Lower Nooksack River Project: Alternatives Analysis

Appendix B: Habitat Analysis Methodology

PREPARED BY: The Watershed Company

TABLE OF CONTENTS

1 Introduction

Habitat for each of the target species was evaluated using a Habitat Equivalency Analysis (HEA) approach, in which areas with different habitat characteristics are assigned a relative habitat value based on the habitat functions they provide. The HEA was developed by the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) as a means to quantify injuries to natural resources, and ensure adequate mitigation. The HEA approach accounts for the time to establish mitigation functions, and it also values near-term habitat changes over habitat changes that occur in the distant future. In the application to the Lower Nooksack River Project, the Habitat Equivalency Analysis will be used to compare the relative habitat functions gained in each of the proposed project scenarios. Habitat improvements are determined by comparing the area and relative value of habitats before and after restoration occurs. Separate HEAs will be conducted for salmon and waterfowl.

The HEA approach includes three key steps: 1) determining a value for each habitat type present before and after restoration; 2) estimating the time needed for each restored habitat to achieve its full ecological function; and 3) calculating the change of total value of the study area over time, with the use of a discount factor, which accounts for the gradual loss in valuation of worth into the future. For the purposes of the HEA, a 3% discount rate is applied to habitat values in each subsequent year, and the project is assumed to remain functional for 300 years. These figures are consistent with measures identified by federal agencies in a variety of HEA analyses.

Habitat benefits (and impacts) are measured using the HEA approach in the value of habitat functions in a given area over time, or Discounted Service Acre-Years (DSAYs). The HEA approach (calculation of DSAYs) incorporates the following inputs:

- Baseline level of functions (value);
- Area of impact and/or restoration;
- The rate of change of functions and the maximum level of functions (value) to be achieved (described as the percent of the baseline level of function);
- The dates when recovery starts and the date when maximum level of services will be achieved; and
- A discount rate, which accounts for the increased value of having resources available in the present, rather than at some time in the future.

DSAYs are calculated using the formula:

$$DSAY = \Sigma \left[\left((1+d)_{(Y_b - Y_i)}\right)\left(Y_i / Y_f\right)\left(V_f - V_0\right)a\right] + \Sigma \left[\left((1+d)_{(Y_b - Y_i)}\right)\left(V_f - V_0\right)a\right]$$

where: Yi= the i[th] year; Yf = final year, or year when habitat reaches full ecological function; d = discount rate, or 0.03; Yb = baseline year of the life of the habitat; n = number of years of habitat existence; V_0 = initial (unrestored) value of habitat; V_f = maximum (or final) value of the restored habitat; and a = acres.

Habitat categories and values were informed by the results of the hydraulic analysis, which provided information on water surface elevation during flood events and under mean flows through a range of daily tides.

2 Target Species and Life Stages

This project will target restoration of tidal freshwater estuarine habitats in the Lower Nooksack River, which has the potential to provide improved foraging, rearing, migration, and/or nesting opportunities for target species. Target species that currently use and would be most affected by potential restoration options include juvenile salmonids, particularly "ocean-type" Chinook salmon, as well as chum salmon and coho salmon, breeding waterfowl, wintering waterfowl, and shorebird assemblages.

Preliminary habitat categories, values and timeframes for full function were assigned based on best professional judgment of the County's consultant, input from staff at the Washington Department of Fish and Wildlife, and readily available public information. These values are presented in Tables 1 and 2.

2.1 Salmonids

The Nooksack basin supports two independent populations of early-timed (spring/summer) Chinook salmon (North Fork early Chinook and South Fork early Chinook), as well as a late-timed (fall) stock. In the Nooksack River, North and South Fork early Chinook salmon populations are both considered critical status (WRIA 1 Salmon Recovery Board 2005), and both populations are critical for recovery of the Puget Sound Evolutionarily Significant Unit (ESU) (NMFS 2006). The hatchery-origin, late-run population is not considered essential for recovery of the ESU.

The majority of both of the early Chinook populations are sub-yearling outmigrants or "ocean-type" Chinook salmon (WRIA 1 Salmon Recovery Board 2005). Ocean type Chinook salmon are the most estuarine dependent of all salmon species (Healey 1982, 1991, Simenstad et al. 1982). Juvenile Chinook salmon captured in the lower Nooksack River and delta are primarily (~99%) sub-yearling ocean-type fish (Brown et al. 2005), indicative of both the pre-dominant life history strategy in the watershed and the extended rearing period of sub-yearling fish in the estuary. Estuarine environments provide subyearling salmon with foraging opportunities, a period of physiological transition to saltwater, and protection from predators (Healey 1982, 1991, Levy and Northcote 1982, Simenstad et al. 1982, Wissmar and Simenstad 1988, Levings et al. 1995).

Limited research conducted on Chinook salmon use of freshwater tidal habitats has found densities of juvenile Chinook salmon use freshwater tidal river habitats in high densities (Beamer et al. 2010, Bottom et al. 2011). Juvenile chum and coho salmon also occur in estuarine habitats, and may derive significant benefits from estuarine rearing (Levy et al. 1979, Levy and Northcote 1982, Koski 2009).

Estuarine salmonid habitat is influenced by a variety of features, including water quality, instream structure, substrate conditions, and floodplain connectivity. Optimal estuarine habitat conditions differ from optimal conditions in non-tidal riverine areas as described by NOAA's Properly Functioning Conditions and the WRIA 1 habitat features (Table 5-1 in the Salmon Recovery Plan). For example, whereas ideal spawning substrates consist of gravels and cobbles with minimal fine sediment, substrate conditions in tidal rearing areas primarily consist of fine grained silts and sands. The turbid waters associated with the movement of this fine-grained material in estuarine environments provide refuge from visual predators. Habitat features that are consistent across tidal and non-tidal habitats include woody debris, off-channel and floodplain habitat, riparian vegetation, among other factors.

The relative value of salmonid rearing habitats can be described by the resources and characteristics a given site (habitat capacity), as well as the potential for juvenile salmon to access and use the habitat (habitat opportunity) (Simenstad and Cordell 2000). The factors affecting habitat capacity and opportunity in tidal freshwater environments are described below.

Known factors that contribute to foraging benefits of estuarine rearing include marsh and riparian vegetation, which provide habitat cover and complexity and a source of insect prey (Simenstad et. al 2000). Shallow edge habitat and slow moving distributary and blind channels provide areas of velocity refuge and benthic foraging potential for rearing salmonids. An assessment of juvenile fish passage found that maximum velocities under 2.0 feet per second allowed most coho fingerlings (85-95 mm fork length) to pass upstream (Powers et al. 1997). Finally, diversity of habitats provides opportunities for optimal habitat conditions under a range of potential flows, and provides conditions that may support a range of juvenile salmon life history strategies.

The relative value of salmonid habitat is intrinsically associated with the opportunity that salmonids have to access the habitat (Simenstad and Cordell 2000). Habitat opportunity is related to the frequency and duration of inundation during outmigration period of February through July; where areas that are more frequently inundated provide greater habitat opportunity to juvenile salmonids. Information on water surface elevation and daily tidal fluctuations produced by the hydraulic analysis will be used to differentiate habitat types by habitat opportunity (e.g., intertidal versus subtidal). Habitat opportunity is also associated with the connectivity of the habitat in the landscape setting (Beamer et al. 2005). Connectivity is inversely related to the complexity of the path and the distance that a fish must travel to reach the habitat (Beamer et al. 2005).

Our approach to evaluating salmon habitat under the proposed alternative restoration scenarios was focused on habitat potential based on channel form, vegetation communities, and habitat complexity. For salmon, habitat values are highest for channel areas that are maintain wetted area throughout the tidal cycle, and that have low velocities and high connectivity to the mainstem channel (Table 1). Vegetated upland areas along channels are also assigned some of the highest habitat values because they are expected to provide detritus and insect prey, habitat cover, shading, and water quality filtration capacity (Table 1). The channel margin category, in particular, accounts for increased habitat value with a higher proportion of vegetated edge habitat (this also provides higher values for greater complexity of channel form). In order to account for the higher habitat value associated with more highly connected and accessible channels, off-channel habitat values decrease with the number of bifurcations and distance from the main channel (Table 1).

Table 1. Preliminary Habitat Equivalency Analysis Inputs for Values and Timeframes for Juvenile Salmon

Habitat	Land Cover	Hydrology	Proposed Approach	
			Function Value	**Years Until Full Function**
Mainstem Nooksack	Open Water	Subtidal and intertidal[1]	0.6	1
Off channel/ Tidal channels/ tributaries	Side channels	Subtidal[1]	1.0	4
		Intertidal[1]	0.8	4
Active channel margin (<25 feet from channel)	Any	NA	0.6	4
Ponded Area	Ponded	Subtidal[1]	0.6	1
Riparian Vegetation	Forested/shrub	Inundated during 3-5 year event[1]	0.5	25
		Inundated during 100 year event[1]	0.25	25
		Outside of floodplain (upland)	0.1	25
	Herbaceous	Inundated during 3-5 year event[1]	0.4	4
		Inundated during 100 year event[1]	0.2	4
		Outside of floodplain (upland)	0.0001	4
Agriculture	Agriculture	Any	0.05	1
Isolated Slough	Water	Lacks connection to flowing channel during daily flows	0.001	1
Unvegetated/Paved	Any	Any	0	1

1. Scores assume connectivity and drainage potential to flowing waters. Where flooded area would be disconnected from flowing waters as floodwaters recede, scores were lowered to upland or isolated slough.

2.2 Waterfowl and Shorebird Assemblages

The selection of waterfowl and shorebirds as restoration targets was based on the known occurrence of these taxa in the area and the importance placed on them by both the public and State agencies. The Washington Department of Fish and Wildlife (WDFW) Priority Habitats and Species (PHS) database recognizes the area as a waterfowl regular concentration area and notes the importance of the area to waterfowl, trumpeter swans, and shorebirds (Washington Department of Fish and Wildlife 2009).

Freshwater tidal marshes serve a variety of habitat functions for waterfowl and shorebirds, depending largely on season (Larsen et al. 2004, Pacific Coast Joint Venture 2013). Habitat suitability and value for waterfowl and shorebirds will be assessed by quantifying the importance of key habitat components. Management focused on a single focal species would not effectively address all habitat factors of importance to the large number of individuals and species that use the Lower Nooksack, so instead, methods proposed herein focus on breeding and wintering lifecycle stages for waterfowl and shorebird assemblages separately.

Breeding waterfowl species typically prefer dense emergent vegetation for nests and for cover, with preferences for forested or more open surroundings varying by species. Nests may be built up from substrate, on dry land surrounded by water, on floating on anchored rafts, or in cavities in trees or snags, depending on the species. Nearby shallow water with emergent vegetation is a preferred habitat attribute for most breeding waterfowl, as the majority of species' diets rely on plant parts, seeds, and aquatic invertebrates filtered from mud or strained from water (Sibley 2003, Taft and Haig 2003). The notable exceptions are pied-billed grebe and hooded merganser, whose omnivorous diets include fish and crustaceans (Sibley 2003). Water is also important for newly hatched young, as the precocial young are more mobile on water than land.

Wintering and migrating waterfowl in the Lower Nooksack tidal area include diving ducks, dabblers, geese, and swans ("North Cascades Audubon Society", electronic reference). Geese and swans often occur in large concentrations to forage and overnight in grasslands and fields (Sibley 2003). Wintering and migrating dabbling ducks generally prefer water or mudflats with emergent vegetation (Taft and Haig 2003); divers typically occur in deeper water than the other species, although the target species listed above also frequent shallower tidal waters in winter.

Shorebirds may use the lower Nooksack year-round, and these habitat types are of greatest importance during migration ("North Cascades Audubon Society", electronic reference). Mudflats provide particularly important foraging and resting areas for these species (Galbraith et al. 2002, Taft and Haig 2003).

While habitat requirements and preferences vary by species and lifecycle stage, there is considerable overlap in the local and landscape habitat types and features. Local factors that contribute to the success of waterfowl include vegetative composition and structure, the availability of forage, and particular features such as cavities or fish-bearing waters for some species. Landscape factors affecting the propensity for waterfowl to access breeding and non-breeding sites are proximity to migratory pathways and presence of adjacent suitable habitat needed for other lifecycle stages.

Breeding

Both breeding and non-breeding waterfowl are associated with water and aquatic vegetation. For breeding birds, the variety and interspersion of open water, shallow water with dense vegetation, slow-moving channels, wetlands, and mudflats in the Lower Nooksack are attractive as many species require access to several of these habitat types during the breeding season. Waterfowl species that breed in the lower Nooksack area are primarily dabbling ducks, which require freshwater wetland habitats. The dabbling ducks that breed in the area depend on emergent vegetation for food, as well as for nesting materials and cover (Sibley 2003). Dabbling ducks generally are most commonly observed in vegetated waters of 12 inches or less. Density of ducks has shown increases with abundance of aquatic vegetation. The presence of vegetation buffering aquatic areas is a key factor in nesting density; the type of vegetation varies with species, but herbaceous, shrub, and forest are all habitat components for nesting ducks.

Hooded merganser and pied-billed grebe also use the Lower Nooksack and, despite being divers, breed in freshwater marshes and frequent shallower waters during the breeding season than in winter. Although their diet is primarily fish, insects, and crustaceans, pied-billed grebes also select nest sites with dense emergent vegetation for nest-building and cover ("Pied-billed Grebe, Life History, All About Birds - Cornell Lab of Ornithology", electronic reference, Sibley 2003). Hooded mergansers require cavities for nesting and normally nest near emergent vegetation as well (Sibley 2003, Larsen et al. 2004). Thus, despite a non-vegetation diet, emergent vegetation is an important habitat component for divers in the Lower Nooksack area.

Like hooded mergansers, wood ducks require cavities for nesting (Sibley 2003, Larsen et al. 2004). Both species will nest in boxes, but forested areas near ponds and wetlands are preferred habitat (Sibley 2003). Cavity nesters depend greatly on the size and abundance of cavities, as well as proximity to aquatic areas.

Features that create and enhance breeding habitat for waterfowl also tend to provide and improve breeding habitat for passerines, including neotropical migrants, many of which are associated with riparian vegetation. The enhancement of vegetative structural and compositional diversity for breeding waterfowl will benefit passerine communities along the river and channels as well. Likewise, management activities that focus on breeding habitat will enhance conditions for many reptiles and amphibians, which generally use emergent or riparian vegetation for breeding, particularly where stems are submerged permanently or seasonally.

Key habitat components in providing and improving summer breeding habitat in the Lower Nooksack area are listed below. Values for each type of habitat are included in Table 2.

- Open water (unvegetated)
- Shallow water supporting aquatic vegetation
- Forested habitat
- Mudflats
- Invertebrate and crustacean productivity
- Cavity tree density
- Potential for snag recruitment
- Proximity of key habitat types, features and components
- Presence of roads, trails, and other development
- Juxtaposition of habitat types, particularly islands within open and shallow waters

Winter/migrating

Wintering and migrating habitat components include the shallow, vegetated wetlands used extensively in the breeding season. In addition, deeper waters are used in winter by divers. While specific habitat preferences vary among species, several sources indicate a minimum depth of 40 inches for diving duck foraging habitat (Torrence and Butler 2006).

The lower Nooksack's importance as a wintering and migration stopover for waterfowl is associated with the fallow fields, pastures, and managed planted agricultural lands, and nearby eelgrass beds in the area (Taft and Haig 2003, Larsen et al. 2004, Pacific Coast Joint Venture 2013). The extent of these areas determines in part the ability of the area to support large flocks of geese and swans, as well as a diversity of game duck species.

The position of the area in the landscape affords easy accessibility to migrating birds along the Pacific flyway. As flight is energetically costly, the position of the area in the landscape and the adjoining Sound are advantageous, as they offer protection from disturbance over highly populated, well-traveled areas.

As noted above, shorebirds frequent the wetlands and mudflats of the lower Nooksack year-round, but these habitat types are of greatest importance during migration, when the majority of species and individuals are present in the region. The presence of mudflats provides foraging and resting areas for a range of these species (Taft and Haig 2003).

Complex channels, freshwater marshes, and shrub and forest in the vicinity of wetlands and streams provide high quality habitat for a great number of songbirds. Many passerine species will benefit from the enhancement and creation of wetland and riparian habitat. The open grasslands and fields that attract wintering and migrating waterfowl also provide habitat for several birds of prey, and peregrine falcon, northern harrier, short-eared owl, American kestrel, rough-legged hawk, and others occur in the area (Sibley 2003, Larsen et al. 2004).

Primary features that affect habitat suitability and value for wintering/migrating waterfowl and shorebirds in particular are listed below. Values for each type of habitat are included in Table 2.

- Open water (unvegetated)
- Shallow water supporting aquatic vegetation
- Fallow and cereal grain fields
- Open grasslands and pastureland
- Mudflats
- Presence of roads, trails, and other development
- The location of foraging and resting areas near migration routes

Table 2. Preliminary Habitat Equivalency Analysis Inputs for Values and Timeframes for Waterfowl and Shorebird Assemblages

Habitat	Land Cover Characteristics	Factors Affecting Functional Value	Functional Value		Proposed Approach	
			Breeding	Wintering/ Migrating	Average Value	Years Until Full Function
Mainstem Nooksack	Open water, unvegetated	NA	0.25	0.8	0.53	1
Wetlands/ Side Channels	Side channels	Subtidal	0.7	0.7	0.7	4
		Intertidal	1.0	0.7	0.85	4
	Emergent/Herbaceous	Inundated in 2-4 year event	1.0	0.8	0.9	4
	Forested/Shrub	Inundated in 2-4 year event	0.9	0.1	0.5	25
Ponded subtidal	Open water, ponded	Subtidal	0.25	0.8	0.53	4
Active channel margin (< 25 feet from channel)	Vegetated margin	NA	0.8	0.5	0.65	4
Upland	Grassland (herbaceous)	Not inundated in 2-4 year flood event	0.1	0.8	0.45	1
	Forest/Shrub	Not inundated in 2-4 year flood event	0.1	0	0.05	25
Agriculture	Agriculture	Vegetation remains	0.1	0.8	0.45	1
		Vegetation cleared	0.1	0.3	0.2	1
Unvegetated/ Paved	Any		0	0	0	0

3 Assumptions and Limitations

This evaluation was limited by the quality and availability of modeled surface elevations and land cover classification. The differentiation between existing intertidal and subtidal habitats is imprecise based on LiDAR data since the data reflect the water surface elevation at the time of the data collection. A field survey during an extreme (~-2 ft) low tide event was used to validate the approximate geographic extent of tidal influence within the left bank channels under existing conditions.

Predictions of future land cover types and vegetation communities are based on best professional judgement given existing vegetation, projected depth of inundation, and anticipated disturbance.

One potential limitation of the HEA model is that it presumes a sequential development of habitat features in defined areas. In the case of a dike breach scenario, areas may transition across habitat categories over time (e.g., mud flat to tidal channels) and the precise location and density of channel features may not be predictable.

Another limitation of the HEA model is that it does not account for species or lifestages other than those targeted. For example, the Lummi Tribe raises manila clams (*Venerupis philippinarum*) at an aquaculture facility at the mouth of the Lummi River on Lummi Bay. Proposed restoration alternatives that affect flow in the Lummi River could also affect clam production. Manila clam production relies on high water quality and salinities ranging from 20-30 parts per thousand (PPT). High flows in the Lummi River have the potential to affect water quality conditions and reduce salinities in Lummi Bay. Only the target species will be evaluated using the HEA approach; potential effects of various restoration scenarios on manila clam aquaculture and other non-target species will be qualitatively evaluated, described, and included in the final alternatives analysis, where applicable.

Additionally, the HEA model does not explicitly account for landscape-scale ecological factors (e.g., interspersion, connectivity, and diversity) that may play a significant role in the value of habitat. We have implicitly incorporated certain landscape measures (e.g., complexity and connectivity) into the proposed habitat values, and otherwise provided a qualitative analysis of possible landscape-scale outcomes.

4 References

Beamer, E., R. Henderson, and K. Wolf. 2010. Juvenile salmon, estuarine and freshwater fish utilization of habitat associated with the Fisher Slough restoration project, Washington 2009.

Beamer, E., A. McBride, C. Greene, R. Henderson, G. Hood, K. Wolf, K. Larsen, C. Rice, and K. Fresh. 2005. Delta and Nearshore Restoration for the Recovery of Wild Skagit River Chinook Salmon: Linking Estuary Restoration to Wild Chinook.

Bottom, D. L., A. Baptista, J. Burke, L. Campbell, E. Casillas, S. Hinton, D. Jay, M. Austill Lott, G. McCabe, R. McNatt, M. Ramirez, G. C. Roegner, C. Simenstad, S. Spilseth, V. Stamatiou, D. Teel, and J. Zamon. 2011. Estuarine Habitat and Juvenile Salmon: Current and Historical Linkages in the Lower Columbia River and Estuary. Seattle, Washington.

Galbraith, H., R. Jones, R. Park, J. Clough, S. Herrod-Julius, B. Harrington, and G. Page. 2002. Global Climate Change and Sea Level Rise: Potential Losses of Intertidal Habitat for Shorebirds. Waterbirds 25(2):173.

Healey, M. 1982. Juvenile Pacific salmon in estuaries: the life support system. Pp. 315–341 *in* V. Kennedy, editor. Estuarine Comparisons: International Estuarine Research Conference. Academic Press, Gleneden Beach, OR.

Healey, M. 1991. Life history of Chinook salmon. Pp. *in* C. Groot and L. Margolis, editors. Pacific Salmon Life Histories. University of British Columbia Press, Vancouver, B.C. Canada.

Koski, K. V. 2009. The fate of coho salmon nomads: The story of an estuarine-rearing strategy promoting resilience. Ecology and Society 14(1):1–15.

Larsen, E., J. Azerrad, and N. Nordstrom. 2004. Management recommendations for Washington's priority species, Volume IV: Birds.

Levings, C. D., D. E. Boyle, and T. R. Whitehouse. 1995. Distribution and feeding of juvenile Pacific salmon in freshwater tidal creeks of the lower Fraser River, British Columbia. Fisheries Management and Ecology 2(4):299–308.

Levy, D. A., and T. G. Northcote. 1982. Juvenile salmon residency in a marsh area of the Fraser River estuary. Canadian Journal of Fisheries and Aquatic Science 39:270–276.

Levy, D. A., T. G. Northcote, and G. J. Birch. 1979. Juvenile salmon utilization of tidal channels in the Fraser River estuary, British Columbia. Vancouver, B.C. Canada.

North Cascades Audubon Society. Electronic Reference. . http://www.northcascadesaudubon.org/birding/locations/. Accessed June 8, 2015.

Pacific Coast Joint Venture. 2013. Habitat and Population Objectives: Wetland Birds and Water Birds North Puget Lowlands Ecoregion.

Pied-billed Grebe, Life History, All About Birds - Cornell Lab of Ornithology. Electronic Reference. . http://www.allaboutbirds.org/guide/Pied-billed_Grebe/lifehistory. Accessed June 8, 2015.

Powers, P. D., K. Bates, T. Burns, B. Gowen, and R. Whitney. 1997. Culvert hydraulics related to upstream juvenile salmon passage.

Sibley, D. A. 2003. The Sibley field guide to birds of Western North AmericaFirst Edit. Alfred A. Knopf.

Simenstad, C. A., and J. R. Cordell. 2000. Ecological assessment criteria for restoring anadromous salmonid habitat in Pacific Northwest estuaries. Ecological Engineering 15(3-4):283–302.

Simenstad, C., K. Fresh, and E. Salo. 1982. The role of Puget Sound and Washington coastal estuaries in the life history of Pacific salmon: an unappreciated function. Estuarine Comparisons. Academic Press.

Taft, O. W., and S. M. Haig. 2003. Historical wetlands in Oregon's Willamette valley: Implications for restoration of winter waterbird habitat. Wetlands 23(1):51–64.

Torrence, S. M., and M. G. Butler. 2006. Spatial structure of a diving duck (Aythya , Oxyura) guild: how does habitat structure and competition influence diving duck habitat use within northern prairie wetlands? Canadian Journal of Zoology 84(9):1358–1367.

Washington Department of Fish and Wildlife. 2009. Priority Habitats and Species on the Web. http://wdfw.wa.gov/mapping/phs/. Accessed June 4, 2015.

Wissmar, R. C., and C. A. Simenstad. 1988. Energetic Constraints of Juvenile Chum Salmon (Oncorhynchus keta) Migrating in Estuaries. Canadian Journal of Fisheries and Aquatic Sciences 45(9):1555–1560.

WRIA 1 Salmon Recovery Board. 2005. WRIA 1 Salmonid Recovery Plan.