangered Species Act recovery planning process. We will provide specific geographic area bull trout recovery plan to the applicable subbasin planning teams that have the responsibility for developing subbasin plans.

Federal Caucus Fish and Wildlife Plan. The Federal Caucus is a group of nine Federal agencies, formed as a result of the Federal Columbia Power System Biological Opinion, that have responsibilities for natural resources affecting species listed under the Endangered Species Act. The agencies are the National Marine Fisheries Service, U.S. Fish and Wildlife Service, Bureau of Reclamation, Bonneville Power Administration, U.S. Army Corps of Engineers, Bureau of Indian Affairs, Forest Service, Bureau of Land Management, and

Environmental Protection Agency. The Federal Caucus has drafted a basinwide recovery strategy for listed anadromous fish in the Columbia River basin which addresses management of habitat, hatcheries, harvest, and hydropower. This recovery strategy, titled 'The Conservation of Columbia River Basin Fish: Final Basin-Wide Recovery Strategy,' will provide the framework for development of recovery plans for individual species and for effects determinations for actions under consultation. As recovery plans for individual species are developed following the basinwide strategy, and measures to address biological needs of all stages of the life cycle are implemented, conditions for listed aquatic species are expected to improve sufficiently to provide for their survival and recovery. The Basin-Wide Salmon Recovery Strategy concludes that restoring tributary and estuary habitat is key to recovering listed fish. Actions focus on restoring tributary (both Federal and non-Federal), mainstem, and estuary habitat.

For long-term actions, the Basin-Wide Salmon Recovery Strategy endorses the Northwest Power Planning Council strategy of conducting subbasin assessments and developing subbasin plans and prioritizing actions based on those plans. Once the assessments are complete, the Federal agencies will participate with State agencies, local governments, Tribes and stakeholders to develop subbasin plans. Draft subbasin summaries were used extensively in the preparation of the bull trout recovery plan.

While the salmon recovery framework has only recently been adopted, and thus the benefits of this recovery framework have not yet been realized, we envision significant improvements in habitat conditions for listed salmonids as recovery activities are implemented. Because bull trout often use the same areas, we expect bull trout to similarly benefit from improved habitat conditions.

U.S. Department of Agriculture. The U.S. Department of Agriculture offers landowners financial, technical, and educational assistance to implement conservation practices on privately owned land. Using this help, farmers and ranchers apply practices that reduce soil erosion, improve water quality, and enhance forest land, wetlands, grazing lands, and wildlife habitat. U.S.

Department of Agriculture assistance also helps individuals and committees restore after floods, fires, or other natural disasters.

This assistance is provided to landowners via Farm Bill programs administered by the U.S. Department of Agriculture, Farm Service Agency and the Natural Resources Conservation Service. The implementation of practices associated with these programs may improve conditions for bull trout. In particular, the Conservation Reserve Enhancement Program is targeted to areas in Oregon and Washington where other listed fish occur and may provide direct benefits to bull trout.

The Conservation Reserve Easement Program is an addition to the Conservation Reserve Program. A Conservation Reserve Enhancement Program for the State of Oregon and the State of Washington was approved October 1998, in a Memorandum of Agreements between the United States Department of Agriculture, the Commodity Credit Corporation and the states of Oregon and Washington. The Conservation Reserve Easement Program is a partnership between Federal agencies, State agencies, and private landowners. Land enrolled in this program is removed from production and grazing, under 10 to 15 year contracts. In return, landowners receive annual rental, incentive, maintenance and cost share payments.

In Washington, eligible stream designations were originally based on spawning habitat for stocks designated as critical or depressed under the 1993 Salmon and Steelhead Stock Inventory. Approximately 9,656 kilometers (6,000 miles) of eligible streams were included. Recent changes allow for the nomination of additional stream segments where riparian habitat is a significant limiting factor, and a new cap of 16,093 kilometers (10,000 miles) of eligible streams.

Other Farm Bill programs encourage farmers to convert highly erodible cropland or other environmentally sensitive acreage to native vegetative cover, provide incentives for landowners to restore function and value to degraded wetlands on a long-term or permanent basis, assist landowners with habitat restoration and management activities specifically targeting fish and wildlife (including threatened and endangered species), provide technical and financial assistance to farmers and ranchers that face threats to soil, water, and related natural resources, and support forest management practices on privately owned, nonindustrial forest lands.

APPENDIX 5.

Glossary of Technical Terms

Adaptive trait

Characteristics that improve an individual's survival and fitness.

Adfluvial bull trout

Bull trout that migrate from tributary streams to a lake or reservoir to mature (one of three migratory bull trout life history forms, the others being anadromous and fluvial forms). Adfluvial bull trout return to a tributary to spawn.

Age class

A group of individuals of a species that have the same age, *e.g.*, 1 year old, 2 year old, etc.

Aggradation/Aggrading stream

A stream that is actively building up its channel or floodplain by being supplied with more bedload than it is capable of transporting.

Alevin

A newly hatched fish still possessing a yolk sac.

Alluvial

Pertaining to or composed of silts and clays (usually) deposited by a stream or flowing water. Alluvial deposits may occur after a flood event.

Alluvial fan

A sedimentary deposit located at a topographic break such as the base of a mountain front, escarpment, or valley side, that is composed of streamflow and/or debris flow sediments and that has the shape of a fan, either fully or partially extended.

Anadromous (fish)

A fish that is born in fresh water, migrates to the ocean to grow and live as an adult, and then returns to freshwater to spawn (reproduce). Anadramous bull trout are one of three migratory bull trout life history forms, the others being adfluvial and fluvial forms.

Artificial propagation

The use of artificial procedures to spawn adult fish and raise the resulting progeny in fresh water for release into the natural environment, either directly from the hatchery or by transfer into another area.

Bedload

Sediment particles that are moved on or immediately above the stream bed, such as the larger heavier particles (gravel, boulders) rolled along the bottom; the part of the load that is not continuously in suspension.

Braided channel/Braided stream

A stream that forms an interlacing network of branching and recombining channels separated by islands and channel bars. Generally a sign of stream disequilibrium resulting from transportation of excessive rock and sediment from upstream areas and characteristic of an aggrading stream in a wide channel on a floodplain.

Bypass system (fish)

Structure in a dam that provides a route for fish to move through or around a dam without going through the turbines.

Canopy cover (of a stream)

Vegetation projecting over a stream, including crown cover (generally more that 1 meter [3.3 feet] above the water surface) and overhang cover (less than 1 meter [3.3 feet] above the water).

Channel morphology

The physical dimension, shape, form, pattern, profile, and structure of a stream channel.

Channel stability

The ability of a stream, over time and in the present climate, to transport the sediment and flows produced by its watershed in such a manner that the stream maintains its dimension, pattern, and profile without either aggrading or degrading.

Channelization

The straightening and deepening of a stream channel to permit the water to move faster, to reduce flooding, or to drain wetlands.

Char (*also* charr)

A fish belonging to the genus *Salvelinus* and related to both the trout and salmon. The bull trout, Dolly Varden trout, and the Mackinaw trout (or lake trout) are all members of the char family. Char live in the icy waters (both fresh and marine) of North America and Europe.

Complex interacting groups

Multiple local populations within a geographic area having connectivity that allows for individuals from each of these populations the opportunity to interact with one another.

Connectivity (stream)

Suitable stream conditions that allow fish and other aquatic organisms to move freely upstream and downstream. Habitat linkages that connect to other habitat areas.

Core area

The combination of core habitat (*i.e.*, habitat that could supply all elements for the long-term security of bull trout) and a core population (a group of one or more local bull trout populations that exist within core habitat) constitutes the basic unit on which to gauge recovery. Core areas require both habitat and bull trout to function, and the number (replication) and characteristics of local populations inhabiting a core area provide a relative indication of the core area's likelihood to persist. In most cases, core areas are presumed to reflect the metapopulation structure of bull trout (see "metapopulation," below).

Core habitat

Habitat that encompasses spawning and rearing habitat (resident populations), with the addition of foraging, migrating, and overwintering habitat if the population includes migratory fish. Core habitat is defined as habitat that contains, or if restored would contain, all of the essential physical elements to provide for the security of and allow for the full expression of life history forms of one or more local populations of bull trout. Core habitat may include currently unoccupied habitat if that habitat contains essential elements for bull trout to persist or is deemed critical to recovery.

Core population

A group of one or more bull trout local populations that exist within core habitat.

Deposition (stream)

The settlement or accumulation of material out of the water column and onto the stream bed. Occurs when the energy of flowing water is unable to support the load of suspended sediment.

Deposition zone/Depositional areas (stream)

Local zones within a stream where the energy of flowing water is reduced and suspended material settles out, accumulating on the streambed.

Discharge (stream)

With reference to stream flow, the quantity of water that passes a given point in a measured unit of time, such as cubic meters per second or, often, cubic feet per second.

Distinct population segment

A distinct population segment is a population subset of a vertebrate species or subspecies that meets the tests of discreteness and significance under the joint policy of the U.S. Fish and Wildlife Service and National Marine Fisheries Service (61 FR 4722). A distinct population segment designated as such under a regulatory rulemaking is a “listable entity” under the Endangered Species Act.

Distributary

A natural stream channel that branches from a trunk stream which it may or may not rejoin. It occurs typically on the surface of an alluvial fan or delta, where it may be part of a complex, fan-shaped network that distributes the discharge and sediment load of the main channel among many small distributary channels.

Effective population size

The number of breeding individuals that would give rise to the same amount of random genetic drift as the actual population, if ideal conditions held. Generally speaking, the effective population size is a measure of the number of individuals that are contributing to future generations from a genetic perspective. The effective population size is often significantly smaller than the census population size.

Entrainment

Process by which aquatic organisms are pulled through a diversion, turbine, spillway, or other device.

Extirpation

The elimination of a species from a particular local area.

Fine sediment (fines)

Sediment with particle sizes of 2.0 millimeters (0.08 inch) or less, including sand, silt, and clay.

Fish ladder

A device to help fish swim around a dam.

Floodplain

Adjacent to stream channels, areas that are typified by flat ground and are periodically submerged by floodwater.

Flow regime

The quantity, frequency and seasonal nature of water flow.

Fluvial bull trout

Bull trout that migrate from tributary streams to larger rivers to mature (one of three migratory bull trout life history forms, the others being adfluvial and anadromous forms). Fluvial bull trout migrate to tributaries to spawn.

Foraging, migration, and overwintering habitat (bull trout)

Relatively large streams and mainstem rivers, lakes or reservoirs, estuaries, and nearshore environments, where subadult and adult migratory bull trout forage, migrate, mature, or overwinter. This habitat is typically downstream from spawning and rearing habitat and contains all the physical elements to meet critical overwintering, spawning migration, and subadult and adult rearing needs. Although use of foraging, migrating, and overwintering habitat by bull trout may be seasonal or very brief (as in some migratory corridors), it is a critical habitat component.

Fry

Young, recently hatched fish.

Headwaters

The source of a stream. Headwater streams are the small swales, creeks, and streams that are the origin of most rivers. These small streams join together to form larger streams and rivers or run directly into larger streams and lakes.

Hooking mortality

Death of a fish from stress or injury after it is hooked and reeled in, then released back to the water.

Hybridization

Any crossing of individuals of different genetic composition, typically different species, that result in hybrid offspring.

Hyporheic zone

Area of saturated sediment and gravel beneath and beside streams and rivers where groundwater and surface water mix. Water movement is mainly in a downstream direction**.**

Interspecific competition

Competition for resources between two or more different species.

Legacy effects

Impacts from past activities (usually a land use) that continue to affect a stream or watershed in the present day.

Local population

A group of bull trout that spawn within a particular stream or portion of a stream system. Multiple local populations may exist within a core area. A local population is considered to be the smallest group of fish that is known to represent an interacting reproductive unit. For most waters where specific information is lacking, a local population may be represented by a single headwater tributary or complex of headwater tributaries. Gene flow may occur between local populations (*e.g.*, those within a core population), but is assumed to be infrequent compared with that among individuals within a local population.

Littoral zone

The shore of a lake to a depth of about 10 meters (33 feet).

Management unit (bull trout)

A subset of a listed entity that is defined by the U.S. Fish and Wildlife Service for administrative and management purposes, usually to manage recovery for a species that is broadly distributed and that may experience a wide range of threats and management authorities across its distribution. In the case of bull trout, the distinct population segment was further subdivided into management units based on several factors, including biological and genetic considerations, political boundaries, and ongoing conservation efforts. In some instances, management unit boundaries were modified to maximize efficiency of established watershed groups, encompass areas of common threats, or accommodate other logistic concerns. Biologically, management units are considered groupings of bull trout for which gene flow was historically or is currently possible. Management units are utilized to more effectively target specific recovery actions, but management units are not eligible for reclassification or delisting separately from the listed entity.

Mass wasting

Loss of large amounts of material in a short period of time, *i.e.*, downward movement of land mass material or landslide.

Metapopulation

There are several different models of metapopulation dynamics, but in general a metapopulation refers to a population structure in which subpopulations may be distributed across the landscape in a patchy or semi-isolated pattern, but connectivity between these subpopulations is critical for maintaining the metapopulation as a whole. In the case of bull trout, we assumed that core areas represent the functional equivalent of a metapopulation structure for bull trout, and that the local populations within these core areas are interconnected by occasional dispersal between them and therefore share some genetic characteristics.

Migratory corridor (bull trout)

Stream reaches used by bull trout to move between habitats. A section of river or stream used by fish to access upstream spawning areas or downstream lake environments. *See also* "foraging, migration, and overwintering habitat."

Migratory life history form (bull trout)

Bull trout that migrate from spawning and rearing habitat to lakes or reservoirs (adfluvial), larger rivers (fluvial), or the ocean (anadromous) to grow and mature.

Mysid

A small, shrimp-like crustacean of the order Mysidacea. Mysids are found primarily in marine waters, but there are some freshwater forms as well.

Nonnative species

Species not indigenous to an area, such as brook trout in the western United States.

Otolith(s)

Otoliths are compact, mineralized structures suspended in the interior of the inner ear of teleost (bony) fishes. Important in orientation and locomotion, otoliths grow in concentric layers (similar to the growth rings of a tree) reflecting the daily growth of the fish and essentially record the environmental conditions encountered by the individual.

Peak flow (stream)

Greatest stream discharge recorded over a specified period of time, usually a year, but often a season.

Penstock

In a hydropower dam, the pipe that carries water from an upstream reservoir or pond downstream to the turbine generator in a power house.

Phenotype

Expressed physical, physiological, and behavioral characteristics of an organism that may be due to genetics, the environment, or an interaction of both.

Piscivorous

Describes fish that prey on other fish for food.

Potential local population

A local population that does not currently exist, but that could exist, if spawning and rearing habitat or connectivity were restored in that area, and contribute to recovery in a known or suspected unoccupied area. Alternatively, a potential local population may be a population that is suspected to exist, but that has not yet been adequately documented.

Probability of persistence

The probability (usually expressed as a percentage) that a population or subpopulation of fish will survive and be present in a specific geographic location through some future time period, usually 100 years.

Ramp (*v.* to)/Ramping

Refers to the change of river flows as the result of dam or diversion operations. How fast the facility changes (increases or decreases) the flow is known as the "ramping rate."

Recovery team (bull trout)

A team of people with technical expertise in various aspects of bull trout biology from Federal and State agencies, Tribes, private industry, and interest groups responsible for assisting in the development of the bull trout recovery plan for a given management unit.

Redd

A nest constructed by female fish of salmonid species in streambed gravels where eggs are deposited and fertilization occurs. Redds can usually be distinguished in the streambed gravel by a cleared depression, and an associated mound of gravel directly downstream.

Refounding

Reestablishment of a species into previously occupied habitat.

Resident life history form (bull trout)

Bull trout that do not migrate, but that reside in tributary streams their entire lives (one of four bull trout life history forms; the other three forms are all migratory [adfluvial, fluvial, or anadromous]).

Revetment

A facing, usually of stone or concrete, that supports an embankment.

Riparian area

Area with distinctive soils and vegetation between a stream or other body of water and the adjacent upland. It includes wetlands and those portions of floodplains and valley bottoms that support riparian vegetation.

Riprap

A common type of streambank armoring or protection, formed of rocks of various sizes.

Salmonid

Fish of the family Salmonidae, including trout, salmon, chars, grayling, and whitefish. In general usage, the term most often refers to salmon, trout, and chars.

Scour

Concentrated erosive action by stream water, as on the outside curve of a bend; also, a place in a streambed swept clear by a swift current.

Seral stage

A developmental stage in ecological succession, not including the climax community.

Smolt

A juvenile salmon or steelhead migrating to the ocean and undergoing physiological changes to adapt its body from a freshwater environment to a saltwater environment.

Spawning and rearing habitat/streams/areas (bull trout)

Stream reaches and the associated watershed areas that provide all habitat components necessary for spawning and juvenile rearing for a local bull trout population. Spawning and rearing habitat generally supports multiple year classes of juveniles of resident or migratory fish and may also support subadults and adults from local populations of resident bull trout.

Spawning escapement

The number of adult fish from a specific population that survive spawning migrations and enter spawning grounds.

Spillway

The part of a dam that allows high water to flow (spill) over the dam.

Splash dam

A temporary or permanent structure in a stream channel that was historically used to store logs and water until sufficient water was retained from precipitation and runoff to transport the logs downstream when the splash dam was opened.

Stochastic

The term is used to describe natural events or processes that are random. Examples include environmental conditions such as rainfall, runoff, and storm events, or life-cycle events, such as survival or fecundity rates.

Stock

The fish spawning in a particular lake or stream(s) at a particular season, which to a substantial degree do not interbreed with any group spawning in a different place, or in the same place at a different season. A group of fish belonging to the same population, spawning in a particular stream in a particular season.

Subpopulation (bull trout)

A reproductively isolated group of bull trout spawning within a particular area of a river system; the basic unit of analysis used in the initial listing of bull trout, but not used extensively in the recovery plan.

Subwatershed

Topographic perimeter of the catchment area of a stream tributary.

Suspended sediment

Solids, either organic or inorganic, found in the water column of a stream or lake. Sources of suspended sediment may be either human induced, natural, or both.

Tailrace

A channel with highly turbulent water, usually confined by concrete or riprap, in the tailwater of a reservoir. The flowing water below a dam which is released from an upstream reservoir forms the tailwater.

Take

Activities that harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect; or attempt to engage in any such conduct to a listed (Endangered Species Act) species.

Transplantation

Moving wild fish from one stream system to another without the use of artificial propagation.

Trap and haul

An operation to physically move migratory fish upstream around a barrier that does not have a fish ladder or other passage to allow spawning. Fish are generally captured in a trap and transported by truck to a release site upstream of the barrier.

Water right

Any vested or appropriation right under which a person may lawfully divert and use water. It is a real property right appurtenant to and severable from the land on or in connection with which the water is used; such water right passes as an appurtenance with a conveyance of the land by deed, lease, mortgage, will, or inheritance.

Water yield (basin yield)

The quantity of water available from a stream at a given point over a specified duration of time.

Watershed

The area of land from which rainfall (and/or snow melt) drains into a stream or other water body. Watersheds are also sometimes referred to as drainage basins or drainage areas. Ridges of higher ground generally form the boundaries between watersheds. At these boundaries, rain falling on one side flows toward the low point of one watershed, while rain falling on the other side of the boundary flows toward the low point of a different watershed.

Woody debris

Woody material such as trees and shrubs; includes all parts of a tree such as root system, bowl, and limbs. Large woody debris refers to the woody material whose smallest diameter is greater than 10 centimeters (4 inches) and whose length is greater than 1 meter (3.3 feet).

Year class (cohort)

Fish in a stock born in the same year. For example, the 1987 year class of bull trout includes all bull trout born in 1987, which would be age 1 in 1988.