APPENDIX H
NOOKSACK CORE AREA

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Nooksack River Core Area

The Nooksack River core area comprises the Nooksack River and its tributaries, including the North, Middle, and South Fork Nooksack Rivers. Fluvial and anadromous are the most abundant life history forms in the Nooksack River core area. Presence of the resident life history form is unknown (USFWS 2008a, Nooksack River core area Chapter, p. 1). Bull trout spawning occurs in the North, Middle, and South Fork Nooksack Rivers and their tributaries. Post-dispersal rearing and subadult and adult foraging probably occur throughout most of the accessible reaches below barriers to anadromous fish. Overwintering likely occurs primarily in the lower mainstem reaches of the three forks and in the mainstem Nooksack River. Bull trout from the Nooksack River core area are known to utilize marine waters at least as far south as the Swinomish Channel in Puget Sound, based on limited acoustic tagging efforts (Goetz et al. 2007, p. 9).

Bull trout and Dolly Varden (*S. malma*) co-occur in the Nooksack River core area, but the level of interaction between the two species and degree of overlap in their distributions is unknown. Limited genetic analysis and observational data suggest Dolly Varden in this core area inhabit stream reaches above barriers to anadromous fish, while bull trout primarily occupy the accessible stream reaches below the barriers. Other salmonids that are present in this watershed include coho salmon (*Oncorhynchus kisutch*), steelhead/rainbow trout (*O. mykiss*), cutthroat trout (*Salmo clarki*), pink salmon (*O. gorbuscha*), chum salmon (*O. keta*) (Currence 2007, pp. 3, 6), Chinook salmon (*O. tshawytscha*) (USFWS 2008a, Nooksack River core area Chapter, p. 2), and sockeye salmon (*O. nerka*) (WSCC 2002, p. 50).

The Nooksack River core area population is considered at "potential risk" for extirpation (USFWS 2008b, p. 35; USFWS 2015b). The status of the bull trout core area population can be summarized by four key elements necessary for long-term viability: 1) number and distribution of local populations, 2) adult abundance, 3) productivity, and 4) connectivity (USFWS 2004, Vol. I, p. 215).

Number and Distribution of Local Populations

Ten local populations are recognized within the Nooksack River core area (USFWS 2004, pp. 56-74; USFWS 2015a, pp. A-10 to A-11): 1) Lower Canyon Creek, 2) Glacier Creek, 3) Lower Middle Fork Nooksack River, 4) Upper Middle Fork Nooksack River, 5) Lower North Fork Nooksack River, 6) Middle North Fork Nooksack River, 7) Upper North Fork Nooksack River, 8) Lower South Fork Nooksack River, 9) Upper South Fork Nooksack River, and 10) Wanlick Creek. Spawning areas used by the local populations are believed to be small and dispersed. Core areas with 5 to 10 interconnected local populations are at an intermediate risk of local extirpation and adverse effects from random naturally-occurring events (USFWS 2004, pp. 216-218). Most, but not all, Nooksack River core area local populations are interconnected (see Connectivity section below).

Adult Abundance

The Nooksack River core area adult abundance is estimated between 250 to 1,000 individuals based on limited spawn survey data. Eight of the local populations likely have fewer than 100 adults each, based on the relatively low number of migratory adults observed returning to the core area. The North Fork has more confirmed spawning areas than the Middle or South Forks (Currence 2007, p. 5). In the North Fork, Thompson Creek has the most consistent and highest numbers of bull trout redds recorded of any stream in the Nooksack River watershed (Currence 2007, p. 6). In the Middle Fork, the anadromous life history form is mostly or entirely blocked at the Bellingham Diversion Dam, and fluvial individuals are infrequently recorded in the upper portion of the system, although survey efforts are limited (USFWS 2008a, Nooksack River core area Chapter, p. 2). Incidental observations of South Fork Nooksack River bull trout redds are occasionally noted during Chinook surveys in the upper river. More often though, incidental observations of staging anadromous adults are recorded during the Chinook surveys, usually between river miles 21 and 30. Although not complete counts, recorded numbers of adults are consistently in the single digits, suggesting a small population size (USFWS 2008a, Nooksack River core area Chapter, p. 2). The Glacier Creek local population has approximately 100 adults, based on incidental redd counts and available spawning habitat. The Upper North Fork Nooksack River local population may support 100 adults, based on the persistent, small numbers of spawning adults observed in tributaries and available side channel habitat.

The Nooksack River core area is at risk from genetic drift because it likely contains fewer than 1,000 spawning adults per year (USFWS 2004, pp. 218-224). Eight local populations are at risk from inbreeding depression because they are believed to contain fewer than 100 spawning adults per year (USFWS 2004, pp. 218-224). Only two local populations – the Glacier Creek and the Upper North Fork Nooksack River populations – are not at risk from inbreeding depression.

Productivity

Currently, there is insufficient information to determine a trend in the size of the core area population (USFWS 2008a, Nooksack River core area Chapter, p. 4). Estimates of population growth rate that indicate a population is consistently failing to replace itself are at increased risk of extirpation. The Nooksack River core area is considered at increased risk of extirpation until sufficient information is available to assess productivity.

Connectivity

There is connectivity among most of the local populations, except for the Middle Fork Nooksack River. The Bellingham Diversion Dam on the Middle Fork Nooksack River obstructs fish movement into and out from the reach occupied by the Upper Middle Fork Nooksack River local population (USFWS 2004, p. 190). High seasonal temperatures on reaches of the South Fork Nooksack River limit migratory movements into and out of this area, temporarily isolating the three local populations found here (Lower South Fork Nooksack River, Upper South Fork Nooksack River, and Wanlick Creek) (USFWS 2004, p. 160). There is a partial barrier limiting movement into and out of the Lower Canyon Creek local population due to previous Whatcom County flood control work (Nooksack Natural Resources et al. 2005, pp. 88-89), although

Whatcom County may improve passage as part of a restoration effort proposed in 2013. There are road culvert barriers in several local populations. For these reasons, the Nooksack River core area is considered at intermediate risk of extirpation from habitat isolation and fragmentation.

Acoustic tagging studies have shown that anadromous bull trout have extensive and complex migrations throughout the nearshore areas of Puget Sound (Goetz et al. 2004; Goetz et al. 2007). These study results strongly indicate that connectivity within nearshore habitats and among major river basins within Puget Sound are necessary for the anadromous form to complete its life history.

Changes in Environmental Conditions and Population Status

Since the bull trout listing, federal actions occurring in the Nooksack River core area have had short- and long-term effects to bull trout and bull trout habitat, and have both positively and negatively affected bull trout. These actions have included: statewide federal restoration programs with riparian restoration, replacement of fish passage barriers, and fish habitat improvement projects; federally funded transportation projects involving repair and protection of roads and bridges; and section 10(a)(1)(B) permits for Habitat Conservation Plans addressing forest management practices. Capture and handling during implementation of section 6 and section 10(a)(1)(A) permits have directly affected bull trout in the Nooksack River core area.

The number of non-federal actions occurring in the Nooksack River core area since the bull trout listing is unknown. Activities conducted on a regular basis, such as emergency flood control, development, and infrastructure maintenance, affect riparian and instream habitat and probably negatively affect bull trout. Additionally, a significant number of mass wasting events have been associated with timber management and associated road construction in the Nooksack basin (WSCC 2002, pp. 91, 93, 117, 130).

Salmon recovery efforts are improving conditions for bull trout. Although directed toward salmonids other than bull trout, the regional salmon recovery plan under the Shared Strategy for Puget Sound (SSPS 2007) and watershed-scale implementation under the Puget Sound Partnership have resulted in general aquatic habitat improvements that are likely benefitting bull trout. Also, the Critical Areas Ordinance and Shoreline Management Plan were updated for Whatcom County, which may benefit bull trout. However, there are concerns with implementation of the ordinance, particularly with variances and enforcement of buffers within riparian areas (Currence, in litt. 2008).

Climate change is expected to have substantial adverse effects to bull trout in the Nooksack River core area. The Nooksack River core area is a glacier fed system except for the South Fork Nooksack River, which does not receive glacial melt (USFS 2006, p. 35). The North and Middle Forks are somewhat buffered against increases in high temperatures due to glacial melt. However, as glaciers continue to contract and recede with climate change, summer discharges are expected to decrease and temperatures increase (Snover et al. 2005). Glacier recession is also expected to increase the incidence of debris flows (Seattle Post Intelligencer 2008; Chiarle et al. 2007), negatively impacting spawning and rearing areas. Several debris flows from the

Deming Glacier were documented in 2013. Such debris flows may occur in more Mount Baker drainages due to increased glacial contraction and exposure of the glacial moraines (MBVRC 2013a; MBVRC 2013b).

The South Fork Nooksack River is seasonally acutely temperature impaired, with peak temperatures in the 20 °C to 24 °C range (Smith 2002, pp. 172-173). Some impairment of water temperatures have also been observed within the North and Middle Forks. The mainstem Nooksack River is generally temperature-impaired throughout the summer months. The temperature criterion in this reach of the river is 16 °C. The annual 7-day average maximum water temperatures measured at the long-term monitoring station at Cedarville (WDOE station 01A120) between 2001and 2010 rarely exceeded 18 °C (19 °C in 2005 and 2009).

Climate change is expected to result in less annual snow pack and earlier loss of snow pack, which is likely to reduce summer low flow migration and rearing habitats. Climate change is also expected to increase fall and winter storm intensities and increase the amount of precipitation that is delivered as rain instead of snow. Thus, redd scour is likely to increase.

Additionally, as summer migrants, adults and sub-adults are exposed to annual minimum flows and maximum temperatures, and thus will likely be more prone to disease. In several recent years, pre-spawn mortalities of adult Chinook salmon have been determined to have *Columnaris* as the primary cause of death (Nooksack Natural Resources et al. 2005, p. 80). This disease becomes progressively more lethal with increased temperatures and has even been an issue in the North Fork, though less commonly than in the South Fork. The effects of this disease on bull trout are not currently known.

Threats

There are three primary threats to bull trout in the Nooksack River core area (USFWS 2015a, p. A-10 to A-11):

Upland/Riparian Land Management: Legacy Forest Management and Agricultural Practices. Impacts associated with legacy forest management and agricultural practices have led to channelization and habitat degradation within lower river foraging, migration and overwintering habitats, which are key to the persistence of the anadromous life history form.

Water Quality: Climate Change. Seasonal high water temperatures in the South Fork Nooksack River are expected to be exacerbated, likely impairing migration, especially for the anadromous life history form, and reducing available spawning and rearing habitat for South Fork Nooksack local populations.

Connectivity Impairment: Fish Passage Issues. Bellingham Water Diversion on Middle Fork Nooksack continues to limit access by the migratory life history form to habitats above the diversion and impairs connectivity between the Lower and Upper Middle Fork local populations.

Additional threats to the Nooksack River core area bull trout population include the following:

- Depressed abundances of naturally-reproducing salmon and steelhead populations in the Nooksack River system likely limit important bull trout forage resources and bull trout abundance. Abundance of spawning anadromous salmonids has been found to influence abundance, growth rates, and size of bull trout (Kraemer 2003, pp. 5, 9-10; Zimmerman and Kinsel 2010, pp. 26, 30; Copeland and Meyer 2011, pp. 937-938), as well as other species (Bentley et al. 2012; Nelson and Reynolds 2014). Anadromous salmonids provide a forage resource in the form of eggs and freshwater-rearing juveniles, which can make up a substantial proportion of the bull trout diet in freshwater habitats (Lowery and Beauchamp 2015). Spawning fish and carcasses also increase ecosystem productivity, thereby increasing the abundance of aquatic invertebrates and resident fishes (e.g., Cederholm et al. 1999; Moore et al. 2008; Copeland and Meyer 2011; Rinella et al. 2012), which may also provide important components of the bull trout diet (Lowery and Beauchamp 2015). Recovering naturally-reproducing salmon and steelhead populations is an important component of bull trout recovery in the Puget Sound region.

- Past timber harvest and harvest-related activities, such as roads, have caused the loss or degradation of a number of spawning and rearing areas. State forest practice regulations were significantly revised following the Forest and Fish Agreement (FFR 1999; WFPB 2001). These regulations are expected to significantly reduce the level of future timber harvest impacts to bull trout streams on private lands; however, most legacy threats from past forest practices will continue to be a threat for decades.

- Residential development, road networks, agricultural practices, and related stream channel and bank modifications have caused the loss and degradation of foraging, migration, and overwintering habitat in mainstem reaches of the major forks and in a number of tributaries. Stormwater runoff from residential development and urbanization continues to be a significant contributor of non-point source water pollution (WSCC 2002). Recent work by the National Oceanic and Atmospheric Administration suggests that the synergistic effects of pesticides found in the waters of the region may pose a greater risk to salmonids than previously estimated (Scholz et al. 2006). Impacts to marine foraging habitats have been, and continue to be, greatly affected by urbanization along nearshore areas in Bellingham Bay and the Strait of Georgia. For example, the Cherry Point herring stock was once a substantial prey resource, and its current diminished condition may appreciably affect bull trout.

- Fisheries pose a general threat to bull trout. There are currently no fisheries for bull trout in the Nooksack River watershed or nearby marine waters. However, bull trout are highly susceptible to incidental capture in fisheries targeting other species when those fisheries overlap in time and space with bull trout. Various commercial, Tribal, and recreational fisheries in the Nooksack River watershed and nearby marine waters are open annually. Incidentally-captured bull trout are exposed to inadvertent injury and immediate and delayed mortality associated with hooking, suffocation (e.g., from gill nets), handling, stress and physical exhaustion, and predation (e.g., Arlinghaus et al.

2007, pp. 105-134). Poaching and intentional killing (i.e., from anglers that believe bull trout are a threat to their preferred target species or confuse them with other species) are also a concern in some areas.

- In addition to the climate change-related temperature threats to the South Fork Nooksack River described above, climate change is expected to negatively affect bull trout throughout the Nooksack River watershed via elevated water temperatures during migration, spawning, and rearing periods; redd scour due to increased peak flows; and decreased habitat quantity as a result of lower summer flows. Climate change will exacerbate the low flow issues and elevated water temperature problems currently existing in the watershed.

- The potential for brook trout and brook trout/Dolly Varden hybrids, detected in many parts of the Nooksack River core area, to increase their distributions is a significant concern. Brook trout are likely more widespread within the system than first suspected (USFWS 2008a, Nooksack River core area Chapter, p. 6). The magnitude of this threat is expected to increase over time if habitat continues to be degraded in the system, and migratory life history forms of bull trout remain in low abundance. Brook trout appear to adapt better to degraded habitats than bull trout (Clancy 1993; MBTSG 1996). 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 1996). The low numbers of adult bull trout observed at known spawning sites may further allow brook trout to become more dominate within the core area.

- There is a potential for impact to subadult and adult bull trout from *Columnaris* outbreaks due to elevated water temperatures in the South Fork Nooksack River. *Columnaris* has been detected in upstream migrating and holding adult salmon (Nooksack Natural Resources et al. 2005, p. 80).

LITERATURE CITED

Arlinghaus, R., S.J. Cooke, J. Lyman, D. Policansky, A. Schwab, C.D. Suski, S.G. Sutton, and E.B. Thorstad. 2007. Understanding the complexity of catch-and-release in recreational fishing: an integrative synthesis of global knowledge from historical, ethical, social, and biological perspectives. Reviews in Fisheries Science 15:75–167.

Bentley, K.T., D.E. Schindler, J.B. Armstrong, R. Zhang, C.P. Ruff, and P.J. Lisi. 2012. Foraging and growth responses of stream-dwelling fishes to inter-annual variation in a pulsed resource subsidy. Ecosphere 3(12):1-17. http://dx.doi.org/10.1890/ES12-00231.1

Cederholm, C.J., M.D. Kunze, T. Murota, and A. Sibatani. 1999. Pacific salmon carcasses: Essential contributions of nutrients and energy for aquatic and terrestrial ecosystems. Fisheries 24:6-15.

Chiarle, M., S. Iannotti, G. Mortara, and P. Deline. 2007. Recent debris flow occurrences associated with glaciers in the Alps. Global and Planetary Change 56:123-136.

Clancy, C.G. 1993. Statewide fisheries investigations: Bitterroot Forest inventory. Montana Fish, Wildlife, and Parks, Job Completion Report, Project F-46-R-4, Helena, Montana.

Copeland, T., and K.A. Meyer. 2011. Interspecies synchrony in salmonid densities associated with large-scale bioclimatic conditions in central Idaho. Transactions of the American Fisheries Society 140:928-942.

Currence, N. 2007. Nooksack Tribe bull trout surveys within the Nooksack basin - final report. Nooksack Tribe, Cooperative Agreement Number 134513J008, Deming, Washington, 2007. 7 pp.

_____. 2008. Email from Ned Currence, Biologist, Nooksack Tribe Natural Resource Department, to Jeffrey Chan, Fish Biologist, USFWS; re: draft nooksack tore template. July 30, 2008.

FFR (Fish and Forest Report). 1999. Recommendations to the Washington Forest Practices Board submitted by a consortium of landowners, tribes, state, federal agencies. Washington Department of Natural Resources, Olympia, WA, April 29, 1999. 177 pp.

Goetz, F.A., E. Jeanes, and E. Beamer. 2004. Bull Trout in the Nearshore. Preliminary Draft Report, U.S. Army Corps of Engineers, Seattle, Washington.

Goetz, F., E.D. Jeanes, and C.M. Morello. 2007. Puget Sound bull trout migration and habitat use study: Nooksack River and estuary and northeast Puget Sound nearshore, USFWS Interagency Agreement # 13410-6-H001, September 2007. 28 pp.

Kraemer, C. 2003. Lower Skagit Bull Trout: Age and Growth Information Developed From Scales Collected From Anadromous and Fluvial Char. Management Brief, Washington Department of Fish and Wildlife. Olympia, Washington.

Lowery, E.D., and D.A. Beauchamp. 2015. Trophic Ontogeny of Fluvial Bull Trout and Seasonal Predation on Pacific Salmon in a Riverine Food Web. Transactions of the American Fisheries Society 144:724-741, DOI:10.1080/00028487.2015.1035452.

MBTSG (The Montana Bull Trout Scientific Group). 1996. Assessment of methods for removal of suppression of introduced fish to aid in bull trout recovery. Prepared for the Montana Bull Trout Restoration Team, Montana Fish, Wildlife, and Parks, Helena, MT. March1996.

MBVRC (Mount Baker Volcano Research Center). 2013a. Large debris flow in middle fork nooksack river-May 31,2013, Available at <http://mbvrc.wordpress.com/2013/06/05/large-debris-flow-in-middle-fork-nooksack-river-may-31-2013/> (Date Accessed: August 26, 2013).

_____. 2013b. More debris flows in middle fork; profound erosion of deposits, Available at <http://mbvrc.wordpress.com/2013/06/12/more-debris-flows-in-middle-fork/> (Date Accessed: August 21, 2013).

Moore, J.W., D.E. Schindler, and C.P. Ruff. 2008. Habitat Saturation Drives Thresholds in Stream Subsidies. Ecology, 89:306–312.

Nelson, M.C., and J.D. Reynolds. 2014. Time-Delayed Subsidies: Interspecies Population Effects in Salmon. PLoS ONE 9(6): e98951. doi:10.1371/journal.pone.0098951.

Nooksack Natural Resources, Lummi Natural Resources, and Whatcom Public Works. 2005. WRIA 1 Salmonid Recovery Plan. Whatcom County Public Works, Bellingham, WA, April 30, 2005. 323 pp.

Rinella, D.J., M.S. Wipfli, C.A. Stricker, R.A. Heintz, and M.J. Rinella. 2012. Pacific Salmon (Oncorhynchus Spp.) Runs and Consumer Fitness: Growth and Energy Storage in Stream-Dwelling Salmonids Increase with Salmon Spawner Density. Canadian Journal of Fisheries and Aquatic Sciences 69: 73–84.

Scholz, N.L., N.K. Truelove, J.S. Labenia. D.H. Baldwin, and T.K. Collier. 2006. Dose-additive inhibition of Chinook salmon acetylcholinesterase activity by mixtures of organophosphate and carbamate insecticides. Environmental Toxicology and Chemistry 25(5):1200-1207.

Seattle Post-Intelligencer. 2008. Rainier glacier melt may boost debris flow risk. July 22.

Smith, C. J. 2002. Salmon and steelhead habitat limiting factors in WRIA 1, the Nooksack basin. Washington State Conservation Commission, Lacey, Washington. 325 pp.

Snover, A.K., P.W. Mote, L.Whitely Binder, A.F. Hamlet, and N.J. Mantua. 2005. Uncertain Future: Climate Change and its Effects on Puget Sound. A report for the Puget Sound Action Team by the Climate Impacts Group (Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Oceans, University of Washington, Seattle. 36 pp.

SSPS (Shared Strategy for Puget Sound). 2007. Puget Sound salmon recovery plan, Volume I. Shared Strategy Development Committee, Shared Strategy for Puget Sound, Seattle, Washington. 503 pp.

USFS (U.S. Forest Service). 2006. Upper Middle Fork and South Fork Nooksack Rivers watershed analysis. Mt. Baker - Snoqualmie National Forest.

USFWS (U.S. Fish and Wildlife Service). 2004. Draft Recovery Plan for the Coastal-Puget Sound distinct population segment of bull trout (*Salvelinus confluentus*). Volume I: Puget Sound Management Unit, 389+xvii pp and Volume II: Olympic Peninsula Management Unit, 277+xvi pp, Portland, Oregon.

_____. 2008a. Bull trout core area templates - an unpublished compilation of updated bull trout core area analysis to support the five-year review. U.S. Fish and Wildlife Service, Portland, OR, August 24, 2008. 1895 pp.

_____. 2008b. Bull Trout (Salvelinus confluentus) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Portland, OR. 53 pp.

_____. 2015a. Coastal Recovery Unit Implementation Plan for Bull Trout. Lacey, WA and Portland, OR. 143 pp.

_____. 2015b. Bull Trout (Salvelinus confluentus) 5-Year Review. U.S. Fish and Wildlife Service, Portland, OR.

WFPB (Washington Forest Practices Board). 2001. Washington Forest Practices: rules - WAC 222 (including emergency rules), board manual (watershed manual not included), Forest Practices Act, RCW 76.09. Washington Forest Practices Board, Olympia, WA.

WSCC (Washington State Conservation Commission). 2002. Salmon and steelhead habitat limiting factors: water resources inventory area 1.

Zimmerman, M., and C. Kinsel. 2010. Migration of Anadromous Juvenile Bull Trout in the Skagit River, 1990-2009. Report FPT 11-01. Washington Department of Fish and Wildlife, Olympia, WA.