CONFLUENCE
ENVIRONMENTAL COMPANY

To: Dave Cline, PE (Shannon & Wilson, Inc.)

From: Paul Schlenger (Confluence Environmental Company)

Date: February 23, 2015

Re: Analysis of Proposed Fish Habitat with Willow Creek Daylighting and Restoration

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The City of Edmonds hired a consultant team led by Shannon & Wilson to complete a final feasibility evaluation of the proposed restoration of a tidal connection between Edmonds Marsh and Puget Sound. The proposed restoration entails daylighting the lowermost reach of Willow Creek to create a new outlet channel from the marsh, including a section of the channel which would pass through the Marina Beach Park to connect to the marine shoreline. The daylighted portion of Willow Creek is entirely within the intertidal zone. As part of the consultant team, Confluence Environmental Company (Confluence) was tasked with evaluating juvenile salmon habitat and access to the salt marsh. This memorandum describes the findings of the evaluation and includes recommended considerations for the restoration design. This evaluation builds upon previous analysis conducted by Confluence as part of the Willow Creek Daylight Early Feasibility Study (Shannon & Wilson 2013). The Early Feasibility Study includes more introductory information, including: Puget Sound shoreline function, habitat structure in the marsh, and potential contaminant impacts to habitat. This memorandum is intended to provide text that will be incorporated into the final feasibility study report.

BEACH OUTLET CHANNEL EVALUATION

During the early feasibility study (Shannon & Wilson 2013), a range of potential alignments to daylight Willow Creek were evaluated and a preferred alternative was selected. The selected alternative entails constructing a daylighted channel for Willow Creek that will run south adjacent to the BNSF railroad tracks before flowing through an existing railroad bridge and flowing out through the City's Marina Beach Park.

In this final feasibility study, two potential beach outlet channel alignments through the park are being evaluated (see Anchor QEA [2015] for figures showing the alignments). In this evaluation, the term beach channel outlet refers to the portion of the daylighted creek that is downstream of the railroad bridge. Both options are identical upstream of the railroad bridge and have the proposed channel bottom elevation under the railroad bridge at +4 feet NAVD88 (+6.2 feet mean lower low water [MLLW]). Option A would turn the beach outlet channel sharply to the south after flowing under the railroad bridge. This option would flow through the existing dog off-leash area of the park and its length downstream of the railroad bridge would be approximately 450 feet. Option B would be oriented north

of Option A and avoid any sharp turns downstream from the railroad bridge. In this option, the channel alignment extends through the existing parking lot and lawn area. The channel downstream of the railroad bridge in Option B is approximately 600 feet long.

The beach outlet channel will provide habitat for juvenile salmon originating from within the Willow Creek and Shellabarger Creek systems, as well as those fish originating from other river and creek systems. Recent research has documented the presence of juvenile salmon using the lower creek and estuaries of creek systems other than the one the fish originated in. Beamer et al. (2004) documented the preferential use of non-natal pocket estuaries by juvenile salmon compared to other marine nearshore habitats. More recently, Beamer et al. (2013) studied juvenile salmon distributions in the lower creek habitats of smaller tributaries and regularly found juvenile salmon in the lower reaches (i.e., lower 600 ft) of non-natal creeks. As a result of this increasing understanding of juvenile salmon utilization of pocket estuaries and lower creek habitats, restoration of these habitats has been a focus of nearshore restoration efforts throughout Puget Sound.

The beach outlet channel will provide two main functions for juvenile salmon: 1) entrance corridor to the entire marsh system, and 2) habitat for species using this portion of the project. A comparison of how the two beach outlet channel options provide these functions is described below.

In considering juvenile salmon utilization of the overall restoration project, the beach outlet channel is particularly important because it forms the entrance point for juvenile salmon access into the channel and marsh system. Fish access from Puget Sound into the restored habitats will be dependent upon the extent to which the restored outlet channel stays open. Given the adjacent infrastructure constraints as well as onsite constraints associated with providing areas for recreational and habitat purposes, either beach outlet channel option will present design challenges for maintaining juvenile salmon access while also avoiding or minimizing the use of rock. Shoreline sediment transport and log accumulation are natural processes along the marine nearshore, but both can affect the accessibility of the restored habitats. Net shore-drift of sediment along this stretch of the Puget Sound shoreline is from south to north. This sediment transport process would naturally tend to push a creek channel to the north. From this perspective, the more northerly outlet alignment provided by Option B is more appropriate given the natural processes acting on the site and is more likely to be sustainable while avoiding or minimizing the use of rock.

For a number of reasons, beach channel outlet Option B would be expected to provide better juvenile salmon habitat downstream of the railroad bridge. First, the outlet location of Option B would be in a more natural channel alignment and would provide a better opportunity to design it to work with natural processes while using less rock than the Option A channel. The sharp turn that Option A would take just downstream of the bridge is one specific area already identified as likely to require rock armoring to keep in place. Second, Option B would be longer and provide more estuarine habitat for juvenile salmon to utilize. For juvenile salmon migrating along the shoreline, the beach outlet channel habitats would be the first part of the Willow Creek/Edmonds Marsh system they encounter. While a subset of the juvenile salmon will move further into the creek and marsh system, there will be other

juvenile salmon that only utilize the beach outlet channel portion of the site. The additional habitat will provide more estuarine habitat for the fish to use. Third and finally, the Option B alignment would be expected to provide fewer disturbances to fish than the Option A alignment. The rationale for this is that Option A would flow through the existing off-leash dog area. Dogs would be more likely to enter the creek throughout the spring and early summer period of the year when most juvenile fish may be present. Dogs would also be more likely to damage riparian vegetation which would otherwise form a visual barrier between the creek and adjacent park areas. Option B would run through the existing park area and could result in people entering the creek; however, that is less likely to happen except during the summer when fewer juvenile salmon would be expected to be present. The potential disturbance associated with the options may change in the future based on the outcome of the park master planning work that is underway.

Based on the considerations described above, beach outlet channel alignment Option B provides better habitat and access for juvenile salmon. The design will need to focus on the alignment, channel geometry, and materials that are conducive to providing regular access to the channel and marsh system, while also providing productive rearing habitat and minimizing or avoiding the use of large rock. To the extent possible given the park needs, the beach outlet channel could be designed to provide better habitat if there is space available for channel movement over time and side slopes that are not steep.

JUVENILE SALMON ACCESS TO EDMONDS MARSH

The primary ecological objective of the proposed daylighting of Willow Creek is to restore the connectivity between Edmonds Marsh and Puget Sound for water, fish, invertebrates, and organic matter contributing to the marine food web. This will be achieved by daylighting the lowermost portion of Willow Creek to provide a surface water connection between the marsh and the marine nearshore. An important aspect of the connectivity is providing flow conditions that support juvenile salmon passage into the daylighted channel and marsh habitats

Semi-diurnal tidal cycles provide continuous changes in water surface elevations in the nearshore areas with two daily high tides and two low tides. These changes in water surface elevations throughout the tidal cycle result in corresponding changes in flow velocities and channel depths as water inundates and drains marsh systems. In barrier estuaries with substantial freshwater sources, such as Edmonds Marsh, there is additional depth and flow variability resulting from runoff from upland areas. Variations in the inundation of the outlet channel and the associated flow velocities result in naturally intermittent access to barrier estuary habitats for juvenile salmon migrating along marine shorelines.

When the tide is rising, the direction of water flow is into these barrier estuary systems. Thus, during rising tides, fish can actively migrate into the areas or passively move with the water as it enters the habitats. In contrast, when the tide is falling, the direction of flow is out of the barrier estuary system and requires fish to swim upstream to access the marsh habitats. As a result, juvenile salmon movement into marshes occurs more often during the rising tide as fish move with the water. Research

by Hering et al. (2010) documented that approximately 80% of juvenile salmon movements in a tidal channel were in the direction of tidal currents.

Fish passage requirements are less clear in tidal areas compared to freshwater streams (WDFW Water Crossing Design Guidelines by Barnard et al. 2013). The law requires that fish passage is provided at manmade barriers, such as water crossings (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.

Allowable depth and velocity criteria for juvenile salmon in tidal systems have not been explicitly developed by WDFW, instead criteria for adult trout (>6 inches long) established in WAC 220-110-070 are the most applicable. The fish passage maximum velocity criteria are presented in Table 1. The minimum depth criterion is 0.8 ft.

Table 1. Most Applicable Fish Passage Velocity Criteria

Culvert Length	Maximum Velocity
10 – 100 ft	4 ft/s
100 – 200 ft	3 ft/s
>200 ft	2 ft/s

Maximum allowable velocities for fish passage range between 2 and 4 ft/s depending on the length of the water crossing (i.e., bridge or culvert). Other research reported in Barnard et al. (2013) indicates that maximum velocities as low as 1 ft/s may be more appropriate for small fish such as juvenile salmon. Barnard et al. (2013) report the following:

> "Based on an evaluation of juvenile passage through culverts conducted by P. D. Powers (Powers and Bates 1997), the recommended design velocities for fry and fingerlings are 1.1 and 1.3 fps respectively. Fry are spring-migrating juveniles generally less than 60 mm in fork length. Fingerlings are fall-migrating fish, generally greater than 60 mm in fork length."

Barnard et al. (2013) also notes that the Muckleshoot Indian Tribe reports that the maximum velocity for fish passage through culverts was found to be 1 ft/s.

In the Willow Creek daylighting project, there will be one or two water crossings. One is the railroad bridge separating the lower creek from the beach. The other is a possible floodgate[1] that may be included in the design to avoid flooding. The floodgate would be approximately 800 feet upstream from the railroad bridge. Both possible water crossings would be much shorter than 100 feet long; therefor,

[1] The term floodgate is used instead of tidegate because if it were included in the design, the floodgate would only close at elevations above mean higher high water (MHHW). These closures would only be for flood control purposes. MHHW at the site is +9.1 ft NAVD 88 (+11.3 ft MLLW) (Anchor QEA 2015).

the maximum velocity criterion is 4 feet per second (ft/s). However, as noted above there are other observations suggesting velocities as low as 1 ft/s would be more typically utilized.

Although fish passage is naturally intermittent in barrier estuary systems such as Edmonds Marsh, it is necessary – and the primary ecological objective – to provide adequate fish passage past the railroad bridge (a water crossing) and past a one is included in the design, as well as the entire daylighted channel alignment.

The suitability of passage conditions for juvenile salmon moving from Puget Sound into Edmonds Marsh was evaluated using depth and velocity predictions from a one-dimensional (1-D) hydrodynamic model prepared for the project (Anchor QEA 2015). The hydrodynamic model was prepared for a two-week spring period (May 1-14, 2008) which is considered representative of conditions during the spring rearing period. The two week timeframe allowed the analysis to encompass one spring and neap tide cycle. The model was run assuming flows from Willow and Shellabarger creeks were 0.8 cfs combined. Throughout the analysis period, depths and velocities were estimated in 15 minute intervals.

The analysis was conducted for two scenarios: with and without a floodgate in the Willow Creek channel. The floodgate scenario is described fully in Anchor QEA (2015). The floodgate would occur approximately 800 feet upstream of the railroad crossing (station 1402). The floodgate would consist of three culverts, one of which is lower than the other two (one at +4.0 ft NAVD 88 and two at +5.5 ft NAVD 88) in order to allow more fish passage during low flow conditions. The floodgate would be open when water levels are below +9.5 ft NAVD 88 (+11.7 ft mean lower low water [MLLW]). The floodgate closure at those water levels is intended to protect SR-104 and Dayton Street areas from tidal flooding during extreme tide and storm surge conditions.

The analysis indicated that during 26% of the time, water will be flowing into the marsh with the rising tide and minimum depths of 0.8 ft will be provided throughout the entire route to the marsh (Table 2). That translates to approximately 3 hours per tidal cycle, flows throughout the daylighted channel will allow for fish to migrate into the marsh without having to swim upstream. In presenting the results of the overall evaluation of fish passage, the percentages are described based on the model results compared to the maximum velocity criteria indicated. Minimum depths of >0.8 ft were available during all times that were considered fish passable. In the no floodgate scenario, maximum velocities of <4 ft/s will be provided during 65% of the time. Fish will be able to access the marsh and encounter no velocities higher than 2 ft/s during 57% of the time. The percentage of time drops to 38% when considering maximum velocities of 1 ft/s.

Suitable conditions for fish passage can also be provided with a floodgate, although the percentage of time is reduced compared to the no floodgate scenario. Due to the constricted release of water through the floodgates, some increases in water velocities is expected to allow the marsh to drain. Considering a maximum velocity of <4 ft/s, a floodgate would have minimal effect on fish passage as the criteria would be achieved 63% of the time (compared to 65% with no floodgate). However, more substantial reductions in the suitability of conditions are expected to occur when evaluating maximum velocities of

3 ft/s and 2 ft/s (47% and 36% of time, respectively). The percentage of time in which maximum velocities are <1 ft/s is 30% in the floodgate scenario.

Table 2. Percentage of Time Providing Fish Passage

Criteria	No Floodgate	With Floodgate
Incoming tide and minimum depth >0.8 ft	26%	26%
Maximum velocity <4 ft/s and minimum depth >0.8 ft[a]	65%	63%
Maximum velocity <3 ft/s and minimum depth >0.8 ft	65%	47%
Maximum velocity <2 ft/s and minimum depth >0.8 ft	57%	36%
Maximum velocity <1 ft/s and minimum depth >0.8 ft	38%	30%

Note: Most applicable criteria per WAC 220-110-070

This analysis shows that depth and velocity conditions allowing juvenile salmon to move into the daylighted creek and marsh will be regularly provided. Based on this analysis, it is reasonable to expect that some juvenile salmon migrating along the Puget Sound shoreline will enter the daylighted creek and marsh system. Given the length of the daylighted channel, not all fish entering the daylighted creek would be expected to move all the way up to the marsh. However, juvenile salmon would be expected to use the pocket estuary and lower portion of the creek. These fish would benefit from the additional rearing habitat and productive prey resources entering these areas from the marsh. In addition, the plant material entering Puget Sound from the marsh would contribute to the food web and increase nearshore productivity near the creek mouth.

SUMMARY OF FINDINGS AND RECOMMENDED DESIGN CONSIDERATIONS

This analysis of the beach outlet channel and fish passage conditions into Edmonds Marsh made the following findings regarding the proposed restoration project:

- The beach outlet channel between the main portion of the marsh and the beach provides important rearing habitat for juvenile salmon while also functioning as a migratory corridor for the fish. The outlet channel can provide highly functional habitat for rearing fish and is an important component of the overall benefits to juvenile salmon.
- Beach outlet channel Option B which would run toward the northern part of the City's existing Marina Park is the better beach outlet channel alignment for juvenile salmon because it would provide more habitat for fish and is in a more sustainable and natural location than an outlet to the south.

- The proposed daylighting of Willow Creek will restore the connection between Puget Sound and Edmonds Marsh and provide conditions that will enable juvenile salmon, other fish, and other nearshore fauna to enter the marsh system during portions of the tidal cycle.
- In the scenario with no floodgate, suitable conditions for juvenile salmon passage will be provided throughout the entire channel length to the marsh from 38% to 65% of the time depending on maximum velocities evaluated.
- Juvenile salmon will be able to move with the water flowing into the marsh and have suitable water depths during approximately 26% of the time. This equates to approximately 3 hours in each tidal cycle.
- More fish access to the marsh is provided in a scenario without a floodgate. Based on the floodgate configuration evaluated, having a floodgate in the channel will increase velocities and there will be more time in which velocities are between 2 and 4 ft/s.

The following considerations are highlighted for incorporation into future design work at the site:

- The beach outlet channel design will need to focus on alignment, channel geometry, and materials that are conducive to providing regular access to the daylighted channel and marsh system, while also providing productive juvenile salmon rearing habitat and minimizing the use of large rock.
- To the extent possible given the park needs, the beach outlet channel could be designed to would provide better habitat if there is space available for channel movement over time and side slopes that are not steep.
- Regardless of the beach outlet channel alignment, dogs should not be allowed to enter the channel. If the channel goes through a dog off-lease area, it is recommended that fencing or other materials are used to prevent dogs from accessing the creek. Restricting people from entering the creek would also benefit fish and the ecological conditions in the creek.
- A vegetated buffer along the outlet channel is important as it will provide multiple functions. A vegetated buffer would reduce behavioral disturbance to fish and other animals in the stream from the activities of park visitors. Riparian vegetation in upland areas along the beach outlet channel would also be beneficial for providing prey inputs, shade, and separation from park visitors.
- Refinement of the channel cross-section geometry to provide a low flow channel can create more suitable fish habitat during the fall tide and low flows. Such refinement should consider the resulting effects on depth and velocity to work toward a design that maximizes fish passage and fish habitat within the channel over a range of flow conditions.
- Instream wood should be included in the outlet channel design to provide habitat structure and lower velocity areas for juvenile salmon. These elements will improve the fish passage conditions for the fish, as well as improve the rearing habitat quality in the channel.
- To the extent possible along the entire alignment, riparian vegetation should be included in the design with a focus on providing shade to the channel. Riparian vegetation overhanging the channel will provide cover for fish from birds and separate the channel from activities on adjacent properties.

- If space allows given other constraints, habitat in the outlet channel would be improved if some sinuosity could be incorporated so the channel is not a prolonged straight channel. If the channel is shifted to the east, there could be more room to provide a vegetated riparian buffer.
- Sediment loads into the daylighted channel should be considered in the channel design. Design techniques should be incorporated to transport sediment through the system in order to reduce the potential for excessive sedimentation in the channel, including the beach outlet portion of the channel.
- In Edmonds Marsh, some removal of cattails and other dominant freshwater vegetation should be considered to facilitate the transition of the marsh to more of a salt marsh. Freshwater vegetation currently encroaches on areas in the marsh where more salt water is expected by daylighting Willow Creek.

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