To: Dave Cline, Shannon & Wilson

From: Paul Schlenger

Date: December 22, 2017

Re: Fish Habitat Conditions Provided by the Expanded Willow Creek Daylighting Alternatives

---

1.0 INTRODUCTION

This evaluation of the fish habitat conditions provided by the alternatives being considered for the Willow Creek daylighting project focused on conditions for juvenile Chinook salmon who are listed in the Endangered Species Act as threatened and are a focus of recovery efforts throughout Puget Sound. Chinook will not spawn in a stream system such as the Willow Creek and Shellabarger Creek complex because they require larger rivers (e.g., Snohomish River); however, juvenile Chinook salmon have been documented to outmigrate from their natal rivers and use the estuaries, marshes, and lower stream areas in smaller streams like those provided in Edmonds Marsh (Beamer et al. 2003, Beamer 2006, Hirschi et al. 2003). Juvenile Chinook move along the shoreline of Puget Sound and would potentially use the Edmonds Marsh during the spring and when they are of sizes typically between 2.5 and 4 inches (approximately 60 to 90mm). The habitat conditions that are favorable for juvenile Chinook are similar to those of other juvenile salmon species (e.g., coho); therefore, this evaluation can be considered indicative of benefits to juvenile salmon.

The potential fish habitat conditions provided by the proposed alternatives were evaluated through consideration of four components:

- Accessibility – ability for juvenile salmon to move into an area based on water velocity and depth
- Instream habitat – quality and quantity of suitable aquatic habitats to support juvenile salmon rearing
- Riparian habitat – quality and quantity of upland habitats adjacent to the instream habitats
- Water and sediment quality – condition of basic water quality parameters and contaminants, as well as sediment contaminant chemistry

2.0 ACCESSIBILITY

As noted above, the juvenile Chinook salmon that the restoration is targeting will be accessing the marsh by moving into the daylighted Willow Creek channel from Puget Sound. Their ability to move into the restored habitats is dependent upon their swimming abilities and habitat preferences for water depth which are both influenced by their body size.

Fish passage requirements are less clear in tidal areas compared to freshwater streams (Washington Department of Fish and Wildlife [WDFW] Water Crossing Design Guidelines (Barnard et al. 2013). The law requires that fish passage is provided at manmade barriers, such as water crossings (Revised Code of Washington (State) [RCW] 77.57.030), but it is not clear how efficiently or continuous over time that passage needs to be provided (Barnard et al. 2013). The complication of fish passage in tidal environments is that access to or through intertidal habitats is naturally intermittent because of tidal processes. In tidal environments, the exchange of water into and out of coastal marshes and embayments creates periods of time when depths are too shallow and velocities are too fast.

Design guidelines or evaluation guidelines for providing suitable conditions for fish access have not been developed for tidal environments such as this creek daylighting project or for fish the size of the juvenile Chinook salmon entering from Puget Sound. Although not strictly applicable in tidal settings like the Willow Creek channel being daylighted, the criteria established in the Washington Administrative Code (WAC) 220-110-070 for culverts in freshwater provides some basis of comparison for the anticipated fish passage conditions to be provided in the proposed restoration alternatives. The closest fish size considered in the WAC compared to the juvenile Chinook which are a focus of this evaluation are 6-inch trout. Given the larger size of the trout, they will have greater swim abilities than the smaller juvenile Chinook and can therefore be expected to be able to swim against faster water velocities than juvenile Chinook. For 6-inch adult trout, the WAC establishes a minimum depth of 0.8 feet and a minimum hydraulic drop of 0.8 feet. The maximum velocity criteria are based on the culvert length such that for culverts less than 100 feet in length, the maximum is 4.0 feet per second (ft/s); for culverts 100 to 200 feet long, the maximum is 3.0 ft/s; and for culverts longer than 200 feet, the maximum velocity is 2.0 ft/s.

Barnard et al. (2013) provides additional guidance on velocities in culverts related to juvenile salmon size. Barnard et al. (2013) references a previous WDFW report on fish passage through culverts which recommended design criteria for juvenile salmon greater than 2.4 inches (60 mm) to be 1.3 ft/s (Powers and Bates 1997). This is approximately the size that juvenile Chinook potentially entering the restoration site will be. The Powers and Bates (1997) velocity is a recommendation that is not a codified design requirement. Barnard et al. (2013) also notes that the Muckleshoot Indian Tribe reports, based on a review of ten references, that the maximum velocity for juvenile salmon passage through culverts was found to be 1.0 ft/s with a range of 0.5 to 2.0 ft/s.

The fact that these criteria were established for freshwater culverts is a significant difference from the proposed daylighted channel and marsh because there are design elements for habitat complexity that can change generally uniform velocity conditions into a series of pools and riffles providing variable velocity conditions. The habitat complexity elements of the design will be added to inform subsequent design steps, so are not available for this evaluation. However, the expectation is that those habitat elements will further benefit fish passage conditions.

For this evaluation, hydraulic modeling data provided by Shannon & Wilson were applied to compare fish access conditions of Alternative 1 (straight channel) and Alternative 4 (sinuous channel). For the purposes of this evaluation, fish passage conditions were evaluated assuming typical spring freshwater flows from the two creeks (0.8 cubic feet per second) entering Edmonds Marsh and the observed tidal exchange over a 14-day period. Depth and velocity outputs were provided at in the downstream end of the daylighted channel (just upstream from bridge under railroad). A full description of the hydraulic modeling methods is provided in a draft memo from Shannon & Wilson.

During typical spring conditions encountered by juvenile Chinook salmon, the maximum water velocities flowing out of the daylighted channel were 1.5 ft/s in Alternative 1 and 1.6 ft/s in Alternative 4 (Table 1). In both alternatives, the minimum depths were predicted to be 0.4 ft and water depths were predicted to be less than 0.8 ft during 30% of the time.

Applying the depth and velocity guidelines to the model outputs for Alternative 1, it is estimated that for 60% of the time, water depths will be greater than 0.8 ft and velocities less than 1.0 ft/s. Running the same analysis for Alternative 4, those conditions are predicted to be provided only 45% of the time. In this most conservative evaluation of fish passage conditions, Alternative 1 is predicted to provide fish passage for small fish such as juvenile Chinook salmon more of the time then Alternative 4.

A similar difference between alternatives is predicted when evaluating velocities less than 1.3 ft/s and water depths greater than 0.8 ft. Alternative 1 is predicted to provide those conditions during 68% of the time whereas Alternative 4 is predicted to do so 54% of the time.

The difference between the alternatives is greatly reduced when running the analysis with thresholds of 2.0 ft/s velocities and 0.8 ft water depths. Alternative 1 is predicted to provide those conditions during 70% of the time whereas Alternative 4 is predicted to do so 68% of the time.

Table 1. Percentage of Time Providing Suitable Fish Passage Conditions

Criteria	Alternative 1	Alternative 4
Depth >0.8 ft, Velocity <1.0 ft/s	60%	45%
Depth >0.8 ft, Velocity <1.3 ft/s	68%	54%
Depth >0.8 ft, Velocity <2.0 ft/s	70%	68%

A portion of the time not meeting the criteria described above is during the rising tide. If it is assumed that fish passage is provided at all times during a rising tide and when water depths exceed 0.8 ft and velocities are less than 1.0 ft/s, then Alternative 1 is predicted to provide suitable conditions during 67% of the time and Alternative 4 during 57% of the time.

Overall, during typical spring conditions, Alternative 1 is predicted to provide fish access during more of the time than Alternative 4. As noted earlier, both alternatives provide the opportunity to incorporate into the design instream features (e.g., large wood) that will slow velocities and improve passage conditions. The sinuosity of Alternative 4 provides more opportunities for such design features; therefore, it is expected that the fish passage conditions provided by either alternative will be nearly equivalent.

3.0 INSTREAM HABITAT

The quantity and quality of aquatic habitat will affect the likelihood of juvenile Chinook salmon entering the Edmonds Marsh system and potentially remaining in the system during multiple tidal cycles. The depth and velocity conditions affect the quantity and quality of habitat. These parameters were already summarized above and provide suitable conditions for juvenile Chinook salmon throughout much of the tidal cycle; therefore, this evaluation of habitat quantity and quality focuses on other aspects of instream habitat. At this early design stage of alternative development, indicators of habitat quantity are more developed than indicators of habitat quality which are design features to be added in later design phases.

Habitat quantity can be interpreted based on the estimated channel lengths and inundated areas provided by the different alternatives. As noted above, the juvenile Chinook salmon that are expected to use Edmonds Marsh will originate in large rivers and move into the marsh from Puget Sound. As such, the most likely habitats to be occupied by juvenile chinook are in entrance channel to the marsh. Since Alternative 1 is a straight channel and Alternative 4 is a sinuous channel, Alternative 4 would provide a longer channel and more fish habitat.

Both alternatives will provide access to the very large tidal marsh habitat provided by Edmonds Marsh. Alternative 4 provides a larger inundation area due to the expanded wetland restoration area at the upstream end of the entrance channel. The expanded restoration occurs in the currently ponded area to the south of the marsh and will provide approximately 2.7 acres more habitat than Alternative 1.

The quality of aquatic habitat in the entrance channel will be strongly influenced by design elements (e.g., channel shape and size, and large wood placement) that will be developed in subsequent design phases. The sinuosity of Alternative 4 will allow for substantially greater opportunities to create complex habitat that includes pools that will benefit juvenile Chinook salmon. Juvenile Chinook are expected to use pools in the entrance channel as lower velocity areas where they do not need to expend as much energy, to prey upon food delivered in water exiting the marsh, and to occupy during low tides when much of the marsh has drained. Alternative 1 can support some of the design elements described above, but will provide less of an opportunity to provide complex habitat for juvenile Chinook salmon.

4.0 RIPARIAN HABITAT

The establishment of a vegetated riparian corridor is also a significant component of the restoration contributing to provide high functioning rearing habitat for juvenile Chinook salmon. The functions of a vegetated riparian corridor along the entrance channel will include: shading of the aquatic areas, input of terrestrial insects and organic matter contributing to prey base, infiltration of stormwater runoff from surrounding areas, and providing a barrier between the creek and surrounding areas which can reduce disturbances to fish.

Both alternatives provide beneficial improvements to the riparian corridor that will benefit juvenile salmon. Both alternatives include a relatively wide riparian buffer along the southern margin of the entrance channel that will provide the benefits listed above. By also including riparian vegetation on the north side of the daylighted Willow Creek, Alternative 4 will provide greater benefits than Alternative 1. Although the riparian north side riparian buffer in Alternative 4 is narrow, it can be expected to contribute each of the functions identified above to a limited, but beneficial, extent. Slight adjustments to the alignment of the Alternative 4 channel can allow for a more continuous narrow riparian buffer. This refinement will be considered in subsequent design phases.

5.0 WATER AND SEDIMENT QUALITY

Water quality sampling conducted by Shannon & Wilson in December 2016, March 2017, and June 2017 provide data on basic water quality parameters, fecal coliform, and metals from seven sampling stations distributed around the marsh and contributing creeks. The data from these sampling events allows for some preliminary interpretation of water quality conditions. Additional sampling events and a more complete list of parameters in the future is planned for in the Shannon & Wilson report and will allow for further evaluation of water quality conditions.

The data show favorable water quality conditions throughout the marsh for all parameters with two exceptions: fecal coliform and dissolved oxygen. Fecal coliform bacteria levels which exceeded water quality criteria at multiple stations during multiple sampling events.

Dissolved oxygen concentrations were very low (<4 mg/L) at the station located near the Harbor Square outfall (WC-03) during both the December 2016 and June 2017 sampling events. Dissolved oxygen concentrations also did not meet water quality criteria at multiple stations in June 2017.

Sediment quality sampling conducted by Shannon & Wilson in June 2017 provides data on sediment chemistry at the same stations as were sampled for water quality. The data from one station located near the Harbor Square outfall (WC-03) had concentrations of numerous semi-volatile organic compounds (SVOCs) that exceeded freshwater sediment standards. Also at station WC-03, two petroleum compounds were present in concentrations exceeding freshwater sediment standards. The SVOCs and petroleum contaminants were also documented at other sampling stations in the marsh and creeks. At stations located in Shellabarger Creek just downstream of SR-104 (WC-04) and a central marsh location where channels from Shellabarger and Willow creeks flow together (WC-05), the concentration of a subset of the SVOCs exceeded freshwater sediment standards. Multiple metals were detected at the sampling stations, but only nickel was reported in concentrations exceeding freshwater sediment standards.

The sediment quality conditions have the potential to affect the prey base available to juvenile Chinook salmon. This includes potential effects to the quantity of prey available and bioaccumulation of contaminants in juvenile salmon.

The water and sediment quality conditions are the same for both alternatives. For the proposed restoration to achieve its goals in providing productive rearing habitat and forage base for juvenile Chinook, it will be necessary to address the sediment quality exceedances in the marsh through remediation of contaminated materials and source control. Additional data on water quality during storm events, especially first flush portions of storm events, is recommended to better understand contaminant and toxic inputs from the contributing watersheds.

6.0 SUMMARY OF FISH PASSAGE EVALUATION

The daylighting of Willow Creek will provide juvenile chinook and other fish species unobstructed access into the Edmonds Marsh system for the first time in many decades. In doing so, the proposed restoration will provide access and suitable habitat for juvenile chinook salmon to support their rearing and growth.

Of the two alternatives evaluated, Alternative 4 would provide more and better habitat conditions than Alternative 1. The sinuosity of Alternative 4 and expanded vegetated riparian corridor would provide substantially better habitat than Alternative 1. The difference in fish accessibility based on modeled future conditions is expected to be neutralized through the placement of instream structures, such as anchored large woody debris which will make water velocities suitable for juvenile chinook passage during more of the time. These structures will also improve habitat complexity to provide more areas preferred by juvenile chinook.

7.0 REFERENCES

Barnard, R. J., J. Johnson, P. Brooks, K. M. Bates, B. Heiner, J. P. Klavas, D.C. Ponder, P.D. Smith, and P.D. Powers (2013), Water Crossings Design Guidelines, Washington Department of Fish and Wildlife, Olympia, Washington. http://wdfw.wa.gov/hab/ahg/culverts.htm.

Beamer, E.M., A. McBride, R. Henderson, and K. Wolf. 2003. The importance of non-natal pocket estuaries in Skagit Bay to wild Chinook salmon: an emerging priority for restoration. Skagit River System Cooperative, LaConner, WA.

Beamer, E.M., 2006, Habitat and Fish Use of Pocket Estuaries in the Whidbey Basin and North Skagit County Bays, 2004 and 2005, for the Samish Nation.

Beamer, E.M., W.T. Zackey, D. Marks, D. Teel, D. Kuligowski, and R. Henderson. 2013. Juvenile Chinook salmon rearing in small non-natal streams draining into the Whidbey Basin. Skagit River System Cooperative, LaConner, WA.

Hirschi, R., T. Doty, A. Keller, and T. Labbe. 2003. Juvenile salmonid use of tidal creek and independent marsh environments in north Hood Canal: summary of first year findings. Prepared by Port Gamble S'Klallam Tribe Natural Resources.