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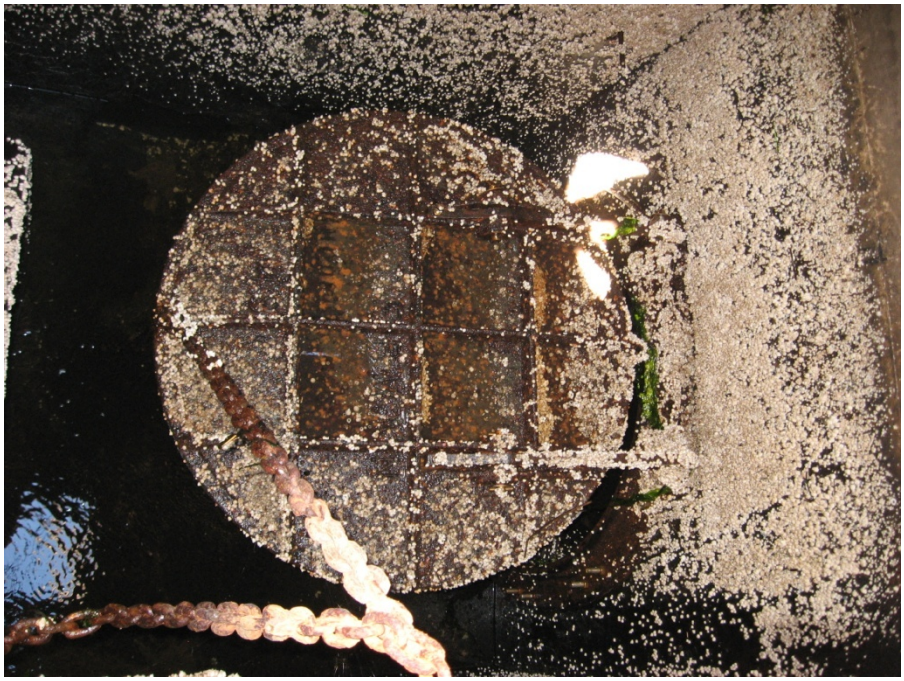

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APPENDIX B

HYDROLOGIC MONITORING

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HYDROLOGIC MONITORING

B.1 INTRODUCTION

Shannon & Wilson, Inc. installed surface water hydrologic data loggers for the Willow Creek Daylight project site (Figure B-1 of main report). The purpose of the monitoring network is to document baseline conditions for use in engineering design and model calibrations.

B.2 DATA LOGGER INSTALLATIONS

A total of six locations had data loggers installed for surface water monitoring (Figure B-1). Data loggers were used at multiple locations over varying periods of time to collect the data. Table B-1 is a summary of data logger information and data collection periods.

Stand pipes were installed with polyvinyl chloride pipes and secured to adjacent structures, or driven into the stream bed sediments. Data loggers were then deployed into the stand pipes with secure locking caps. The top of cap was then surveyed to facilitate calculation of water surface elevations from the data logger output.

B.2.1 Surface Water Level, Salinity, and Temperature Measurements

Water level, temperature, and salinity were collected at each of the data logger locations, except for LTC-3b and LTC-4 in Shellabarger and Willow Creek, respectively, which only collected water level and temperature. Salinity was not collected as these are known freshwater sections of the streams. Water level, temperature, and salinity were recorded early in the study at the Port of Edmonds Marina (LTC-1A), the Lower Willow Creek channel (LTC-2), and the Shellabarger Creek Marsh (LTC-3A). Water level and salinity were recorded and reported in the WSDOT manhole data logger LTC-1B. Water level and temperature were recorded for the upstream tributaries Shellabarger Creek and Willow Creek, LTC-3B and LTC-4, respectively.

B.2.2 Data Observations and Interpretations

LTC-1A was the tidal data logger located in the Port of Edmonds Marina. This data logger recorded tidal water levels, conductivity (salinity), and temperature (Figures B-2 through B-4). The water level data collected confirmed that the Seattle, Elliott Bay National Oceanic and Atmospheric Administration Gauge 9441370 was very similar in tidal elevations and timing, and

could be used as a reference and data source for tidal data. Observed salinities and temperatures were typical of Puget Sound seawater conditions.

LTC-2 was the data logger located in Lower Willow Creek channel near the Union Oil Company of California stormwater pond (Figures B-2 through B-4). This data logger recorded water surface elevations that fluctuated between elevation 6 feet (North American Vertical Datum of 1988 (NAVD88), which is roughly the bottom of the channel, and elevation 8 to 9 feet on average. The data indicate muted tidal inflows. A maximum observed water surface elevation of 10.4 feet on November 19, 2012. For reference, the Dayton Street catch basin low point is approximately elevation 10.1 feet. Salinities for the Lower Willow Creek channel LTC-2 range from 0 to 35 parts per thousand. Temperatures ranged from 0 degrees Celsius (ºC) to 24ºC for LTC-2. The higher temperatures near 24ºC are above the lethal limits for fish (16ºC). The likely source of high water temperatures is the shallow nature of flows in the Lower Willow Creek channel, which has little shading.

LTC-3A was the data logger located in lower Shellabarger Creek Marsh (Figures B-2 through B-4). The water levels recorded in Shellabarger Creek marsh lie around elevation 10 feet (NAVD88) and are on average about 4 feet higher than in the Lower Willow Creek and Edmonds Marsh. This is likely due to clogged or blocked WSDOT culverts beneath State Route 104. The peak observed water surface elevation was 11.84 feet (NAVD88), which is above the Dayton Street catch-basin inlet, and near the top of curb along the WSDOT cueing lane of 11.53 feet.

LTC-1B was the data logger located in the WSDOT manhole at the downstream end of the existing Lower Willow Creek channel (Figures B-5 and B-6). The water levels recorded in the WSDOT manhole show tidal flows, with a peak tidal water elevation of 12.67 feet on November 28, 2014. The top of the manhole elevation is 11.83 feet and is evidently overtopped. A riser could be added to the manhole to reduce the potential for overtopping and flowing into Willow Creek. The overflows appear to be associated with high tides, and not necessarily stormwater runoff flows alone. Storm flows occurring at high tide would undoubtedly overtop the manhole. We note salinity levels fluctuate with the tide at this gage. The fluctuations are likely related to the drying out of the data logger on each cycle, and not upstream freshwater inflows to the pipe system.

LTC-3B and 4 are the data loggers installed in upper Shellabarger and Willow Creeks that are recording water level and temperatures (Figures B-7 and B-8). The water levels recorded in the streams are fairly consistent between the two stream systems with Shellabarger

Creek being more “flashy” due to the confined nature of the channel where the gauge is located, and in a more urbanized watershed. The peak observed water surface elevation for LTC-3B Shellabarger Creek was 18.9 feet on October 11, 2014. The peak observed water surface elevation for LTC-4 Willow Creek was 18 feet on December 11, 2014. Water temperatures ranged between 4ºC and 18ºC for both creeks, with Shellabarger Creek exhibiting about a 2ºC higher water temperatures during the summer months compared to Willow Creek.

B.3 DATA QUALITY ASSURANCE

Quality control activities involves comparisons of onsite measurements of water surface elevations of wells against the compensated water surface elevation time-series. These differences vary from 0.0 to 0.3 foot and can be attributed to slight adjustments in data logger cable lengths during data download and redeployment and accuracy of measuring water surface depth in wells.

We note several data logger failures during the data collection period, for which new equipment was installed and replaced when the failures occurred.

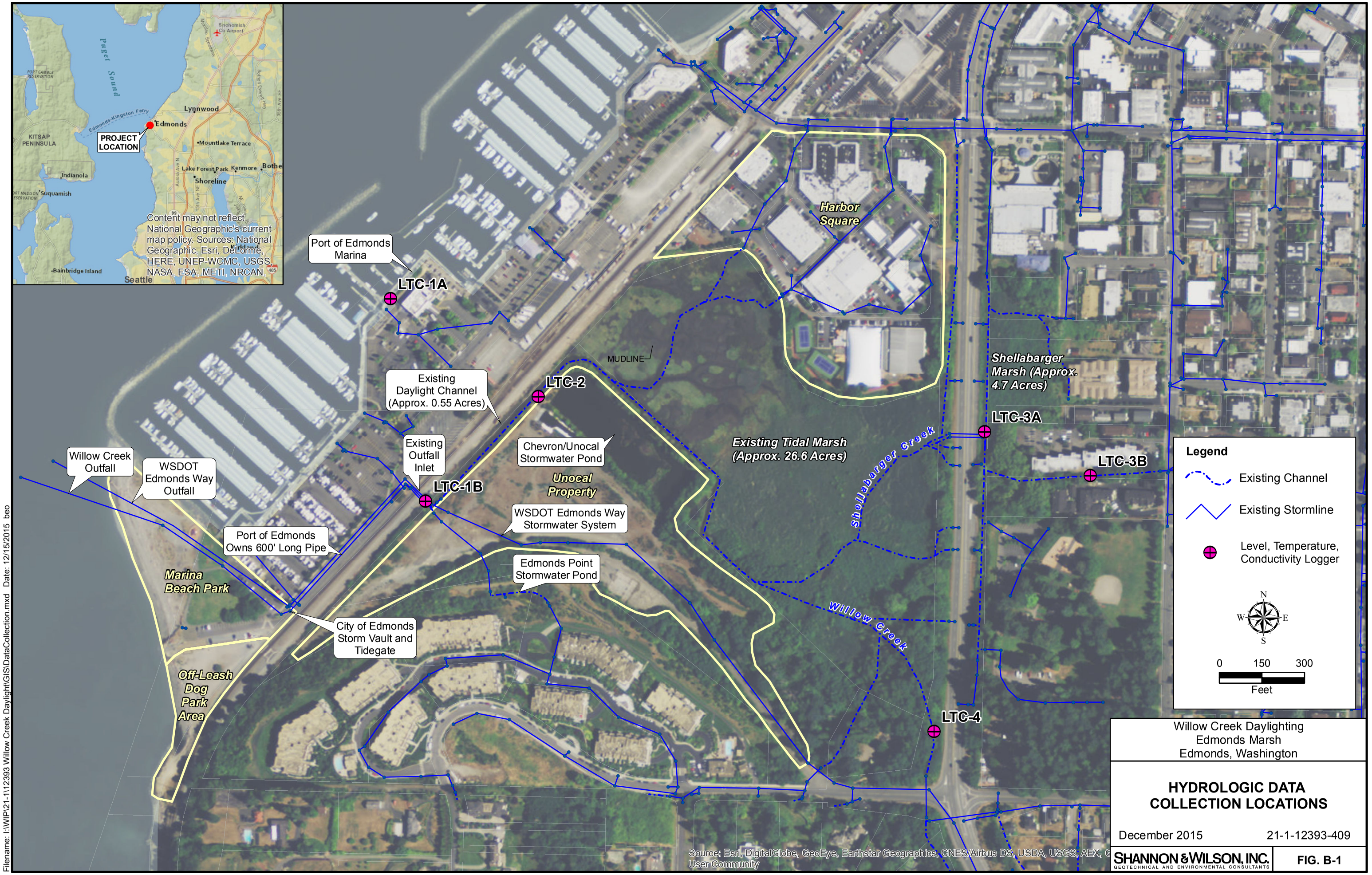
B.4 FUTURE DATA COLLECTION SCHEDULE

The end of the data collection monitoring period is July 2015.

TABLE B-1
DATA LOGGER SUMMARY

ID	Type	Serial Number	Date of Deployment	Date of Removal	Top of Casing Elevation (ft) (NAVD88)	Description
LTC-1a	Level, Temp., Conductivity	0121068287, 0121068547	8/30/2012	7/30/2013	2.67	Located Edmonds Marina near J-Dock, on pile underneath weather station.
LTC-1b	Level, Temp., Conductivity	1069279	12/18/2013	N/A	11.83	Located in WSDOT Manhole.
LTC-2	Level, Temp., Conductivity	121068297	8/31/2012	7/25/2014	10.10	Located in Lower Willow Creek just upstream of Unocal Stormwater Pond Outlet.
LTC-3a	Level, Temp., Conductivity	121068299	8/31/2012	7/18/2013	14.48	Located in Shellabarger Creek Marsh northeast of SR-104 near WSDOT culverts.
LTC-Barrow	Barometric Pressure	12013265	8/31/2012	N/A	N/A	Originally located in Lower Shellabarger Creek Marsh. Now located in Upper Shellabarger Creek.
LTC-3b	Level, Temp.	121068299	12/18/2013	N/A	22.12	Located in Upper Shellabarger Creek. Access from 3rd Avenue Condominiums parking lot.
LTC-4	Level, Temp.	2025122	12/18/2013	N/A	22.34	Located in Upper Willow Creek, upstream from Trout Unlimited Hatchery footbridge.

Notes:
Ft = feet
ID = identification
N/A = not applicable
NADV88 = North American Vertical Datum of 1988
SR = State Route
Unocal = Union Oil Company of California
WSDOT = Washington State Department of Transportation



Willow Creek Daylighting
Edmonds Marsh
Edmonds, Washington

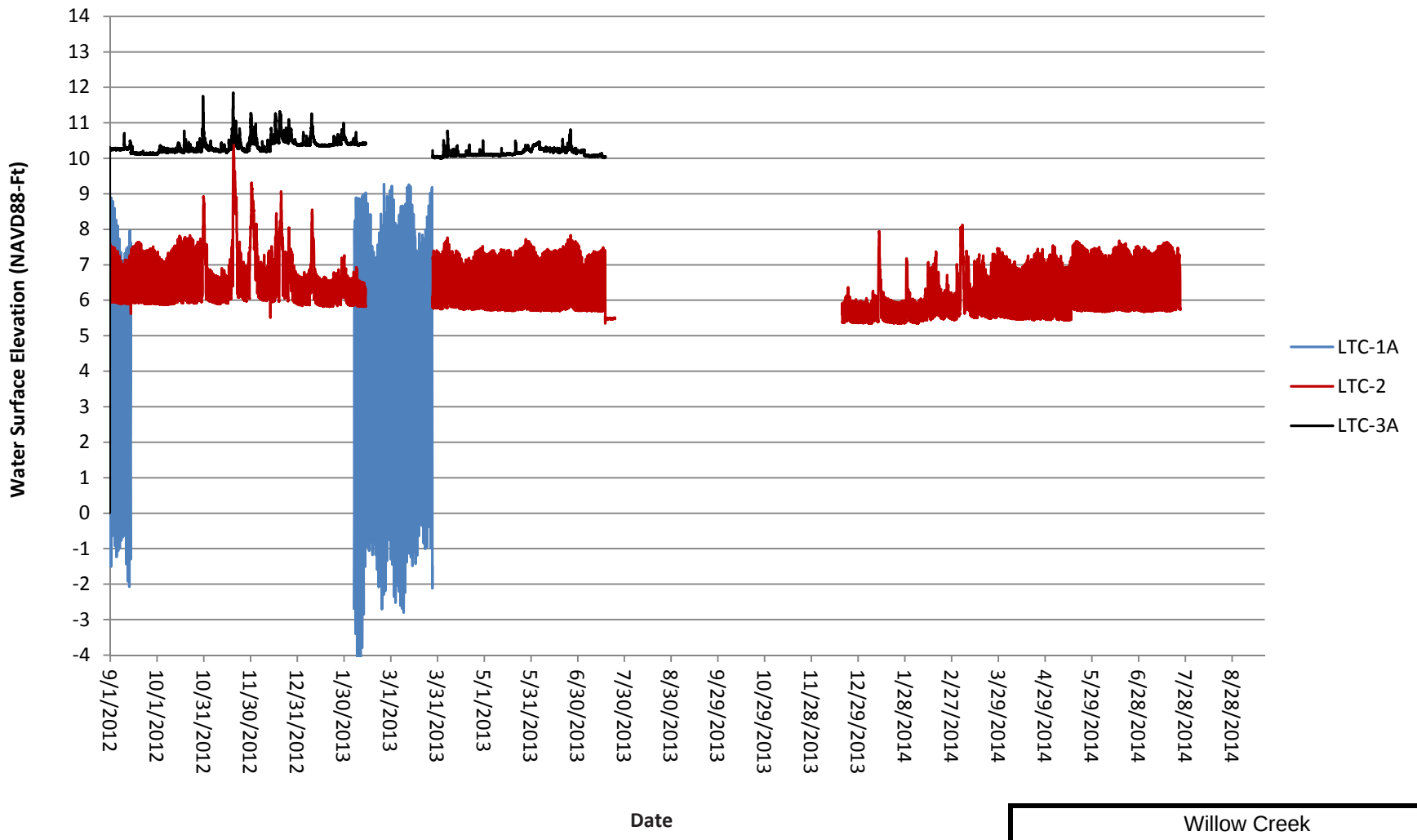
HYDROLOGIC DATA COLLECTION LOCATIONS

December 2015 21-1-12393-409

SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. B-1

Filename: I:\WIP\21-1\12393 Willow Creek Daylight\GIS\DataCollection.mxd Date: 12/15/2015 beo



Willow Creek

Edmonds, WA

LTC-1A, 2, 3A
WATER LEVELS
AUGUST 2012 - AUGUST 2014

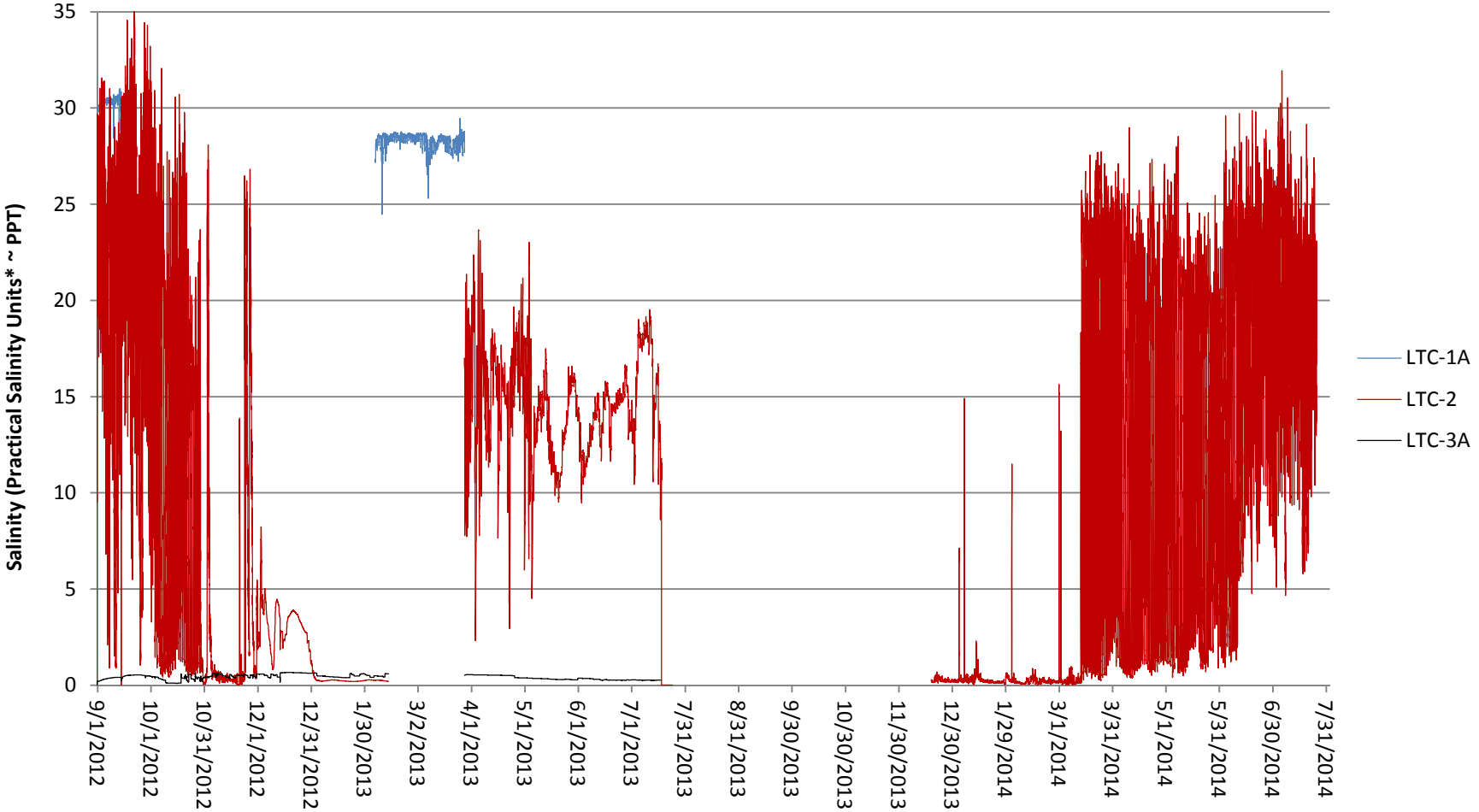
August 2015 21-1-12393-409

SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. B-2

FIG. B-2

I:\WIP\21-1\12393 Willow Creek Daylight\409. FINAL FEASIBILITY STUDY\Appendix B_Hydrologic Monitoring\WILLOW_CRK_MASTER_20150416 <FIG_B2_LTC-1A,2,3A_WSE>



*Practical Salinity Units (PSU) are approximately equivalent to Parts Per Thousand (ppt)

Willow Creek

Edmonds, WA

LTC-1A, 2, 3A
SALINITY
AUGUST 2012 - JULY 2014

August 2015 21-1-12393-209

SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. B-3

FIG. B-3

I:\WIP\21-1\12393 Willow Creek Daylight\409. FINAL FEASIBILITY STUDY\Appendix B_Hydrologic Monitoring\WILLOW_CRK_MASTER_20150416 <FIG_B3_LTC-1A,2,3A_SALINITY>

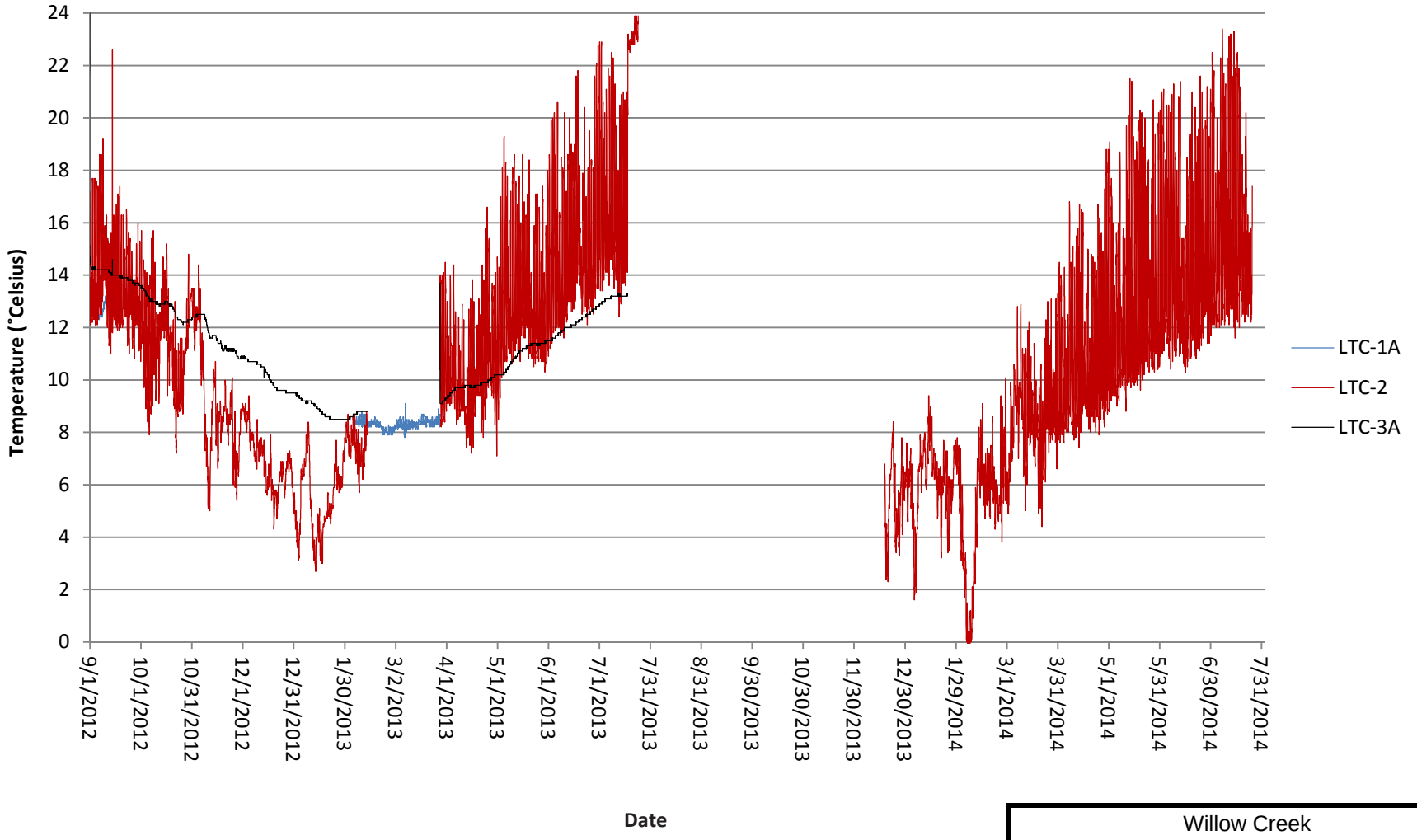


FIG. B-4

Willow Creek

Edmonds, WA

TEMPERATURE
SEPT 2012 - MAY 2014

August 2015 21-1-12393-209

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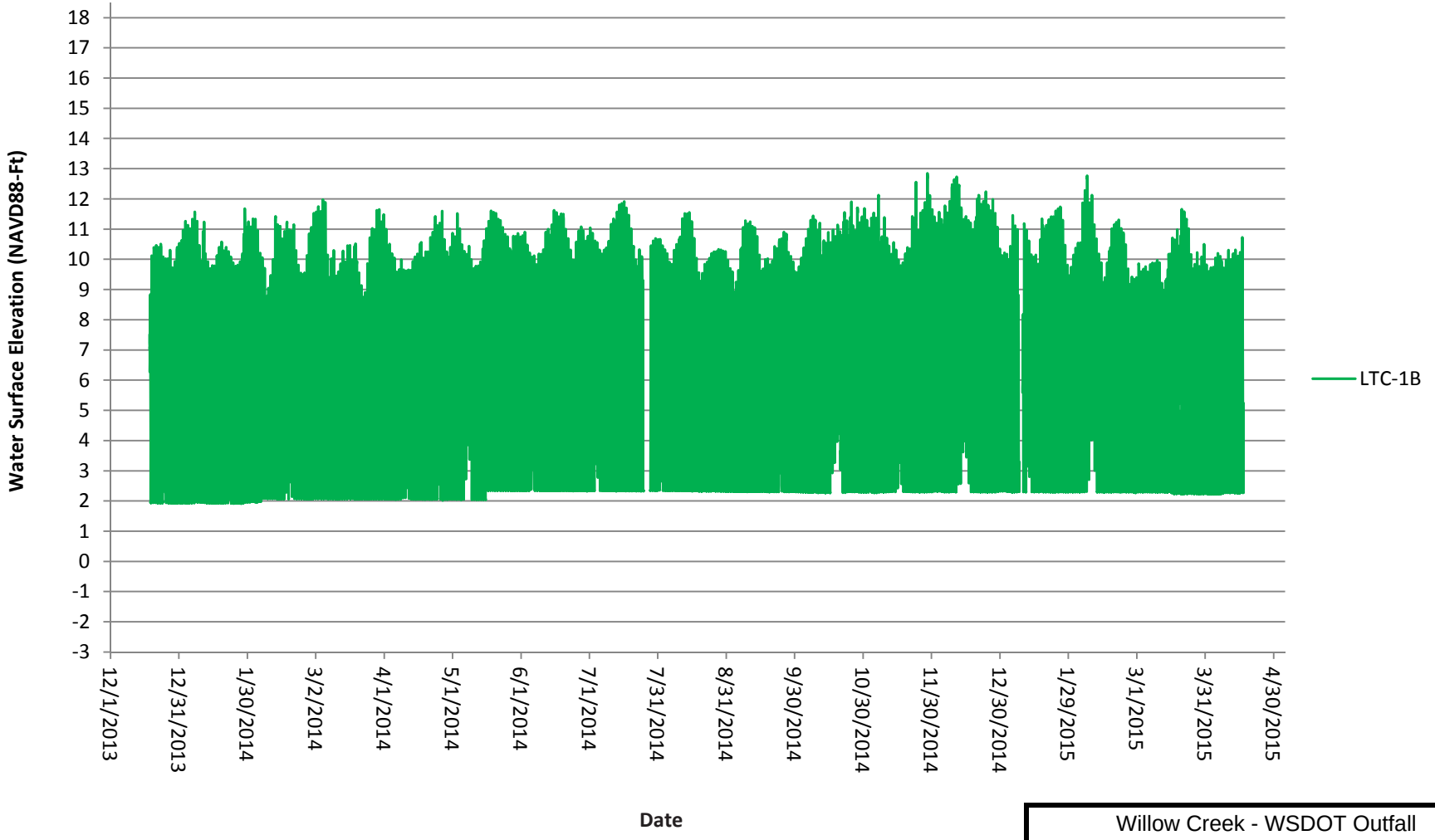
FIG. B-4

I:\WIP\21-1\12393 Willow Creek Daylight\409. FINAL FEASIBILITY STUDY\Appendix B_Hydrologic Monitoring\WILLOW_CRK_MASTER_20150416 <FIG_B4_LTC-1A,2,3A_TEMP>



Willow Creek - WSDOT Outfall

Edmonds, WA

WATER LEVELS
DECEMBER 2013 - APRIL 2015

August 2015 21-1-12393-209

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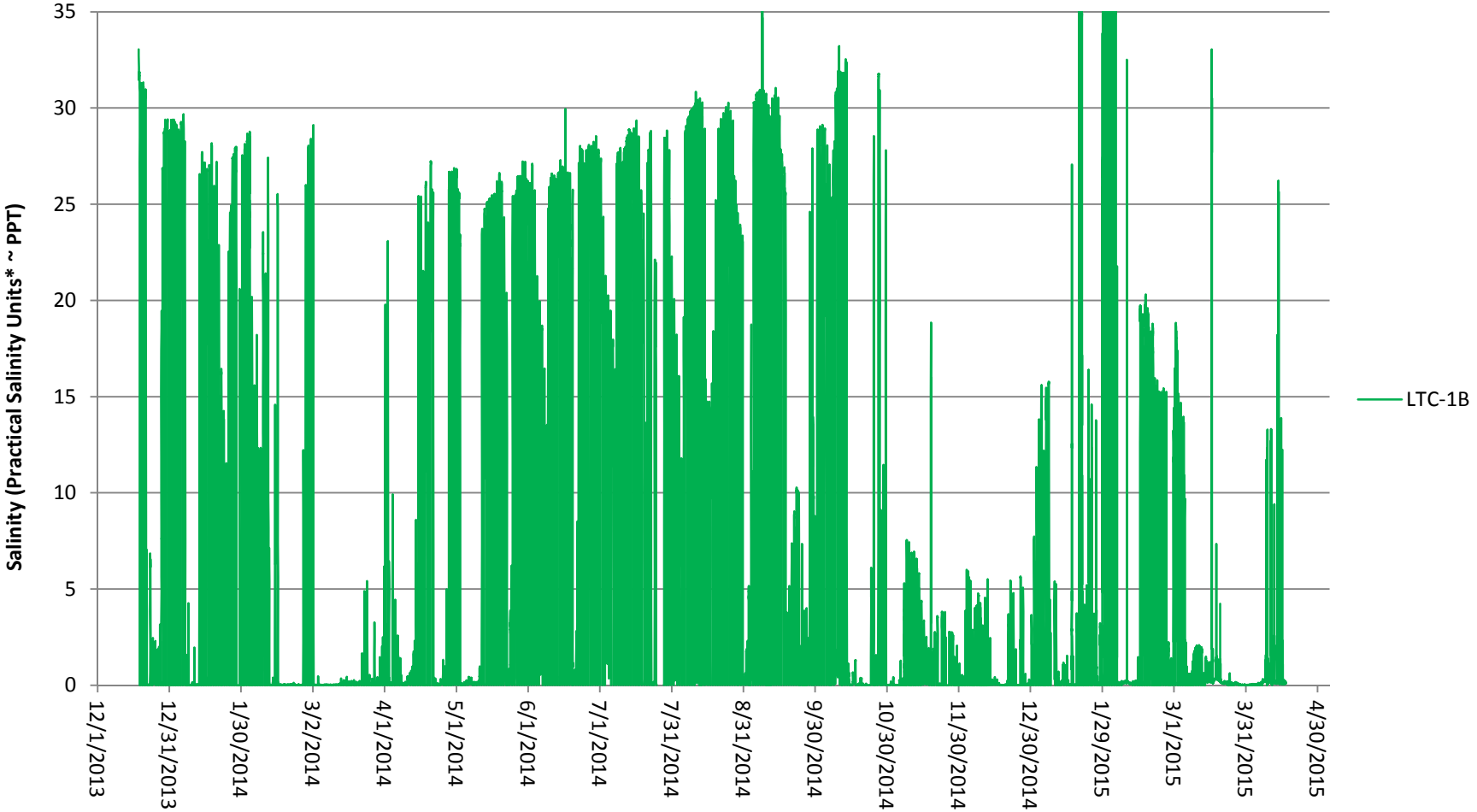
FIG. B-5

FIG. B-5

I:\WIP\21-1\12393 Willow Creek Daylight\409. FINAL FEASIBILITY STUDY\Appendix B_Hydrologic Monitoring\WILLOW_CRK_MASTER_20150416 <FIG_B5_LTC-1B_WSE>



*Practical Salinity Units (PSU) are approximately equivalent to Parts Per Thousand (ppt)

Willow Creek

Edmonds, WA

SALINITY
DECEMBER 2013 - APRIL 2015

August 2015 21-1-12393-409

SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. B-6

FIG. B-6

I:\WIP\21-1\12393 Willow Creek Daylight\409. FINAL FEASIBILITY STUDY\Appendix B_Hydrologic Monitoring\WILLOW_CRK_MASTER_20150416 <FIG_B6_LTC-1B_SALINITY>

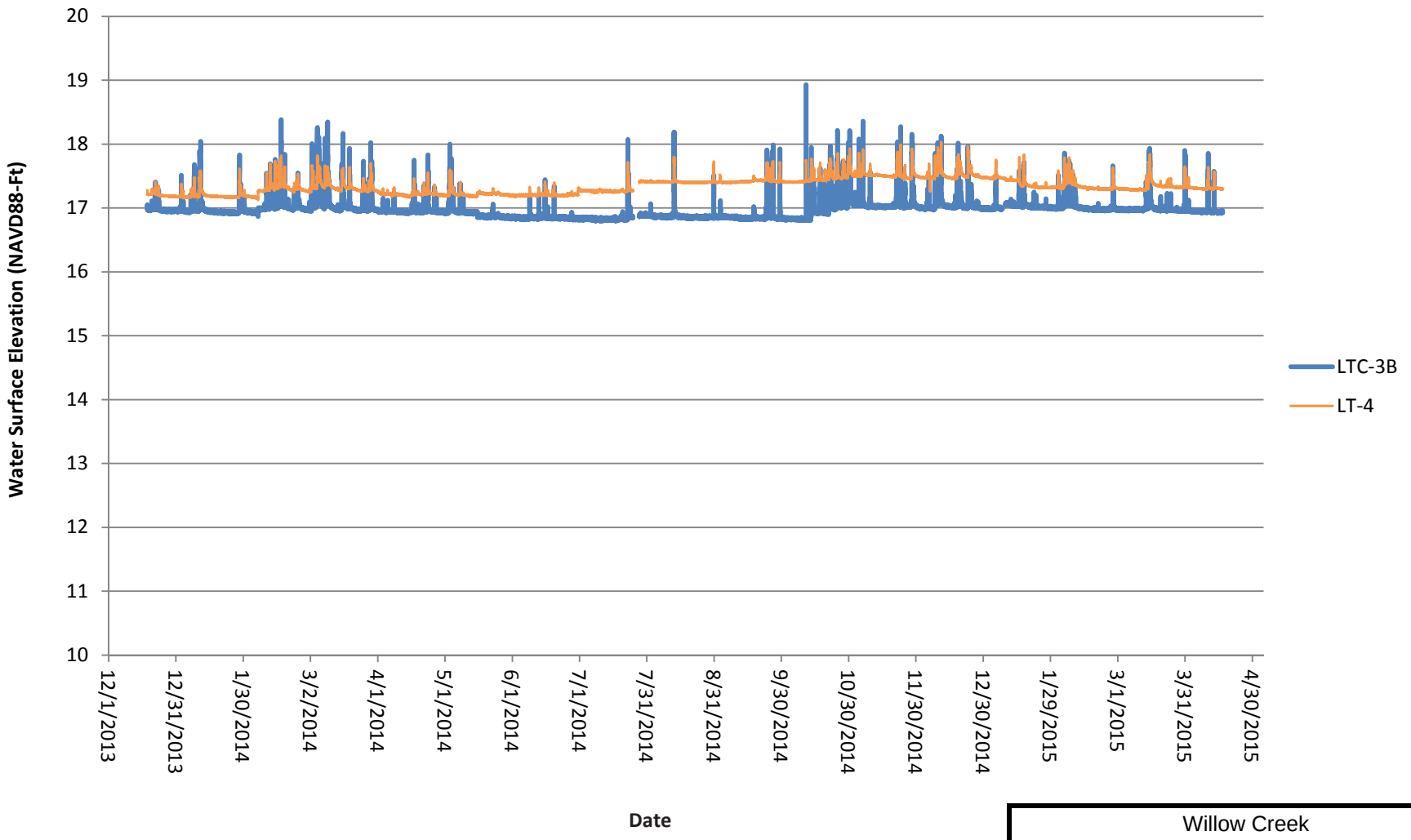


FIG. B-7

Willow Creek

Edmonds, WA

WATER LEVELS
DECEMBER 2013 - MAY 2015

August 2015 21-1-12393-209

SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. B-7

I:\WIP\21-1\12393 Willow Creek Daylight\409. FINAL FEASIBILITY STUDY\Appendix B_Hydrologic Monitoring\WILLOW_CRK_MASTER_20150416 <FIG_B7_LTC-3B,4_WSE>

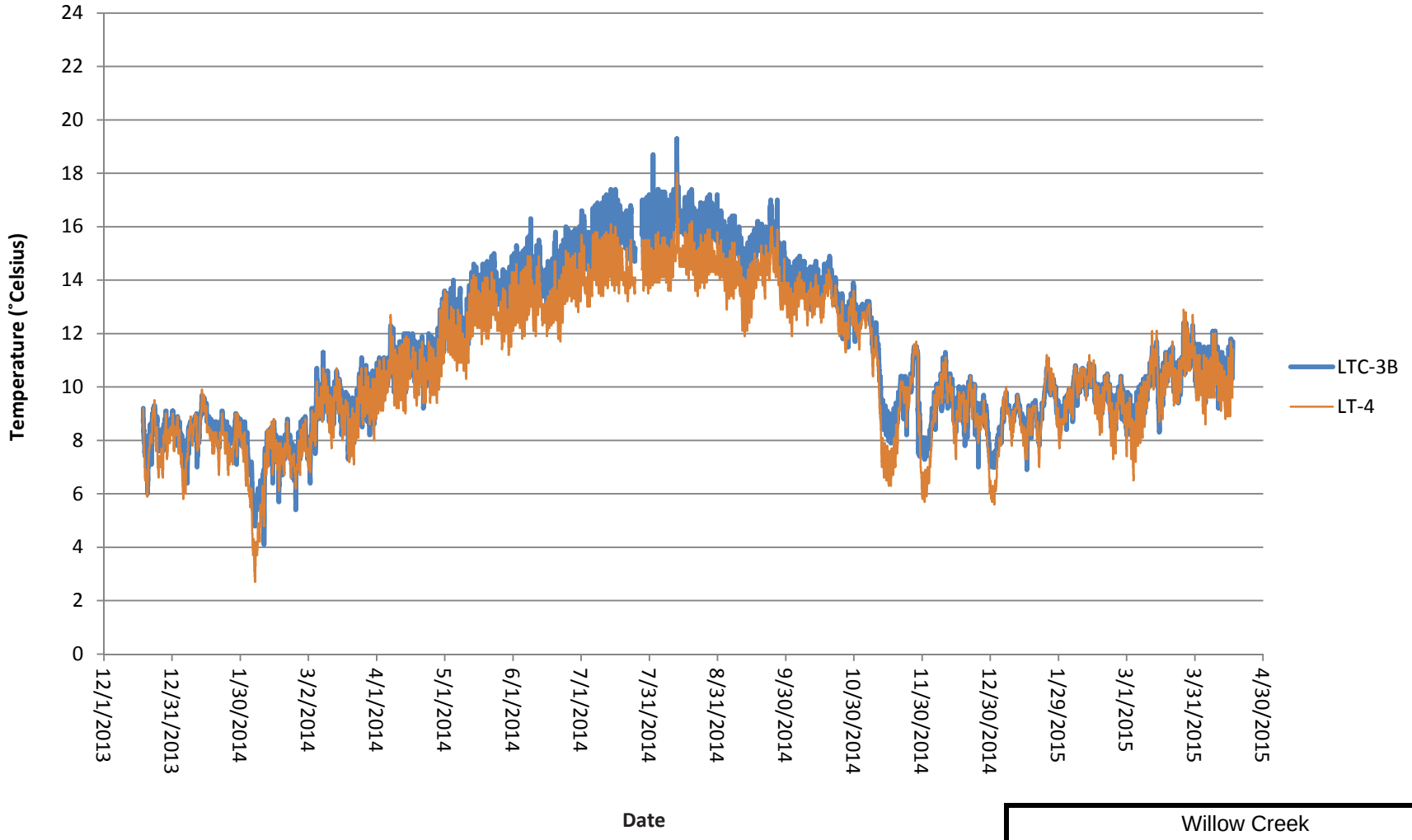


FIG. B-8

Willow Creek

Edmonds, WA

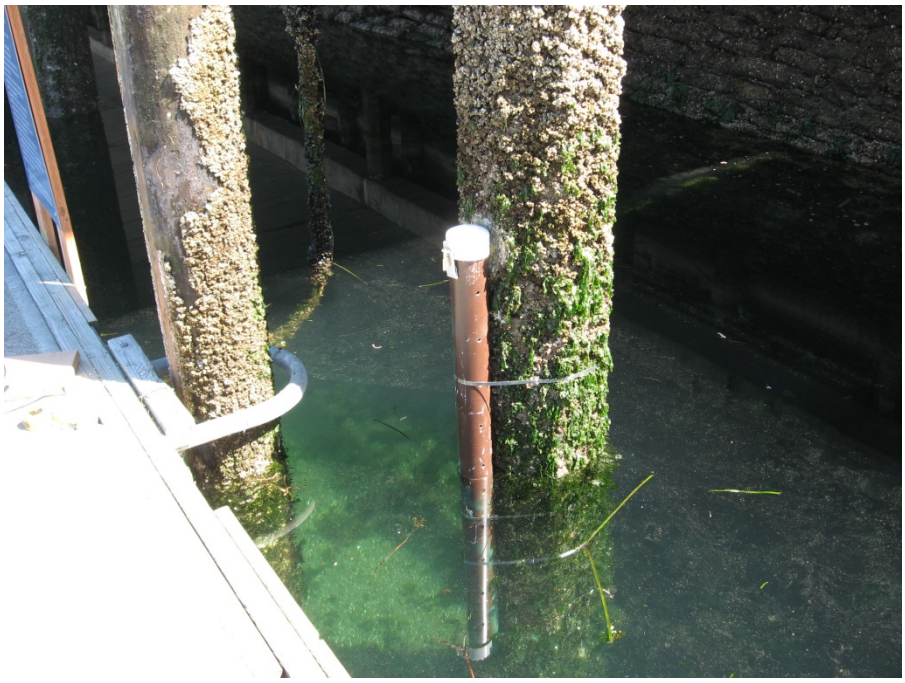
TEMPERATURE
DECEMBER 2013 - MAY 2015

August 2015 21-1-12393-209

SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. B-8

I:\WIP\21-1\12393 Willow Creek Daylight\409. FINAL FEASIBILITY STUDY\Appendix B_Hydrologic Monitoring\WILLOW_CRK_MASTER_20150416 <FIG_B8_LTC_3B,4_TEMP>



Photograph B-1 – LTC-1 Data Logger in Edmonds Marina Near J Dock.

Photograph B-2 – LTC-1B Data Logger in WSDOT Manhole.

Photograph B-3 – LTC-2 Data Logger in Lower Willow Creek.

Photograph B-4 – LTC-3A Data Logger in Lower Shellabarger Creek Marsh.

Photograph B-5 – LTC-3B Data Logger in Upper Shellabarger Creek.

Photograph B-6 – LTC-4 Data Logger in Upper Willow Creek.

APPENDIX C

DAYLIGHT ALTERNATIVE ALIGNMENTS ANALYSIS

APPENDIX C

DAYLIGHT ALTERNATIVE ALIGNMENTS ANALYSIS

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DAYLIGHT ALTERNATIVE ALIGNMENTS ANALYSIS

C.1 DAYLIGHT ALTERNATIVE ALIGNMENTS

Three alternative alignments were identified during the early feasibility phase of the project and evaluated for the preferred general alignment for daylighting Willow Creek from the tidal marsh to the Puget Sound (Figure 1). These alternatives were identified in previous studies (Pentec, 1998), and also for this study as potential locations to daylight and realign Willow Creek. All three alternatives involve daylighting either portions of, or the entire, creek channel downstream of the marsh and increasing the tidal connection to Puget Sound. Daylighting in this context is referred to as realigning the creek from a pipe into an open channel. All alternatives would cross the BNSF Railway Company (BNSF) railroad tracks and flow through property owned by the Port of Edmonds (the Port), the City of Edmonds (the City), or both. Alternative 1 also involves the Union Oil Company of California (Unocal) property, which has an escrow purchase agreement with the Washington State Department of Transportation (WSDOT) for the entire lower yard site. The following sections describe the alternative alignment evaluation approach, findings, and selection of the preferred alignment.

Evaluation of the three proposed alternatives used a screening analysis involving a qualitative review of habitat modifications and impacts, evaluation of coastal hydrodynamics, and an assessment of each alignment's impact on infrastructure and property. The primary evaluation components of the screening analysis include fish habitat and biological response, using a set of technical criteria developed specifically for the project. Other evaluation components include a pros/cons analysis of coastal/tidal hydrodynamics and sediment transport conditions, infrastructure constraints, drainage effects, potential costs, and social-political factors for the alternatives.

A key step in the assessment includes the evaluation of the likelihood of juvenile Chinook and other salmonids to use and access into the daylighted alternative alignments. The following biological response criteria and definitions were used in the screening analysis.

- **Likelihood of juvenile Chinook salmon encountering the marsh outlet**
  - *Explanation of Criterion:* This criterion is a qualitative assessment of the likelihood of juvenile Chinook moving in close proximity to the shoreline of each marsh outlet alignment.

- **Likelihood of the marsh outlet connection remaining open and accessible for juvenile Chinook salmon**
  - *Explanation of Criterion:* Qualitatively assess the potential for sediment transport and/or large wood accumulations to block the access channel to the marsh for juvenile Chinook during the spring and early summer outmigration timeframe.
- **Suitability of marsh outlet and channel for juvenile Chinook salmon passage into restored marsh**
  - *Explanation of Criterion:* Consider the marsh outlet features and their effect on juvenile Chinook salmon's ability or willingness to migrate into the marsh. Considerations include access channel length, generally anticipated flow velocity conditions throughout tidal cycle, number/length of overwater structures (or remaining culvert reaches), and potential habitat features within access channel.
- **Potential to integrate with future restoration**
  - *Explanation of Criterion:* Assess whether the marsh outlet would accommodate potential future restoration opportunities along the outlet channel and in the vicinity of the marsh outlet.

A second component of the screening analysis includes a review of coastal and tidal hydrodynamics in the context of maintaining a permanent connection between Edmonds Marsh and Puget Sound. This review includes a qualitative coastal engineering discussion of tidal hydrodynamics, future marsh conditions, local sediment transport, deposition, and shoaling effects on the alternatives.

The third component of the screening analysis focuses on engineering, property, and socio-political issues. These include a qualitative discussion of infrastructure constraints, drainage effects, potential costs, landowner willingness, and social-political factors for the alternatives from a hydraulic/civil engineering perspective.

C.1.1 Alternative 1 Alignment – Edmonds Marina Beach Park

Daylighting Willow Creek at the Edmonds Marina Beach Park would involve constructing a new channel across the beach park area from the BNSF railroad. Depending on the alignment, the length of the park beach channel would vary from 350 feet if located in the dog park area to the south, or up to 700 feet if located north through the existing parking lot and grassy areas of the park. Appropriate habitat features would be included to make the channel both biologically functional and aesthetically pleasing to park users. For example, instream

wood, natural tidal channels, and riparian vegetation would improve flow complexity and cover conditions in the channel.

At the BNSF railroad, the daylighted creek would cross under the railroad embankment through a pair of two bridges. These bridges were installed as an agreement between BNSF and Sound Transit, and federal and local resource agencies for Sound Transit's plans for a second rail improvements between Seattle and Everett. The plan involves loss of wetland and streams filled as a result of the Second Rail Easement Improvements (Appendix D). The two bridges were installed by BNSF as part of this agreement in 2010 (Photograph 6). These bridges were built and paid for by others, and provide cost savings benefit to the daylighting project.

Upstream from the BNSF bridges, Willow Creek would be daylighted. The daylight channel would travel approximately 700 feet from the BNSF railway bridge, along the Unocal property outside the BNSF right-of-way, and connect to the existing Lower Willow Creek channel. The alignment of the channel would closely follow the alignment shown in the Edmonds Crossing environmental impact statement (EIS) (WSDOT, 2004), thereby meeting the requirements of the EIS and future plans for Edmonds Crossing, if it were to occur in the future.

C.1.1.1 Alternative 1 Alignment – Fisheries

Improving the connection of Edmonds Marsh to Puget Sound by an outlet alignment through the Edmonds Marina Beach Park offers a great deal of potential for fish movement between Puget Sound and the marsh, including juvenile Chinook salmon and adult salmonids such as coho salmon, sea-run cutthroat trout, and possibly chum salmon. The large marsh can provide favorable rearing conditions for migrating juvenile salmon and promote rapid fish growth, which improves likelihood of survival to adulthood.

In this alignment, the marsh outlet would be located in Marina Beach Park which is a favorable location for fish because the natural conditions of the beach. Much of the Central Puget Sound shoreline is armored with protective riprap. Riprap shoreline areas impact juvenile Chinook salmon who tend to remain close to the shoreline during their early marine life stage, before moving into deeper water and eventually migrating to the ocean (Fresh, 2006).

The Edmonds Marsh outlet at Marina Beach Park would be between approximately 9 miles from the Cedar River/Lake Washington Ship Canal, and 16 to 18 miles from the Snohomish River; the closest Chinook salmon bearing rivers to Edmonds Marsh. Given these distances, non-natal fish use of the marsh may be reduced as compared to streams closer to one of the major rivers. However, some juvenile Chinook salmon do remain in close

proximity to the shoreline over long distances in Puget Sound. Several studies of juvenile Chinook salmon distributions in the Puget Sound nearshore have documented fish use of shoreline habitats, such as the Marina Beach Park, at far distances from their river of origin (e.g., Brennan and others, 2004; Dorn and Best, 2005; Fresh and others, 2006; Beamer and Fresh, 2012). It is likely that juvenile Chinook salmon would locate and utilize the marsh, particularly given Alternative Alignment 1, which daylight the marsh outlet stream along a sandy beach that provides favorable foraging habitat. More juvenile Chinook salmon would likely encounter the marsh outlet stream located at the Marina Beach Park as compared to the alternative alignment through the marina (see Alignment Alternative 2 discussion). For adult salmonids returning to Puget Sound, the marsh outlet in the Marina Beach Park is more likely to be encountered compared to the likelihood of the adults entering the marina. There is higher potential for the fish to detect the odor of the freshwater source from a greater distance if it flows across a natural beach rather than through a marina which has a variety of boating related discharges and environmental factors.

A marsh outlet in the Marina Beach Park would be exposed to the wind and wave conditions of Central Puget Sound and, depending on the outlet configuration, some shifting of the outlet should be expected. As long as the design does not detrimentally impact expected adjacent park uses and infrastructure, such movement of the outlet channel across the beach face is a favorable condition such as naturally occurs at other marshes and tributary outlets. Currently, the upper beach accumulates drift logs that come and go with storm events. Beach logs, as well as shifting beach sediments, may partially impede access to the marsh during some time periods, but it is expected that outflows from the marsh will scour sediment deposits and maintain migratory routes into the marsh for fish.

Fish locating the marsh outlet will need to swim several hundred feet from the beach to the marsh. The alternative includes a short portion of overwater structures as the channel runs under proposed Marina Beach Park pedestrian access bridges, and the BNSF railroad track. Otherwise the access channel would be entirely open with the opportunity for habitat features to be included in the design to provide favorable in-channel conditions. Juvenile Chinook salmon and adult salmonids can be expected to migrate this distance to access the marsh habitat. The short distance of overwater structures would not be expected to markedly affect the likelihood of fish entering the marsh entrance channel. The habitat conditions in the entrance channel can be improved by including instream wood, pools, and riparian plantings and vegetation.

The Marina Beach Park outlet channel realignment will need to accommodate a channel platform along east of the BNSF railroad. The restored marsh entrance channel could

potentially be expanded in size and/or realigned further to the east. The rationale for these modifications is related to the fact that a straight daylight alignment along the BNSF right-of-way would have a sharp turn at the bridges, which can be problematic from a hydraulics and fish passage perspective if secondary hydraulic forces occur at the abrupt channel angle. Also, expansion or realignment to the east would allow for developing a meandering channel platform more similar to natural channels, and allow for native riparian plantings on both sides of the channel. This would require that at some point in the future some of the former Unocal site property becomes available and suitable for habitat restoration. This would reduce some of the problems identified with the BNSF railroad culvert crossing configuration being perpendicular to the tracks. In the current plan, the daylight channel follows the BNSF right-of-way property line, and is located along the Unocal property, is straight and has little meandering or platform aside from the curvature necessary to pass through the BNSF railroad bridge.

C.1.1.2 Alternative 1 Alignment – Coastal Hydrodynamics

Alternative 1, which includes the alignment through the Marina Beach Park, is the only alternative that does not require the connection between Puget Sound and the marsh to be placed (at least partially) through pipes or culverts. The use of open channels for nearly the entire alignment (except for the BNSF railroad bridges) would allow for larger volumes of natural tidal prism exchange and marsh inundation (both filling and draining) of the marsh compared to the other proposed alternatives. The proposed outlet, as mentioned above, is located along a relatively natural, nearshore reach with minimal shoreline armoring. The connection can, therefore, be designed as a continuous sloping channel from the marsh down to approximately the mean tide elevations at the Puget Sound. This mimics the type of channel that historically existed connecting the nearshore area with the marsh; although the historic location of the outlet is to the north of the location proposed as part of Alternative 1 more closely associated with Alternative 2 outlet location in the Marina. The channel could be designed as a relatively unconfined inlet to the marsh or could be designed as an engineered channel to better control in-channel velocities and minimize erosion and migration of the channel location due to nearshore processes depending on park maintenance requirements. Littoral transport along the shoreline in this area is from the south to the north (U.S. Geological Survey [USGS], 2010). The shoreline to the south is armored; however, there are littoral drift cells and sand bars just south of the Park, and a local source of sediment to the system from Deer Creek that discharges one mile south of the proposed outlet. The natural drift process has the potential to continue to deposit sediments in the proposed outlet channel during extended periods of low flow from the upstream marsh to the beach. This may result in some limited access to the channel for fish at lower tides during portions of the year. However, it is anticipated that higher flows from the marsh, as well

as coastal storm events, would have the ability to flush a majority of the deposited sediment out of the channel. The orientation and sediment dynamics of the Willow Creek outlet on the beach were studied further after this alignment was selected, as described later in this report.

The Marina Beach Park daylight alternative is subject to direct impact from storm waves from the west and southwest. Depending on the tide level at the time of the storm event, these impacts could include erosion of nearshore sediments at the mouth of the creek, transport, and deposition causing infilling of the mouth of the creek by deposition in the channel, and/or lateral migration and changes in channel location and or depth of the mouth of the creek due to these sediment movements.

The proposed outlet for Alternative 1 has the potential to be the most natural of the proposed alternatives, based on historical understanding of the marsh outlet. In addition, there are opportunities to enhance nearshore restoration activities at the Marina Beach Park mouth that would benefit the marsh restoration project, provide additional nearshore fish habitat, as well as be an environmental amenity to the Marina Beach Park and community of Edmonds.

C.1.1.3 Alternative 1 Alignment – Engineering, Infrastructure, and Property

The Alternative 1 daylight mouth originates in the Marina Beach Park, travels through the BNSF railroad, and then northward along the edge of the BNSF railroad property line on the Unocal property. As such, there are various infrastructure and property ownership considerations for this alignment.

Within the park, a southern alignment would impact the existing dog park facilities (Appendix A, Photograph A-8). As dogs and a freshwater salmon habitat may not be compatible features, exclusion fencing and vegetation screening may be necessary to protect and shelter fish from external stimulus and allow the fish to migrate through the dog park area. Adjacent to the northern edge of the dog park is a gravel parking lot, which could be impacted by the northern bank of the tidal channel (Appendix A, Photograph A-9).

A northern channel alignment through the park would address potential loss, or reconfiguration of parking spaces and grass landscape areas.. The alignment would cross the southern parking lot, and likely flow through or along the southern margin of the grassy “knoll” area and onto the beach at the north (Appendix A, Photographs A-10 and A-11). This general alignment is closer to the existing Willow Creek stormwater outfall pipe alignment, as well as other underground utilities, and may require some type of buried erosion protection to ensure that the daylight channel will not migrate north over time to buried underground utility areas. A

northern alignment could become a natural setting for the stream restoration, but could involve significant changes in the park landscape and uses. The north and south alignments have been addressed by the City Marina Beach Park Master Plan study. From this study, a third alignment was selected midway between the north and south alignments.

At the upstream end of the park, the stream would flow under the pre-constructed BNSF bridges. The stream crossing through the bridges is perpendicular to the tracks and next to a steep hillside on the east side of the railroad. A tight meander channel radius has been developed, with soldier pile walls has been developed as the current plan for daylight channel in this area having multiple topographic, geologic, and infrastructure constraints. It is not known if the current bridges subgrades and foundations were designed and constructed to protect the BNSF railroad from the future scour conditions from a daylighted channel. A bridge hydraulics and design report has not been identified at this time. It is noted that this structure may increase in width (to the west) if BNSF expands the third rail line through the Edmonds area along Admiral Way. The Willow Creek Daylight plan has made accommodations and designed the channel curves outside the BNSF right-of-way.

Known utilities for Alignment 1 include the City stormwater pipeline, nearby water and sewer lines crossings to the north, and a buried communication lines beneath the BNSF railroad. A full investigation of utility locations and topographic survey of the as-built structures is needed for the final design phase of work.

Property ownership for Alignment 1 is limited to the City, BNSF, and Unocal (which after the cleanup is complete will be WSDOT Ferries). The park area and the marsh are owned by the City, the bridges and railroad right-of-way owned by BNSF, and the upstream daylight channel would be located on Unocal property.

In summary, Alternative 1 would include a new channel excavation downstream from the current confined channel between the BNSF and Unocal property, for which contaminated soils remain a concern. There are additional restoration opportunities to the east on the Unocal property, if the "future" owner WSDOT is amenable. The existing BNSF bridges are a great benefit to the daylight project. Any other alternative would require the additional cost of a new bridge or culvert crossing the railroad. The one downside is that the crossing alignment may not be ideal due to the abrupt angles through the bridge opening. The bridge alignment and three alternative alignments were considered in the Marina Beach Master Plan process. The primary impacts associated with Alignment Alternative 1 are the potential impacts to parking and grassy areas of the park and the dog park areas.

C.1.2 Alternative 2 Alignment – Port of Edmonds (the Port) Dock F

The Port Dock F alternative alignment would divert the stream towards the north into an existing storm drainage pipe alignment, and then underneath Admiral Way to the west through the Edmonds Marina parking lot discharging at the historical marsh outlet which is now in the middle of the marina (Figure 2). The estimated length of this realignment from the marsh to the waterline in the marina is 400 feet. In the 1998 report for the Port, Pentec (1998) describes a possible open channel configuration as:

> *"…a slightly sinuous open channel into the marina between existing Slips F and G, a lineal distance of approximately 275 ft. Appropriate in-channel structures could be installed to make the channel both biologically functional and aesthetically pleasing to the Edmonds community. For example, a series of step pools with appropriate spacing would facilitate fish access over potentially prohibitive low-tide gradients, while providing nice stream habitat for public enjoyment."*

This alignment would could keep the existing pipes under the railroad tracks and modify storm drainage piping underneath Admiral Way, and would have a daylighted channel through the existing marina parking lot. The discharge location would be inside the existing marina between Docks F and G (Appendix A, Photograph A-7).

C.1.2.1 Alternative 2 Alignment – Fisheries

Like Alternative 1, an Edmonds Marsh outlet alignment through the Edmonds Marina would offer a great deal of potential for fish movement between Puget Sound and the marsh, including juvenile Chinook salmon. The marsh would be a productive habitat for fish entering the system. With a marsh outlet in the marina, somewhat fewer juvenile Chinook salmon would be expected to encounter the marsh entrance than an outlet to the beaches north or south of the marina (Alternatives 1 and 3, respectively). Not all fish are expected to enter the marina as they navigate past it, and there are few if any forage areas within the marina. This expectation stems from the fact that the marina is a partial obstruction to juvenile Chinook salmon that tend to migrate along shallow portions of the shoreline and avoid deep water (until they grow larger).

The marina requires the fish to swim around the outside of the marina and either cross the deep water marina entrance or enter the marina. Juvenile Chinook salmon migrating from south to north would be expected to encounter the marsh outlet if it was located in the Marina Beach Park. A marsh outlet in the marina may, or may not be encountered by as many fish because some may not enter the marina as they navigate around the outside of it. Those fish

that enter the marina would encounter poor habitat conditions including extensive overwater coverage, deeper water, modified shoreline within the marina, and potential exposure to chemical contaminants (petroleum), and boat and marina noise. These conditions affect the foraging opportunities and prey base quality, as well as increase predation risks.

A marsh outlet into the marina would be a highly engineered channel and system of culverts and pipes fixed in place to maintain and protect existing marina infrastructure. The channel would be designed to provide suitable depth and velocity conditions to enable fish to move between Puget Sound and the marsh. Due to the fixed position of the outlet and the anticipated design to provide suitable flow conditions for access, this marsh outlet would have little risk of being blocked by sediment deposits. The Alignment Alternative 2 would likely impact the marina dock and parking areas during construction, and potentially removing or changing marina infrastructure along the bulkhead. A marsh outlet alignment through the marina would provide the shortest access length into the marsh, which implies improved fish access to the marsh. However, this alternative requires a hardened channel and pipe system and fish traveling through the marina, which offsets potential gains from a shorter system. There are no clear advantages to fish habitat for the marina location.

C.1.2.2 Alternative 2 Alignment – Coastal Hydrodynamics

Alternative 2, which includes the alignment through what is now a parking lot and into the existing marina basin, would consist of an engineered hardened channel outlet into the marina with an upstream pipe or culvert connections to the marsh due to site constraints (as discussed above). The use of pipes and culverts within the channel system between the marsh and the sound will result in attenuation of the tide into the marsh, as well as delay or lag in draining of the marsh at low tide. The proposed outlet would be through what is now a parking area and would terminate within the marina directly into relatively deep water. Therefore, the channel would need to be engineered in such a way to ensure the mouth of the creek is below the mean lower low water or the outlet of the creek may be perched above low tide levels due to the lack of an intertidal beach area (low tide bench) at the proposed outlet to support a low tide channel. Without the deep water outlet, the result would be an oversteepened outfall, with higher velocities and shallower depths that would likely be a fish access problem into the marsh, during the low tide conditions.

Littoral transport along the shoreline in this area is designated as “no appreciable drift” (USGS, 2010), which means that there is either little to no sediment drift at this location or there is no appreciable net drift (however, there could be gross transport north and south during different times of the year). At the location of the proposed outlet for Alternative 2, there is most

likely little to no shoreline sediment transport due to the presence of two breakwaters which shelter the marina from waves. There would likely be sediment transport and deposition that would occur from upstream marsh sediment supplies. This additional sediment transport into the marina is undesirable and would increase maintenance dredging requirements for the marina. It is not likely that the amount of sedimentation would block the channel, rather, the rate of sedimentation in the marina would increase, thereby requiring more frequent marina maintenance dredging.

C.1.2.3 Alternative 2 Alignment – Engineering, Infrastructure, and Property

The Alternative 2 daylight outlet in the marina is located within an array of infrastructure. Infrastructure includes buildings, walls, piles, stormwater pipelines, sewer, water supply, electrical (possibly gas), car parking, and boat docking areas. This amount of infrastructure would likely require a significant amount of engineering design, as well as coordination and protection of infrastructure during construction. The outfall would result in reconfiguration of the marina bulkhead and result in reduction of parking spaces. Additionally, construction would likely occur during the busiest times at the marina and could impact marina operations. The amount of adjacent infrastructure implies an increased large cost for installation of a new daylight channel.

Bob McChesney of the Port was contacted during coordination activities for installation of the project data logger in the marina. At that time, he was asked about the viability of daylight channel exiting into the marina between Docks "F" and "G." His response was firmly that the Port did not support a Willow Creek daylight alternative with an outlet into the marina (B. McChesney pers. comm., August 22, 2012).

Further east, the channel would need to cross beneath Admiral Way, where the road tees and heads east near the Port parking lot. This would require traffic control and coordination during construction, which also implies additional costs. Upstream of the Admiral Way road culvert crossing, the channel would follow the existing Port stormwater outfall and WSDOT stormwater pipe alignments. If a stream channel were designed in this area, it would likely encroach upon the parking area to the east. This may be done without impacting parking, but could potential require the removal of existing trees and vegetation.

Finally, the daylight channel would need to cross the BNSF railroad embankment. This will require installation of a new culvert or bridge structure and protection of the railroad embankment, as the existing culverts would not meet fish passage criteria. The new culvert or

bridges would likely have higher costs than a typical roadway bridge or culvert crossing. Construction in the BNSF railway right-of-way requires special easements and permits from BNSF, as well as special construction contract specifications for safe-zone working along the railroad. This applies for any alternative where construction through, in, and around the embankment and within the right-of-way is required.

Property ownership along Alignment 2 is the City, the Port, and BNSF. It is doubtful that a viable agreement could be reached with the Port, considering their stated position on the Alignment 2 alternative. Alternative 2 alignment is considered a high cost alternative, with elevated property ownership risks, and is not recommended.

C.1.3 Alternative 3 Alignment – Sunset Beach Alignment

The Sunset Beach alignment would relocate the outlet of Willow Creek to the northwest corner of the marsh (Figure 2*)*. The estimated length of this proposed realignment alternative would be approximately 900 feet long. This alignment would require installation of a new culvert or pipe underneath the BNSF railroad, similar to Alternative 2. The alignment would then run northwest through an open gravel parking lot owned by the Port. We have assumed that a property sale or exchange with the Port is not a viable element of the project for a full daylight channel and, therefore, a nearly 600-foot-long pipe would need to be installed underneath the Port, overflow gravel parking lot, or build a daylight channel agreed to through the parking lot by the property owner. The pipe would then cross underneath W. Dayton Avenue/Admiral Way and daylight on Sunset Beach between the Edmonds Marina breakwater near the fishing pier access and onto the beach.

C.1.3.1 Alternative 3 Alignment – Fisheries Perspective

Reconnecting Edmonds Marsh through this alignment would offer some potential for fish use of the marsh; however, the extensive channels and long pipe system necessary to connect the beach to the marsh would limit the likelihood that juvenile Chinook salmon and even limit adult salmonids ability to enter the system. The extended pipes would have to be designed to provide suitable depth and velocity conditions to allow fish passage; however, fewer fish would be expected to enter pipes compared to an open channel. This is a significant factor limiting the potential benefits associated with this alignment.

The Sunset Beach alignment of the marsh outlet is in a slightly more protected location than the Marina Beach Park alignment because the marina blocks the strong wind and waves from the south, but could be subjected to strong northerly winds. As a result, the Sunset Beach alignment can be expected to have fewer issues with partial outlet closure than the Marina

Beach Park. For fish, this means the Sunset Beach alignment would provide clearer access at the mouth for fish moving between Puget Sound and the marsh.

The Sunset Beach location for a marsh outlet would be located in a sand and gravel beach area adjacent to the marina. This is a favorable foraging area along the beach where prey forage fish are found on the beach sands, macroalgae, and eel grass beds. Also, the marsh outflow would transport prey items to fish along the beach. However, based on the adjacent marina and buildings, the marsh outlet would likely have to be engineered to remain in a fixed position to prevent it from migrating into the breakwater, which would limit the opportunity to provide a natural marsh outlet. In this way, the Sunset Beach alignment is more like the marina outlet alternative than the Marina Beach Park alignment.

While the proposed outlet for Alternative 3 has limited spatial extent in the nearshore compared to Alternative 1, there may be some limited opportunities to conduct beach/nearshore restoration activities at the Sunset Beach outlet location, such as placement of large woody debris and native plantings. This would also benefit the marsh restoration project and provide additional nearshore fish habitat.

C.1.3.2 Alternative 3 Alignment – Coastal Hydrodynamics

Alternative 3 includes a northern outlet alignment through Sunset Beach and would consist of an engineered hardened channel with upstream pipe/culvert connections to the marsh due to site constraints (as discussed above). While the location of the outlet for this alternative coincides with its historical location, as with Alternative 2, the use of pipes/culverts within the channel system between the marsh and the sound will result in attenuation of the tide into the marsh, as well as delay or lag in draining of the marsh during periods of low tide.

The proposed outlet is located along at Sunset Beach where a small intertidal beach area is backed by shoreline armoring above mean higher high water and adjacent to one of the breakwaters for the marina (located south of the proposed outlet location). The outlet channel can likely be designed as a continuous sloping channel from the marsh down to lowest tidal elevations at Puget Sound; similar to Alternative 1. However, the nearshore area at this location is significantly smaller than that of Alternative 1 due to the physical constraints of the area (adjacent armoring and upland property).

Littoral transport along the shoreline in this area is designated as “no appreciable drift” (USGS, 2010). At the proposed outlet location, the lack of appreciable drift is likely due to the interaction of the site with the large breakwater to the south, which shelters the area from

storm waves from the south, southwest, and west, which are the most frequent storm directions for this area. There would likely be minor sediment transport and deposition from the marsh at the outlet. It is more likely that the outlet of this channel will remain open and free of sediment deposition than Alternative 1.

This site is subject to direct impact from storm waves from the northwest and north, but is sheltered from all other storm wave directions. The presence of the breakwater is anticipated to greatly limit the impact of storm waves on the proposed outlet in terms of sediment transport and infilling. However, it is possible that storm events from the north and northwest could impact the site in similar ways (influencing the channel to migrate in one direction or another) as described for Alternative 1, and may require additional engineering or maintenance activities.

C.1.3.1 Alternative 3 Alignment – Engineering, Infrastructure, and Property

The Alternative 3 daylight outlet at Sunset Beach, to the north would encounter a variety of infrastructure and property owners. This alternative alignment most closely represents the historical marsh mouth to the Puget Sound. Significant development and changes to the landscape have occurred in this area.

Immediately upstream (south) of the beach, the daylight channel would encounter Admiral Way or Dayton Street at the corner. This would require a pipeline, and would need to be built around existing stormwater drainage utilities among other existing underground utilities. This pipeline would need to be a significant structure and would likely have high construction costs compared with Alternative 1.

South of the Admiral Way street corner, the stream channel would flow into the Port overflow gravel parking lot. The channel could daylight through the parking lot, but would reduce parking spaces overflow parking in this area, with the support of the Port. This lot was under consideration for the Edmonds Crossing project as an alternative alignment for State Route 104, but was not identified as a recommended alternative. The Port was not interviewed regarding this alignment.

At the southeastern corner of the gravel parking lot, the realigned channel would then flow through a culvert or pipe through the BNSF embankment and directly into the marsh. This would likely require construction of bridges or culvert similar to the existing bridge for Alternative 1. The costs and construction requirements associated with a bridge are similar to those discussed as part of Alternative 2.

Property ownership along Alignment 3 includes the City, the Port, and BNSF. A significant amount of the project is located on Port property. The daylight channel would require a lengthy easement or purchase of the current gravel parking lot area on the corner of Admiral Way and Dayton Street. It is unlikely that a viable agreement could be reached with the Port, considering their stated position on daylight channel realignment on other Port property. We would recommend confirming this position with the Port, if Alternative 3 is identified as having merit warranting further investigation.

C.1.4 Preferred Alignment Recommendation

From a fisheries perspective, all three of the alignments would improve shoreline conditions and expand the saltwater influence in the marsh so it functions more like a natural salt marsh and can provide fish access. The Marina Beach Park alignment is the most beneficial to fish because it provides an open channel connection that can be designed to provide a natural channel with habitat for fish moving between Puget Sound and Edmonds Marsh. In addition, the marsh outlet into the Marina Beach Park would add a beneficial feature to an area that provides favorable nearshore rearing conditions for juvenile Chinook salmon, especially compared to the extensive areas riprapped shoreline to the north and south. The concerns of the Port Dock F alignment are the increased rearing time in the marina for juvenile Chinook salmon that enter the marina, and the pipes that the fish would navigate associated with both the Alternative 2 – Marina and the Alternative 3 – Sunset Beach alignments. These factors limit the suitability of both the Marina a Sunset Beach marsh outlet alignments.

From a coastal hydrodynamics perspective, all three of the alignments would provide connectivity between the marsh and Puget Sound, and likely improve tidal inflow and drainage from the marsh. Each alternative has distinctly different littoral drift sediment conditions. Alternative 1 will have design challenges related to littoral drift and sedimentation in the channel that could potentially cause fish access issues at low tides. This, however, is a similar condition observed at other natural stream mouths throughout Puget Sound, and would likely occur only periodically. Alternative 2 would impact maintenance in the Port marina by increasing maintenance dredging. Both Alternatives 2 and 3 would require long pipe runs that would be difficult and costly to design for fish passage. Based on these observations, Alternative 1 has the best potential to both improve tidal inflow and drainage from the marsh, while still providing hydraulic conditions conducive to fish passage, relative to Alternatives 2 and 3.

From engineering design, infrastructure protection, and property ownership perspectives, Alternative 1 requires the least amount of new infrastructure to complete the proposed alternative. Alternative 1 is the only proposed outfall location that has existing BNSF bridges,

although additional approach work may be required. Alternative 1 does require property agreements with either Chevron / Unocal, or WSDOT Ferries after the property exchange is complete. Alternatives 2 and 3 would require contending with significant Port, Marina, and City roadway and drainage infrastructure, which implies increased costs for construction, easements, property purchases, and negotiations. Based on direct discussions with the Port, they would not support Alternative 2, which would outfall in the Port-owned marina. Alternative 3 has a long alignment through Port property, and also would not be viable from a property easement or purchase perspective. Acquiring or purchasing an easement could be difficult, which would significantly increase project costs.

In summary, it is our opinion that Alternative 1, realigning the Willow Creek outfall through the Edmonds Marina Beach Park, is the most logical location, given the urban area site and property ownership constraints. This alternative will:

- Provide the best attractants for juvenile salmonids at a natural beach area.
- Allow for potential additional beach restoration benefits.
- Improve saltwater tidal inflow and marsh drainage conditions.
- Has the least amount of existing infrastructure constraints.
- Is located in a position acceptable to the BNSF.

Alternative 1 is not without challenges, including:

- Identification and design of a preferred alignment within the park that meets multiple user requirements.
- Potential modifications needed at the pre-constructed BNSF bridges.
- Location of the realigned stream along to the Unocal property with known contamination, and long-term legal and property ownership transfer obligations.

The study team recommends the early feasibility study evaluate the Preferred Daylight Plan, Alternative 1 – Edmonds Marina Beach Park alignment. Our findings are presented in the following section of the report.

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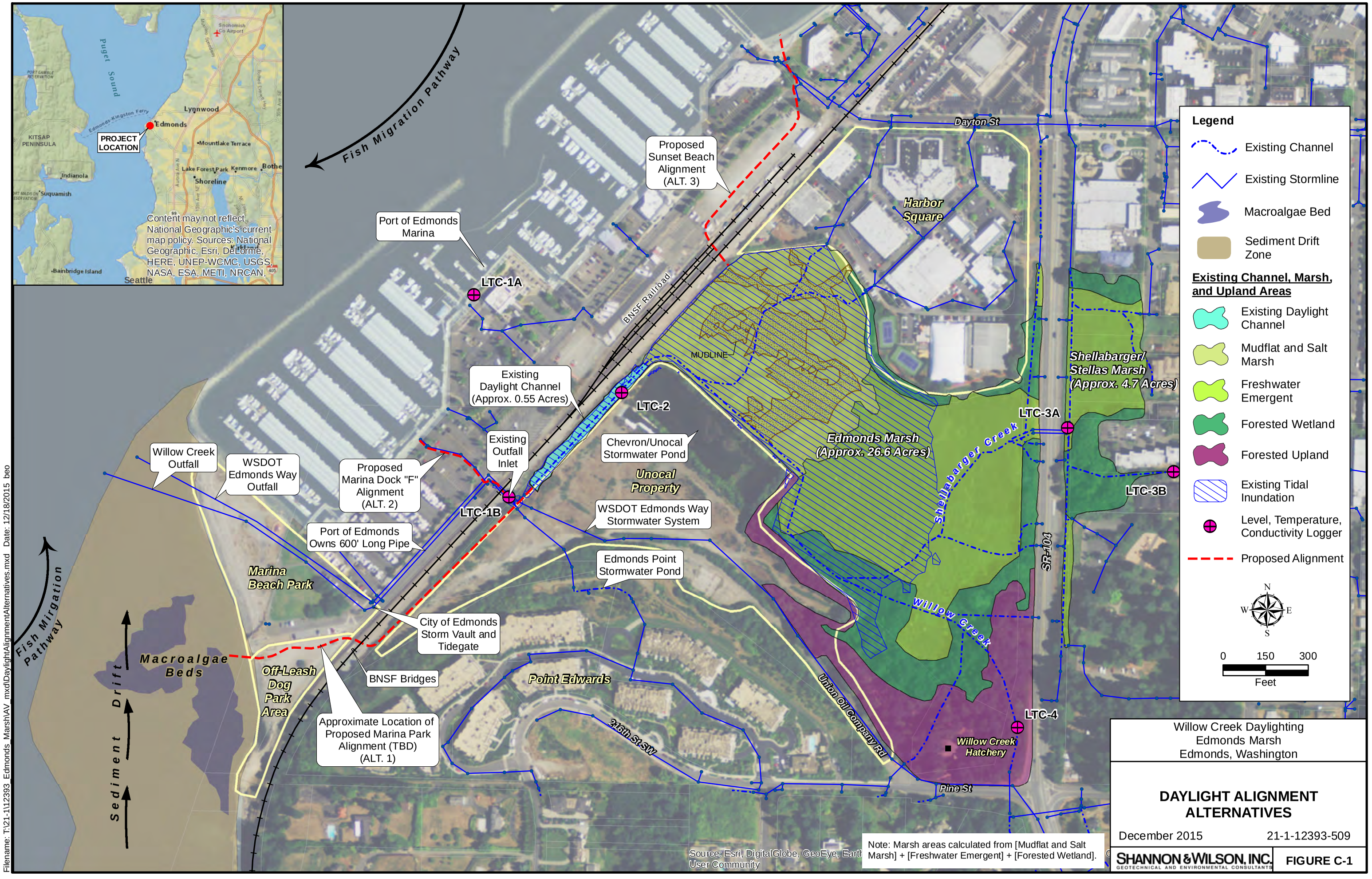

Willow Creek Daylighting
Edmonds Marsh
Edmonds, Washington

DAYLIGHT ALIGNMENT ALTERNATIVES

December 2015 21-1-12393-509

SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIGURE C-1

Filename: T:\21-1\12393 Edmonds Marsh\AV mxd\DaylightAlignmentAlternatives.mxd Date: 12/18/2015 beo

APPENDIX D

CONCEPT DESIGN PLAN AND COST ESTIMATE

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Scale in Feet

Willow Creek Daylight Project
Contaminated Soils Assessment
Edmonds, Washington

SITE PLAN

December 2015 21-1-12393-409

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 1

TABLE D-1
COST ESTIMATE

Item	Description	Quantity	Units	Unit Cost	Item Cost[1]	Subtotal
1.0	Mobilization and Demobilization	1	LS	$ 50,000.00	$ 50,000	
1.1	Contract Administration, Submittals, Closeout	1	LS	$ 100,000.00	$ 100,000	**$ 150,000**
2.0	**Marina Beach Park (Channel and Habitat Features)**					
2.1	Temporary Erosion and Sediment Control	1	LS	$ 50,000.00	$ 50,000	
2.2	Demolition and Removal (existing tidegate and water main)	1	LS	$ 50,000.00	$ 50,000	
2.3	Dewatering	1	LS	$ 100,000.00	$ 100,000	
2.4	Channel Excavation	8,000	CY	$ 10.00	$ 80,000	
2.4.1	Haul and Dispose Excavated Material (uncontaminated)	3,900	CY	$ 10.00	$ 39,000	
2.4.2	Haul and Dispose Excavated Material (50 percent contaminated)	3,900	CY	$ 95.35	$ 372,000	
2.5	Vegetated Reinforced Soil Slope	1,000	VSF	$ 81.50	$ 82,000	
2.6	Channel and Shoreline Habitat Features	1	LS	$ 50,000.00	$ 50,000	
2.7	Revegetation	1	LS	$ 50,000.00	$ 50,000	**$ 873,000**
3.0	**Daylight Channel Construction**					
3.1	Temporary Erosion and Sediment Control	1	LS	$ 50,000.00	$ 50,000	
3.2	Dewatering	1	LS	$ 250,000.00	$ 250,000	
3.3	Dewatering (Contaminated GW Treatment)	1	LS	$ 50,000.00	$ 50,000	
3.4	Channel Excavation	16,900	CY	$ 7.00	$ 118,000	
3.5.1	Haul and Dispose Excavated Material (uncontaminated)	13,520	TON	$ 50.00	$ 676,000	
3.5.2	Haul and Dispose Excavated Material (50 percent contaminated)	13,520	TON	$ 80.00	$ 1,082,000	
3.6	Demolition, Protection, Modification of Stormwater Structures	1	LS	$ 250,000.00	$ 250,000	
3.7	HDPE Channel Liner for Contaminant Protection	84,600	SF	$ 2.50	$ 212,000	
3.8	Self-regulating Tidegate	1	LS	$ 400,000.00	$ 400,000	
3.9	Import Clean Liner Backfill	9,400	CY	$ 16.20	$ 152,000	
3.10	Utility Relocations	1	LS	$ 25,000.00	$ 25,000	
3.11	BNSF Railroad ROW Work					
3.11.1	BNSF Permits and Construction Maintenance Agreement	1	LS	$ 50,000.00	$ 50,000	
3.11.2	BNSF Railroad Crossing Special Insurance	1	LS	$ 100,000.00	$ 100,000	
3.11.3	BNSF Railroad Flagger	30	EA	$ 2,000.00	$ 60,000	
3.11.4	Erosion Protection Rock Bedding Material	250	CY	$ 60.00	$ 15,000	
3.11.5	Erosion Protection Rock (12-inch Riprap)	500	CY	$ 60.00	$ 30,000	
3.14	Soldier Pile Wall	150	LF	$ 2,500.00	$ 375,000	
3.15	MSE Wall Facing	750	SF	$ 50.00	$ 38,000	
3.16	Daylight Channel Revegetation	1	LS	$ 50,000.00	$ 50,000	**$ 3,983,000**
4.0	**Marsh Improvements**					
4.1	Clearing and Grubbing (remove cattails)	1.4	AC	$ 10,000.00	$ 14,000	
4.2	Channel Excavation/Dredging	970	CY	$ 50.00	$ 49,000	
4.3	Haul and Dispose Excavated Material (uncontaminated)	485	CY	$ 10.00	$ 5,000	
4.4	Haul and Dispose Excavated Material (contaminated)	485	CY	$ 95.35	$ 46,000	
4.5	Marsh Habitat Features	1	LS	$ 25,000.00	$ 25,000	
4.6	Revegetation	1	LS	$ 50,000.00	$ 50,000	**$ 189,000**
				Equipment, Labor, and Material Costs	**$ 5,195,000**	**$ 5,195,000**
				Taxes (9.5%)	$ 494,000	
				Bonding & Insurance (5%)	$ 260,000	
				Contingency (25%)	$ 1,487,000	
				Construction Cost	**$ 7,436,000**	**$ 7,436,000**
				Real Estate Agreements, Easements, Real Property (TBD)	$ -	
				Engineering, Permits (15%)	$ 1,115,000	
				Project Costs	**$ 8,551,000**	**$ 8,551,000**

Notes:

[1] Costs are rounded to nearest thousand.

% = percent

AC = asphalt concrete; CY = cubic yards; EA = each; GW = groundwater; LS = lump sum; TBD= to be determined; VSF = volume scattering function

TABLE 2
WILLOW CREEK DAYLIGHT
QUANTITY TAKEOFFS

Quantity Takeoffs - Willow Creek Restoration

2.0 Beach Channel Restoration

Item 2.2 channel excavation

V_1=	7793	cy	Civil3d surface volume
V_2=	185.2	cy	erosion protection rock quantity (see below)
V=	8000	cy	total volume (rounded)

Item 2.4 haul & dispose

V=	8000	cy	assume equal to excavated volume

Item 2.5 erosion protection rock

L=	50	ft	length of protection
W=	50	ft	width of protection (one side of channel)
T=	2	ft	thickness of protection (2*D50)
V=	185.2	cy	volume of riprap
V=	190	cy	volume (rounded)

Item 2.6 shoring along parking area

L=	100	ft	length of shoring
D=	10	ft	max depth of shoring
A=	500	ft^2	area of shoring, assume triangular

Item 2.7 pedestrian bridge

Excavation (in addition to channel ex)

D=	12	ft	depth		
SS=	1	h:1v	side slope		
W=	5	ft	width at bottom of excavation	29	width at top
L=	15	ft	length at bottom of excavation	39	length at top
V=	268.0	cy	excavation volume per structure		
V=	540	cy	total excavation, rounded		

CIP Concrete

L=	3	ft	abutment length (parallel to flow)
W=	12	ft	abutment width (perpendicular to flow)
H=	12	ft	abutment height
V=	16	cy	concrete volume per abutment
V=	30	cy	total concrete volume, rounded

Pedestrian Bridge

L=	50	ft	length of bridge
W=	12	ft	width of bridge
A=	600	sf	area of bridge deck (1 bridge)

Item 2.10 reveg

L=	400	ft	length of disturbance
W=	90	ft	width of disturbance, including 10' buffer for equipment ea. Side
A=	36000	ft^2	area of disturbance, to be revegetated
A=	0.8	ac	rounded area

3.0 Daylight Channel Construction

Item 3.1 channel excavation

V_1=	7500	cy	Civil3d surface volume
V_2=	9400		additional excavation for liner (see below)
V=	16900	cy	total volume (rounded)

Item 3.2 haul & dispose (contaminated)

V=	8450	cy	assume equal to 50% excavated volume

Item 3.5 channel liner

L=	1410	ft	length of lined section
W=	60	ft	average width of lined section (accounts for slope distance)
A=	84600	ft^2	area of liner (rounded)
D=	3	ft	depth of overexcavation required to install liner
V=	9400	cy	additional excavation for liner installation

Item 3.6 liner backfill

V=	9400	cy	assume equal to overexcavated volume (rounded)

Item 3.7 erosion protection rock

L=	100	ft	length of protection
W=	100	ft	width of protection (one side of channel)
T=	2	ft	thickness of protection (2*D50)
V=	740.7	cy	volume of riprap
V=	740	cy	volume (rounded)

Item 3.8 reveg

L=	750	ft	length of disturbance
W=	70	ft	width of disturbance, including 10' buffer for equipment ea. Side
A=	52500	ft^2	area of disturbance, to be revegetated
A=	1.2	ac	rounded area

4.0 Marsh Restoration

Item 4.1 cattail removal

A_1=	37000	sf	cattail removal area
A_2=	22500	sf	cattail removal area
A=	1.37	acre	area in acres

Item 4.2 excavation/dredging

V_1=	670	cy	Civil3d surface volume (Shellabarger & Willow)
L=	200	ft	length of minor tidal channels (ea)
W=	10	ft	average width of minor tidal channels
D=	2	ft	average depth of minor tidal channels (assume triangular section)
N=	4	ft	number of minor tidal channels
V_2=	300	cy	volume of minor tidal channels
V=	970		volume of excavation

Item 4.3 haul & dispose (uncontaminated)

%=	50%		percent of soil that is uncontaminated
V=	970.683	cy	assume 50% of total volume

Item 4.4 haul & dispose (contaminated)

%=	50%		percent of soil that is contaminated
V=	970.683	cy	assume 50% of total volume

Item 4.6 revegetation

A_1=	59500	ft^2	cattail removal area
A_2=	15000	ft^2	shellabarger and willow creek excavation area (from CAD)
A_3=	8000	ft^2	minor tidal channel area
A=	82500	ft^2	area of disturbance, to be revegetated
A=	1.9	ac	rounded area

TABLE 3
WILLOW CREEK DAYLIGHT
COST ESTIMATE BACKUP

Cost Back-up - Willow Creek Restoration

1.0 Mob/Demob

Assume ~10% of total cost

2.0 Beach Channel Restoration

2.1 Remove Existing Tidegate / Water main

Cost comparisons

$	25,000.00	LS	Fisher slough item 15.8 2nd lowest bid (Interwest)
$	63,000.00	LS	Fisher slough item 15.8 2nd highest bid (IMCO)
$	13,000.00	LS	PSB item 21.0 successful bid

Assumptions

Assume water main demolition or abandonment will occur incidentally to water main construction and channel exc

Estimated price

$	**50,000.00**	**LS**

2.2 Channel excavation

Cost comparisons

$	5.50	CY	Fisher slough item 5.1.09 (tidal channel realignment) 2nd lowest bid (Northwest)
$	11.00	CY	Fisher slough item 5.1.09 (tidal channel realignment) 2nd highest bid (Granite)
$	4.00	CY	PSB item 8.0 successful bid

Estimated price

$	**7.00**	**CY**

2.3 Dewatering

Cost comparisons

$	33,000.00	LS	PSB item 4.0 successful bid
$	1,100.00	DAY	RS Means 312319.20 1100
	30	DAYS	
$	33,000.00	LS	

Estimated Cost

$	40,000.00	LS	Assumed Cost

2.4 Haul & Dispose uncontaminated material

Haul

$	5.35	CY	RS Means 2012 312323.20 3046; 15 min wait, 25 mph, haul 10 miles

Disposal

$	-	CY	Assume clean material disposed of at no additional cost

Total

$	5.35	CY

2.5 Riprap (12")

$	44.00	Ton	PSB item 16.0
$	59.57	CY	Fisher Slough item 6.4.05 (2 ft riprap)
$	60.00	CY	

2.6 Shoring along parking

$	81.50	SF	2011 RS Means 323260.10 Stone Retaining Wall, random stone, <6' high

2.7 Tidegate/Pedestrian Bridge

Excavation

$	7.00	CY	See above

Concrete

$	300.00	CY	RS Means 033053.40 5900 (Pile caps)

SRT

$	50,000.00	LS	Estimate

Pedestrian Bridge

$	91.00	SF	RS Means 323420.10 1600

2.8 8" PVC Water Main

$	40.00	LF	WSDOT Unit Bid Prices 2012

2.9 Habitat Features

$	100,000.00	LS	Placeholder

2.10 Reveg

$	1,500.00	AC	PSB Item 22.0

3.0 Beach Channel Restoration

3.1 Channel Excavation

$	7.00	CY	See above

3.2 Dewatering

$	40,000.00	LS	See above

3.3 Haul & Dispose contaminated material

Haul

$	5.35	CY	RS Means 2012 312323.20 3046; 15 min wait, 25 mph, haul 10 miles

Disposal

$	50.00	TON	WSDOT Unit Bid Prices
$	90.00	CY	Assuming 1.8 tons/cy

Total

$	95.35	CY

3.4 Demo/dispose old gates

$	50,000.00	LS	See above

3.5 Channel Liner

$	1.75	SF	Horse Creek supplier cost estimate

3.6 Import clean liner backfill

$	9.00	TON	PSB Item 12.0
$	16.20	CY	Assuming 1.8 tons/cy

3.7 Riprap

$	60.00	CY	see above

3.8 Reveg

$	1,500.00	AC	see above

4.0 Marsh Improvements

4.1 Clearing

$	3,500.00	AC	PSB Item 5

4.2 Dredging

$	12.00	CY	WSDOT Unit Bid prices for wetland excavation

4.3 Haul/dispose

$	5.35	CY	see aove

4.4 Haul/dispose contaminated

$	95.35	CY	see above

4.5 Habitat Features

$	100,000.00	LS	Placeholder

4.6 Reveg

$	1,500.00	AC	PSB Item 22.0