Appendix A – Willowmoor Phase 1 Hydrologic Characterization, NHC 2013

Willowmoor Restoration Design Hydrology

Phase 1 – Hydrologic Characterization

October 2013

King County

Willowmoor Restoration Design Hydrology
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Executive Summary

King County (County) is planning the Willowmoor Project, a flood control and habitat restoration project for the Sammamish River Transition Zone (TZ), which extends from the Lake Sammamish outlet weir approximately 1,400 feet downstream through Marymoor Park. Northwest Hydraulic Consultants (NHC) was contracted by the County to provide recommendations for design hydrology for the Willowmoor project. The initial phase of this work focuses on characterizing the original U.S. Army Corps of Engineers (Corps) design hydrology within the current hydrologic context and on identifying potential future hydrologic conditions to provide background for a robust project design.

The Sammamish River Flood Control Project was completed by the Corps in 1964 to provide spring flood control for the Sammamish River valley. The project was designed to accommodate an event similar to the March 1950 storm, which was the spring flow of record at the time. The design objectives were to eliminate flooding for a design flow of 1,500 cfs in the Sammamish River downstream of Bear Creek while keeping Lake Sammamish levels below 29.0 feet NGVD (32.6 feet NAVD).[1] The design flow was characterized by the Corps as a 10-year annual flood or a 40-year spring flood, meaning that on average that flow had a ten percent chance of occurring at all or a 2.5 percent chance of occurring after March 1 in any given year. This frequency estimate is relatively consistent with results of current frequency analysis on 18 years of peak flow data (1940-1957) from the discontinued Sammamish River near Redmond gage that would have been available to the Corps during project design.

The original Lake Sammamish outlet weir was modified in 1998 to enhance summer flows to improve fish passage into Lake Sammamish. Modifications included adding a low flow notch and flattening the weir profile on either side of the notch. The change to the weir profile resulted in raising the crest elevation by up to half a foot.

Water levels in Lake Sammamish, and corresponding discharges, have been shown to be affected by conditions through the TZ and downstream to Bear Creek. Vegetation management practices in the TZ downstream of the weir have varied over time, and impacts of different vegetation conditions on flow capacity in the TZ have been demonstrated in several previous studies and by shifts in the stage-discharge relationship at the weir corresponding to changes in vegetation management. A reduction in lake outflows associated with high Bear Creek discharges—the Bear Creek backwater effect—has been demonstrated with measurements showing variable discharge at the weir for the same lake level during large events and can be reproduced by a hydraulic model of the system.

Existing hydrologic and hydraulic models of the Lake Sammamish/Sammamish River system have been used to characterize existing conditions—e.g., to determine flood inundation extents for FEMA mapping—and to explore the sensitivity or impact to the system of observed and proposed changes in the TZ, such as vegetation and sediment levels. The hydraulic model is well-calibrated to water levels at the weir and downstream of the TZ and reproduces lake levels quite well. The hydrologic models, which have been used to estimate long periods of inflows for the hydraulic model, are less accurate in reproducing observed flows on Bear Creek and Issaquah Creek.

Based on nearly 50 years of observed peak flows since construction of the weir, the 10-year flow in the Sammamish River downstream of Bear Creek is currently about 2,000 cfs, which is 33 percent higher than the 10-year flow characterized by the Corps during project design. It seems likely that this increase

[1] Lake Sammamish water levels have been customarily expressed relative to the NGVD29 (or MSL) datum. The conversion factor to the NAVD88 vertical datum is +3.59 feet. This report will clearly indicate the datum for any elevations and provide elevations on both scales where reasonable.

is primarily a result of the original project, which increased the capacity of the lake outlet and downstream channel. Development in parts of the basin, especially Bear Creek and east Lake Sammamish, has likely contributed to increased peak flows, but would not be expected to have so substantial an impact in a system with significant storage, as is provided by Lake Sammamish. Examination of precipitation and streamflow trends indicates that climate is also not a driving factor; there is no long-term evidence of increasing precipitation or streamflow trends.

Analysis of lake levels, however, shows a significant increase in the amount of time that Lake Sammamish exceeds the Corps-defined ordinary high water (OHW) level of 27 feet NGVD (30.6 feet NAVD). This is consistent with anecdotal reports from lakeside homeowners. Both visual inspection and statistical tests suggest that higher lake levels begin around 1998, and these changes would be consistent with weir modifications that reduce lake outflow at low to moderate lake levels. The data do not link the weir modifications as clearly to maximum lake levels (above about 28 feet NGVD).

In looking at the historic events with the highest observed lake levels, we can identify a number of contributing factors. Inflow is certainly a primary driver but cannot explain the lack of strong correspondence between the events with the highest peaks or inflow volumes and those with the highest lake levels. Examination of the record indicates that lake level prior to the event (i.e., the starting condition) and coincident high flows on Bear Creek are also recurring factors in several extreme lake level events. Different lake level response to events where inflow, starting level, and Bear Creek flows are similar also suggests that vegetation conditions in the TZ have an influence on high lake levels. It is interesting to note that nearly 90 percent of the events where the lake has exceeded 29 feet NGVD (32.6 feet NAVD) since 1964 have occurred since 1989, when annual TZ maintenance was discontinued. In contrast, only half of the highest Issaquah Creek flows in the same period have been since 1989. (Issaquah Creek is the largest tributary to Lake Sammamish and the only one with a streamflow record extending back to completion of the Sammamish River project.)

The review and analyses documented in this report provide a characterization of the current hydrologic setting and the various factors and influences that have affected performance of the weir and TZ over the past couple of decades. Hydrologic design conditions for the Willowmoor project will need to take into account these various influences on flow and lake level. For this reason, and because the project is expected to have a broader range of objectives, it is unlikely that a single design flow and lake elevation can continue to be used. The design process will also need to take some account of potential future hydrologic conditions to ensure that the selected project will continue to meet performance objectives going forward.

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1 Introduction

King County (County) is planning the Willowmoor Floodplain Restoration Project (Willowmoor Project), a flood control and habitat restoration project for the Sammamish River Transition Zone (TZ). The TZ extends from the Lake Sammamish outlet weir approximately 1,400 feet downstream through Marymoor Park.

Northwest Hydraulic Consultants (NHC) was contracted by the County to provide recommendations for design hydrology for the Willowmoor project. The initial phase of this work focuses on characterizing the original U.S. Army Corps of Engineers (Corps) design hydrology within the current hydrologic context and on identifying potential future hydrologic conditions to provide background for a robust project design. The goals of this effort are to evaluate the relevance of the original Corps design hydrology with respect to current and future conditions, to determine whether updated hydrologic design criteria are warranted, and, if so, to recommend next steps for developing updated hydrologic design criteria.

As part of the Phase 1 effort, NHC reviewed the Corps design documentation and subsequent available studies of Lake Sammamish and the Sammamish River; assessed existing hydrologic and hydraulic modeling; and statistically evaluated precipitation, flow, and lake level records. This report documents these reviews and analyses and provides recommendations for an approach to determine an appropriate suite of design flows and hydrologic conditions for the Willowmoor project.

2 Review of Previous Studies

NHC reviewed several previous studies and reports related to the Sammamish River TZ and Lake Sammamish (Table 1). The review was limited to readily available documents, though information from additional studies is incorporated by reference as relevant. We believe that this review provides a reasonably good characterization of the original design context and of subsequent changes that may affect hydrologic planning and design for the Willowmoor project. The following sections summarize key relevant findings from previous work.

Table 1. List of documents reviewed

Abbreviated Title	Date	Author
General Design Memorandum	1962	Corps of Engineers
Operation and Maintenance Manual, Vol 1	1964	Corps of Engineers
Lake Sammamish Special Study	1997	Corps of Engineers
Results of Re-Calibration of Sammamish River	2002	Corps of Engineers (draft memo)
Habitat Enhancement Conceptual Proposal	2003	King County
Lake Sammamish Ordinary High Water Mark Study	2004	Watershed Company (for City of Bellevue)
Transition Zone H&H Investigation	2004	WEST Consultants (for King County)
Sammamish River Floodplain Mapping Study	2010	NHC (for King County)
Climate Change Impacts on River Flooding	2010	King County
Findings on Lake Sammamish Outflow	2012(a)	King County
Transition Zone Sediment Removal Feasibility Study	2012(b)	King County

2.1 Project History

The Sammamish River Flood Control Project was completed by the Corps in 1964 to provide flood control for the Sammamish River valley. The project consisted of lowering , enlarging, and in some places straightening the main river channel; construction of the TZ connecting the modified channel with the Lake Sammamish low water control; and regrading of the downstream ends of major tributaries to meet the lowered Sammamish River channel, as well as an overflow channel on Bear Creek (USACE, 1962). At the time of construction, land use along the river was largely agricultural, and the primary goal of the project was to "substantially [prevent] all spring flood damage" (USACE, 1962, p. 7) without Lake Sammamish levels exceeding 29.0 feet NGVD[2] (32.6 feet NAVD).

The March 1950 flood, which was the maximum spring (after March 1) flood of record at the time, was selected as the inflow design flood. The Corps determined that the March 1950 flood had an annual recurrence interval of ten years and a spring recurrence interval of 40 years (USACE, 1962). The design memorandum does not specify the data used in this frequency analysis. Based on the available streamflow data reported in the design memorandum, it is likely that the frequency determination was based on the Sammamish River flow below Bear Creek[3].

The design criteria for the TZ were to "pass the design flood of about 1,500 [cfs] (including Redmond Bear Creek discharge) without exceeding a lake elevation of 29.0 feet [NGVD] while maintaining present minimum lake elevations (USACE, 1962, p. 7)." It is interesting to note that the 1,500 cfs design flow is higher than the March 1950 flow (1,360 cfs per the design memorandum) and close to the maximum flow of record at the time for the Sammamish River near Redmond gaging station[4] (1,520 cfs in February 1951). Per the design memo, the 1,500 cfs design flow applied to the TZ (upstream of Bear Creek) and to the main channel from the end of the TZ all the way downstream to Little Bear Creek near Woodinville. Thus, TZ design capacity was relatively high compared to the channel below Bear Creek.

The design memorandum does not specify separate design flows for the TZ above Bear Creek and the coincident Bear Creek contribution, though the design flow in the TZ (i.e., outflow from the lake) has subsequently been interpreted by the Corps to be 1,200 cfs (e.g. USACE, 2002). The basis for this interpretation is not entirely clear from the review conducted for this study. The Conceptual Proposal for the TZ (King County, 2003) reports 1,200 cfs as the 10-year annual recurrence flow at the TZ, and the 2007 Flood Insurance Study (FIS) used 1,233 cfs as the 10-year flow at the weir (as reported in King County, 2012a). The source of the FIS flow is not documented in the available reports. Since we are unaware of systematic data collection in the reach above Bear Creek until King County installed gage 51m in 2001, it seems likely that these values may have been based on 10-year lake levels and outlet rating curves. An internal Corps memo (USACE, 2002) suggests that there had been an assumption of a one to one correspondence between stage and discharge frequencies for the lake.

Support for a corresponding 300 cfs contribution from Bear Creek is also unclear. The Corps memo suggests that a defined ratio of Bear Creek to Sammamish River flows may have been assumed, though a 20 percent design ratio (300 cfs from Bear Creek out of 1,500 cfs on the Sammamish River below Bear

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[3] Today's Bear Creek is referred to in the design memorandum as Redmond Bear Creek; Little Bear Creek is referred to as Woodinville Bear Creek.

[4] Sammamish River near Redmond (USGS 12125000) discontinued in 1957. Comparable to Sammamish River near Woodinville (USGS 12125200) activated in 1965. The Woodinville station drains about 5% more area (159 to 150 square miles).

Creek) would seem to be low given that the Bear Creek basin makes up roughly one third of the Sammamish River basin at the USGS gage site. The Corps memo reports an average contribution of 30 percent from Bear Creek (plus local inflow, assumed to be minor) to Sammamish River at Redmond flows over an unspecified monitoring period (possibly the overlapping period between discontinued Bear Creek and Sammamish River at Redmond USGS stream gages). The memo suggests that the difference could be explained by restrictions at the outlet reducing lake contributions to the flow, or that the design ratio was incorrect.

It seems clear that the 300 cfs flow is not intended to represent a coincident peak flow on Bear Creek. The Bear Creek peak flow for the March 1950 design event was 654 cfs and the 10-year annual recurrence flow based on the short Bear Creek record available at that time (1946 to 1958 at USGS 12124500) is 630 cfs. Review of the observed record shows that Bear Creek peak flows typically lead Sammamish River peaks, though lag time is variable and has been relatively small in several larger events.

As the local sponsor for the Corps' Sammamish River Project, King County assumed responsibility for operation and maintenance of the project. Per the Operation and Maintenance Manual (USACE, 1964) adopted by the County in 1965 (King County Commissioners, 1965), maintenance responsibilities included:

> Debris which may impede the flow in the channel shall be removed. The growth of trees and brush along the channel banks and levee face shall be prevented, as it can result in the displacement of bank stabilization, impede inspection and access to the channel banks and levee face, and impair hydraulic capacity of the channel. Particular attention shall be paid to the intake transition. The transition shall be repaired immediately if found deficient, as the characteristics of the transition are critical to flow. (USACE, 1964, p. 8)

Accepted stream and vegetation management practices have changed from these original operation and maintenance standards, and King County and the Corps of Engineers have worked jointly to develop subsequent agreements for maintenance policies consistent with project objectives, changing environmental regulations, and current policy (King County, 2012a). Impacts of different vegetation conditions on flow capacity in the TZ have been demonstrated in several modeling studies (USACE, 1997; NHC, 2010; King County, 2012a and 2012b) and through examination of rating curve shifts at the weir over the past decade (King County, David Funke, pers. comm., May 2013).

Information about vegetation management actions in the TZ was provided by King County (Nancy Faegenburg, pers. comm., June 2013). From project completion through 1989, annual maintenance, including mowing of both banks and sediment removal in the channel, was performed annually. In 1993, the County and the Corps reached an updated maintenance agreement calling for a 10-foot willow buffer along both sides of the low flow channel in the TZ and an alternating two-year mowing cycle for the high flow channel that would result in cutting of each bank every four years, with both banks cut the first year. Vegetation removal was suspended from 1994 through 1998. Cutting resumed in 1998 with a "one-time only maintenance regime establishing a 20' no-cut buffer zone on either side of the low flow channel; cutting one third of all woody stems between the buffer and the banks on both sides of the Transition Section; and removal of all non-native vegetation" (King County, Nancy Faegenburg, pers. comm., June 2013). In 2003, a mediation process between the County and the Corps restored the maintenance program from the 1993 agreement. Maintenance actions from 1998 through 2011, as provided by the County, are summarized in Table 2; no sediment management was reported during this period.

Table 2. TZ maintenance actions from 1998 to present

Year	Action	Right Bank	Left Bank
1998	Cutting to 20-foot buffer (fall)		X
1999	Cutting to 20-foot buffer (spring)	X	
2001	Selective thinning of willows on left bank; hand clearing on right bank	X	X
2003	Cutting to 10-foot buffer	X	
2004	Cutting to 10-foot buffer		X
2008	Mechanical cutting	X	
2009	Hand cutting		X
2010	Mechanical cutting		X
2011	Intensive mowing	X	X

The Corps modified the Lake Sammamish outlet weir in 1998 to enhance summer flows to improve fish passage into Lake Sammamish (King County, 2012b). The original wood sill with a shallow v-section was replaced with a flat-crested concrete weir with a low-flow notch in the center. The notch lowered the minimum discharge elevation by 0.65 feet, and the crest was raised by as much as half a foot per the Corps' design drawings (included in King County, 2012b) to ensure sufficient flow through the notch (Merri Martz, pers. comm., October 2013). This also served to raise summer lake levels by roughly the same amount (Merri Martz, pers. comm., October 2013).

2.2 Hydrologic Data Analysis

Several studies have used gage data analysis, modeling, or both to evaluate hydrologic and hydraulic conditions for Lake Sammamish and through the TZ. This information is helpful in assessing how hydrologic and/or hydraulic conditions may have changed since project construction.

2.2.1 Lake Levels

The Corps conducted a Special Study of Lake Sammamish in 1996 (USACE, 1997) that reviewed stage frequency for the lake and investigated impacts of four vegetation scenarios for the TZ on lake levels using HEC-1 and HEC-2 models.[5] It is notable that the 10-year lake elevation determined in the analysis exceeded the 29.0 feet NGVD (32.6 feet NAVD) flood control elevation (see Section 2.1) for all four of the vegetation management scenarios evaluated, including the "Initial Condition" scenario representing the design maintenance condition, which had a 10-year lake elevation of 29.6 feet NGVD (33.2 feet NAVD) (USACE, 1997).

In a later internal memorandum documenting recalibration of an earlier Sammamish River hydraulic model (USACE, 2002), the Corps concluded that "the Lake is expected to exceed the design elevation of 29.0 feet [NGVD (32.6 feet NAVD)] at the design discharge of 1,200 cfs" (USACE, 2002, p. 1). Failure to meet the design objective was attributed primarily to dense vegetation in the TZ, particularly the high flow bench, downstream of the weir. A comparison of the Corps' recalibrated model to previous model

[5] The HEC-1 model was used to compute lake stages for two historic events (1933 and 1951) that occurred prior to construction of the outlet control weir.

results indicated that the weir modifications, refinements to channel geometry, and channel constriction due to willow encroachment added about 0.4 feet to the simulated lake level.

The City of Bellevue conducted an ordinary high water (OHW) level study for Lake Sammamish in 2004 (Watershed Company, 2004). The study used several approaches to estimate OHW elevation, including field identification and statistical analysis of lake level data. The OHW level as determined from the mean elevation of field indicators of OHW level (e.g., change in vegetation type, debris lines, staining) surveyed for the study was 27.74 feet NGVD (31.32 feet NAVD)[6]. The study did not find statistically significant differences in OHW marks along different segments of the City of Bellevue shoreline, indicating that lake level is fairly consistent along most of the lake's western shoreline. Depending on the method used (e.g., mean annual peak, mode annual peak, 1.05-year recurrence interval elevation), the OHW level determined from historical record analysis (for the period from 1965 through 2003) varies between 27.42 feet NGVD (31.01 feet NAVD) and 28.28 feet NGVD (31.86 feet NAVD). The OHW study reports that the Corps-determined OHW level is 27.00 feet NGVD (30.59 feet NAVD) and that King County uses that same level as a basis for development setbacks. Increases in the OHW level are one of the primary concerns of Lake Sammamish property owners and shoreline groups, based on public input received in relation to King County's proposed sediment removal project (King County, 2012b).

Previous studies have noted that lake levels and flows in the TZ can be significantly impacted by vegetation in the channel and overbanks (expressed in the models as channel roughness) and, during large events, by backwater from high flows on Bear Creek. King County (2012a) explored two hydraulic influences on weir outflow and the rating curve used to determine flows at the weir (King County gage 51m).

The backwater impact from Bear Creek is evident for several historic high flow/high lake level events as a pronounced loop (referred to as a hysteresis) in the stage-discharge relationship at the weir. For two events (December 2010 and January 2006) for which flow *measurements* were taken at the weir throughout the event, discharge at the weir is initially lower at a given lake level, coinciding with the peak flow from Bear Creek, then increases as Bear Creek flows recede. This relationship is also evident for the December 1996/January 1997 event, with lake outflows estimated from an empirical function of Bear Creek and Sammamish River near Woodinville flows (see also Section 3.2). The unsteady HEC-RAS model developed for the floodplain mapping study (NHC, 2010) also demonstrates this backwater effect. Using a steady-flow sensitivity analysis approach, the County demonstrated that lake levels could increase by as much as 1.4 feet at roughly a 10-year discharge from the lake depending on the Bear Creek discharge; at lower weir discharges, Bear Creek inflows did not have an effect (King County, 2012a). This effect is discussed further in Section 3.2.

King County's Hydrologic Data Collection staff has employed four primary rating curves since 2001 (Figure 1). There was a significant upward shift (i.e., higher lake level for the same discharge) between 2006 and 2009, coinciding with a period with no TZ maintenance, followed by a significant downward shift following intensive mowing in 2011 (King County, David Funke, pers. comm., May 2013). Vegetation conditions do not explain the upward shift between 2003 and 2004, as cutting of both banks occurred over that period.

Hydraulic modeling conducted by the County found that channel roughness in the TZ could affect lake levels by as much as half a foot, though impacts decrease somewhat for larger events (King County,

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[6] Primary elevations for this study were reported in NAVD88. The conversion factor reported in the study is 3.59 feet, but converted elevations as reported fluctuate between 3.58 and 3.59 (possibly due to rounding). Elevations on both datums are reported here as in the document.

2012a). Modeling of estimated sediment accumulation in the TZ (King County, 2012a and 2012b) shows impacts on lake level ranging from 0.05 feet to about 0.3 feet, with the largest impacts at moderate flows (750 to 1000 cfs).

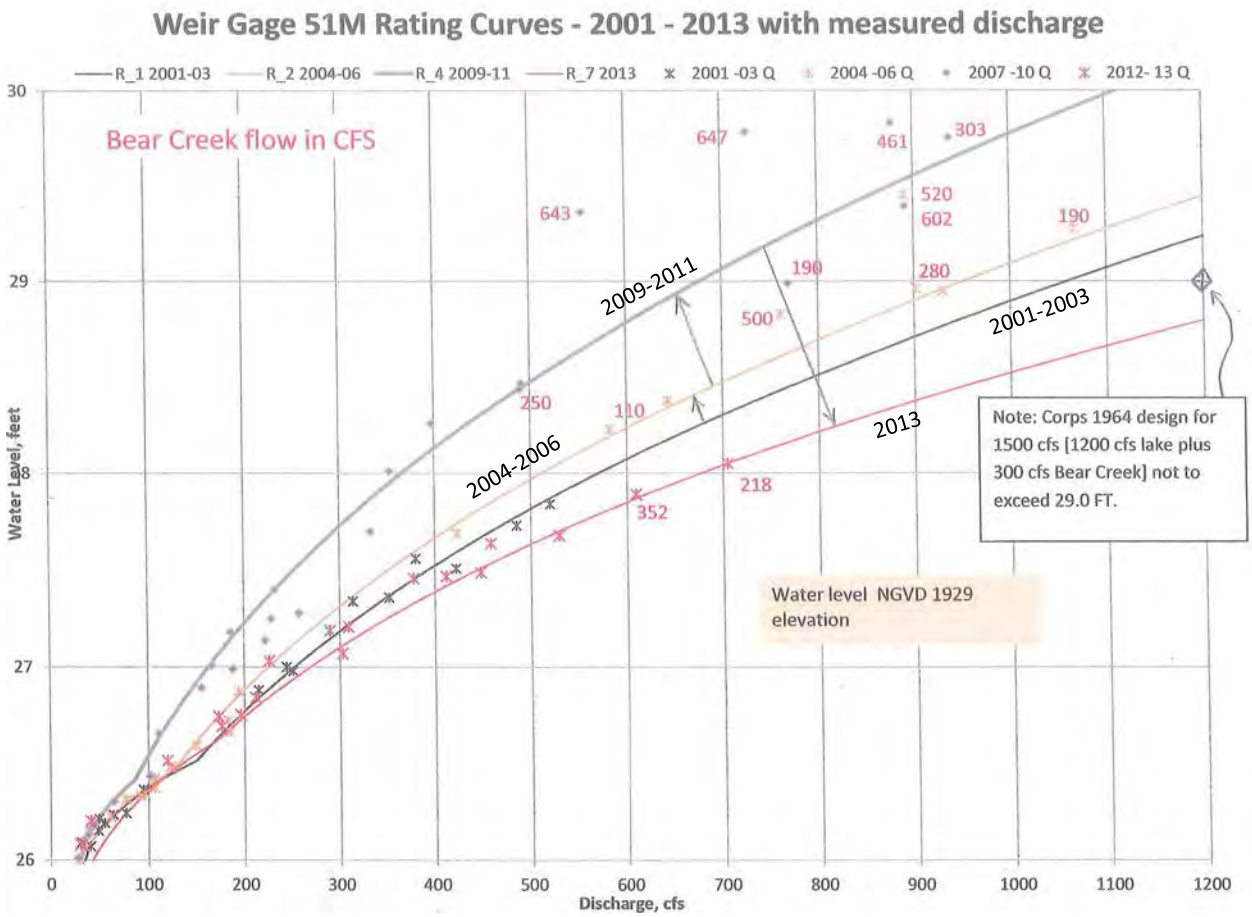


Figure 1. King County gage 51m rating curves and flow measurements for 2001 through 2013 (provided by King County)

2.2.2 Hydrologic Trends

King County conducted a thorough analysis of observed hydrologic data relating to Lake Sammamish outflows to the Sammamish River in 2010 and 2011 (King County, 2012a). The study included statistical analysis for trends in precipitation, lake levels, and Issaquah and Bear Creek flows, in addition to the evaluation of rating curves at the weir and sensitivity analysis for lake elevation and outflows to multiple vegetation and sediment management alternatives discussed in the previous section.

Precipitation analysis in this study consisted of trend analysis of monthly 1-day, 3-day, and 7-day maxima and monthly totals from the SeaTac daily record for 1949 through 2011. The only significant trend noted was a decrease in February totals for all four categories. There was also a moderate upward trend (though not statistically significant) in monthly and 3-day maximum precipitation for May, though small enough that changes were noted as not likely to be measurable (King County, 2012a).

The only highly significant statistical trend in Issaquah Creek flows (which make up roughly half of the Lake Sammamish inflow) was a decrease in September flows, which was noted as consistent with trends determined for other King County rivers (King County, 2010). The 2012 report notes that Issaquah Creek trends may not be representative of the remaining drainages into the lake, which are smaller and have

experienced more significant development (on a watershed-scale basis). However, data are very limited for these remaining tributary drainages. Magnitude and timing of flow changes from these smaller tributaries could be estimated using hydrologic modeling for multiple development scenarios, though that effort is beyond the scope of the current study.

For Bear Creek, King County evaluated trends in annual peak flows in addition to the monthly maximum, monthly mean, and maximum daily flows also evaluated for Issaquah Creek. The available period of record for Bear Creek (King County 02a) was 1988 to 2011, which proved to be somewhat short to identify statistically significant trends. "However, there are indications of declining storm flows in late winter [through] early spring, and increasing storm flows during late summer through mid-winter…. Similarly, peak annual flow rates indicate a moderate upward trend…" (King County, 2012a, p. 20). Trend analyses on frequency and duration of large storms weakly suggested an increase in the number of storms with peak flows greater than 300 cfs and more strongly indicated an increase in flow duration above 400 cfs.

There is evidence that land use change contributed to increased peak flows and possibly storm volumes between the mid-1980s and the mid-1990s (Hartley and Funke, 2001), and continued development may explain some of the storm flow tendencies detected in the King County study. However, the presence of apparent trends in Bear Creek flows that are absent from Issaquah Creek may be attributable to the range of hydrologic conditions captured in the shorter Bear Creek analysis versus the longer Issaquah Creek analysis. Visual inspection of the 1988 to 2010 period in the Issaquah Creek monthly maximum daily flow rate plots in the King County study (Figure 2-1, King County, 2012a) suggests that similar weak trends might also be identified over that period for Issaquah Creek. Our examination of variability in high flow occurrences on Issaquah Creek (see Figure 6 in Section 3.2) also lends support to this explanation. Climate in the Pacific Northwest is subject to several cyclical atmospheric circulation patterns, fluctuating over periods from years to decades, so it is not unusual for periodic short-term trends to emerge (e.g., in transitioning from a dry cycle to a wet cycle) that are lost within the natural variability over a longer period.

The study also evaluated trends in frequency of lake levels exceeding a range of elevations between 27 feet and 29 feet NGVD (30.6 feet and 32.6 feet NAVD) over the period from 1965 through 2010. The study counted the number of days per water year exceeding each flow level (shown later in this report as Figure 5), and a trend analysis was performed on the number of exceedances. The study found statistically significant increasing trends at the 27.0-, 27.5-, and 28.0-foot NGVD levels that were suggested as being attributable to altered maintenance protocols (King County, 2012a). There were too few exceedances at the 28.5- and 29.0-foot NGVD levels to calculate valid statistics.

2.3 Existing Models

NHC (2010) developed an unsteady HEC-RAS model of the Sammamish River from Lake Sammamish to the mouth at Lake Washington for the Sammamish River floodplain mapping study. The HEC-RAS model was calibrated to stage and flow hydrographs at both Sammamish River gaging stations (King County 51m at the weir and USGS 12125200/King County 51t downstream) and to high water marks along the river for three flood events.

Inflows to the hydraulic model were obtained from existing HSPF hydrologic models developed in previous studies by King County and Snohomish County. The FIS study did not include recalibration of the HSPF models, though discrepancies between simulated and observed flows were noted for some locations, such as Bear Creek. These were addressed in the FIS by applying calibrated multipliers to the

long-term flow hydrographs to achieve reasonable matches for lake level in Lake Sammamish and flows in the Sammamish River.

NHC reviewed the ability of these two models to consistently match observed lake levels (HEC-RAS model) and inflows from Bear Creek and Issaquah Creek (the largest tributary to Lake Sammamish).

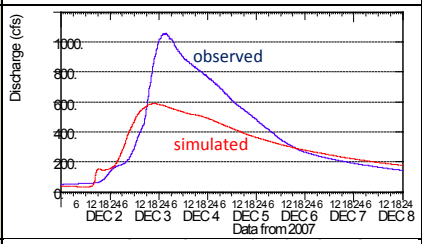
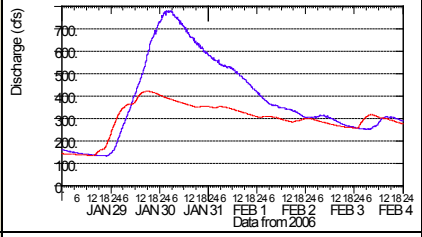
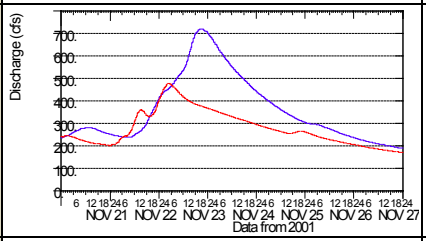
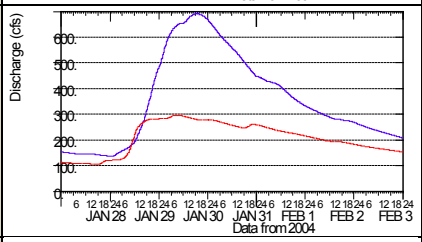
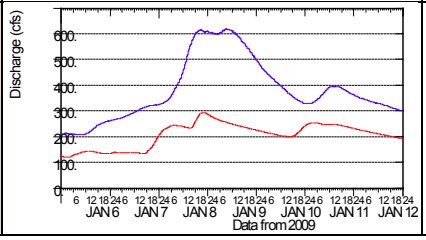
2.3.1 HSPF Models

The current HSPF models for Bear Creek and Issaquah Creek roughly simulate annual runoff volume (plus or minus ten percent) but are generally quite poor at representing specific events. HSPF-simulated flows were compared to observed flows for Bear and Issaquah Creeks for the period for which model simulations and observed 15-minute data (at King County 02a and USGS 12121600, respectively) were available. Peak timing and hydrograph duration are reasonably well-simulated for Bear Creek, as is the relative magnitude of historic events, but peak flows and event volumes are very low (Table 4), as are winter monthly volumes (Table 3). These results suggest that surface runoff is being underestimated, possibly due to too little impervious area specified in the basin model. The model designates only seven percent of the combined Bear/Evans Creek basin as effective impervious area, which seems low even for the late 1990s land use supposedly represented. A WRIA 8 screening analysis (WA DOE, 2001) estimated effective impervious percentages for the lower Bear, Evans, and Cottage Lake basins between 11 and 15 percent and upper Bear between 6 and 10 percent.

Table 3. Comparison of HSPF-simulated and observed (KC 02a) monthly volumes for Bear Creek (WY 2002-2009).

	Maximum (cfs)			Minimum (cfs)			Mean Total (AF)		
	02a	HSPF	% Diff	02a	HSPF	% Diff	02a	HSPF	% Diff
October	435	361	-17%	15.6	12.9	-17%	39.3	32.4	-18%
November	718	477	-34%	23.6	16.7	-29%	107.6	83.4	-23%
December	1055	587	-44%	28.0	18.7	-33%	150.6	125.9	-16%
January	780	420	-46%	55.1	43.5	-21%	150.3	129.9	-14%
February	583	896	54%	46.3	33.8	-27%	111.0	108.9	-2%
March	326	312	-4%	34.7	26.4	-24%	98.0	94.8	-3%
April	292	316	8%	29.1	27.0	-7%	79.4	77.4	-3%
May	158	142	-10%	21.7	21.0	-3%	46.8	42.7	-9%
June	180	111	-38%	16.4	18.8	15%	40.5	36.2	-11%
July	66	104	57%	10.0	13.9	39%	22.9	23.1	1%
August	132	106	-20%	9.2	13.1	43%	19.4	19.8	2%
September	97	149	54%	10.0	13.3	33%	22.8	20.6	-10%
Mean Annual Flow (cfs)							75.1	66.6	-11%

Table 4. Comparison of observed (KC 02a) and HSPF-simulated flows for large events on Bear Creek (WY 2002-2009). Observed flows in blue; simulated flows in red.

Date	Observed Rank	Simulated Rank	7-Day Hydrograph Comparison	Peak Flow (cfs)	Event Volume (kAF)
3-6 Dec 2007	1	2		Observed: 1055 Simulated: 587 % Difference: -44%	Observed: 4.5 Simulated: 3.4 % Difference: -26%
29-31 Jan 2006	2	7		Observed: 780 Simulated: 420 % Difference: -46%	Observed: 2.5 Simulated: 1.8 % Difference: -30%
22-25 Nov 2001	3	4		Observed: 718 Simulated: 477 % Difference: -34%	Observed: 3.5 Simulated: 2.6 % Difference: -26%
29-31 Jan 2004	4	19		Observed: 693 Simulated: 296 % Difference: -57%	Observed: 2.9 Simulated: 1.5 % Difference: -48%
8-10 Jan 2009	5	20		Observed: 619 Simulated: 293 % Difference: -53%	Observed: 2.9 Simulated: 1.4 % Difference: -51%

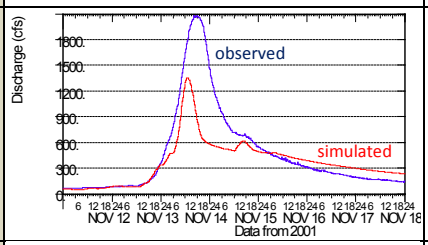
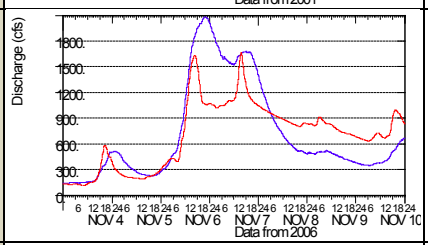
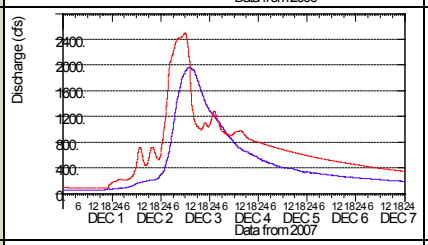
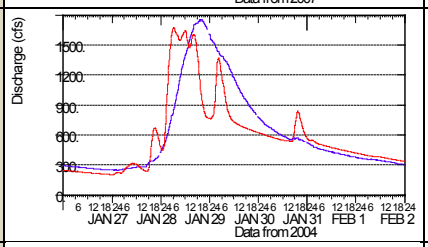
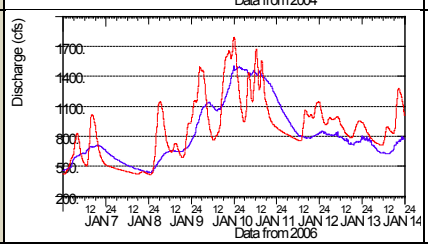
Note: cfs = cubic feet per second, kAF = 1000 acre-feet

For Issaquah Creek, which makes up roughly half of the Lake Sammamish drainage area, HSPF-simulated hydrographs do not match observed flow patterns or magnitudes well during the winter months. Winter flow volumes overall are substantially over-simulated (Table 5), as are peak flows for small to moderate events. Performance for larger events is somewhat better (Table 6), but simulated hydrographs are much spikier than observed, resulting in poor reproduction of the relative magnitude of storm events. These factors suggest that the model is producing excess surface runoff, in contrast to Bear Creek results.

Table 5. Comparison of HSPF-simulated and observed (USGS 12121600) monthly volumes for Issaquah Creek (WY 2002-2008).

	Maximum (cfs)			Minimum (cfs)			Mean Total (AF)		
	12121600	HSPF	% Diff	12121600	HSPF	% Diff	12121600	HSPF	% Diff
October	1450	603	-58%	11.0	15.8	44%	55.0	53.9	-2%
November	2080	2017	-3%	17.0	15.7	-8%	166.8	185.3	11%
December	1970	2500	27%	23.0	21.9	-5%	214.3	252.0	18%
January	1750	2207	26%	44.0	63.2	44%	280.9	315.4	12%
February	720	1487	107%	57.0	48.3	-15%	171.3	204.5	19%
March	1120	1473	32%	44.0	36.2	-18%	170.5	211.9	24%
April	983	1942	98%	44.0	47.6	8%	134.3	156.4	16%
May	670	806	20%	26.0	30.1	16%	81.1	83.8	3%
June	279	1022	266%	24.0	27.1	13%	62.7	55.7	-11%
July	87	126	45%	12.0	17.0	41%	29.7	26.8	-10%
August	422	238	-44%	9.2	13.7	49%	24.0	22.3	-7%
September	168	165	-2%	6.2	13.7	122%	27.3	27.4	0%
Mean Annual Flow (cfs)							119.7	134.0	12%

Table 6. Comparison of observed (USGS 12121600) and HSPF-simulated flows for large events on Issaquah Creek (WY 2002-2008). Observed flows in blue; simulated flows in red.

Date	Observed Rank	Simulated Rank	7-Day Hydrograph Comparison	Peak Flow (cfs)	Event Volume (kAF)
14-16 Nov 2001	1	28		Observed: 2080 Simulated: 1352 % Difference: -35%	Observed: 5.2 Simulated: 3.5 % Difference: -33%
6-8 Nov 2006	2	10		Observed: 2080 Simulated: 1199 % Difference: -46%	Observed: 7.1 Simulated: 5.8 % Difference: -19%
2-4 Dec 2007	3	1		Observed: 1970 Simulated: 2500 % Difference: 27%	Observed: 4.7 Simulated: 6.0 % Difference: 27%
29-31 Jan 2004	4	9		Observed: 1750 Simulated: 1673 % Difference: -4%	Observed: 5.8 Simulated: 5.3 % Difference: -8%
9-12 Jan 2006	6	6		Observed: 1500 Simulated: 1792 % Difference: 19%	Observed: 7.9 Simulated: 8.1 % Difference: 2%

Note: cfs = cubic feet per second, kAF = 1000 acre-feet

Recalibration of the Issaquah Creek and Bear Creek models is strongly recommended if further analysis of peak flows, high flow durations, or storm volumes is needed to support an updated design hydrology. Though the scaling approach used in the FIS was suitable for the targeted storm event modeling, Willowmoor project design will likely need to consider system response over a wider range of flows , and potentially future conditions scenarios, where relative watershed response may change. Given the importance of Bear Creek flows to the hydraulic capacity of the system (see Sections 2.2.1 and 3.2), ability to simulate peak flows and hydrograph timing from Bear Creek is likely to be critical to any further modeling analysis to support the project design. Based on the results of calibration of the

Issaquah and Bear Creek models, there may be systematic adjustments that could also be applied to the East and West Lake Sammamish Tributary models, for which only limited calibration data are available.

2.3.2 HEC-RAS Model

The HEC-RAS model was constructed to simulate general conditions from Lake Sammamish to Lake Washington for an approximately 60 year period. Figure 2 shows the simulated results for a portion of this time, from water year 1998 to 2009, at the Marymoor Weir gage location (King County gage 51m) compared to measured stage at the same location and also upstream in Lake Sammamish (USGS station 12122000). Typically, USGS-recorded lake stage at the south end of the lake is a few tenths higher than the water level at the weir.

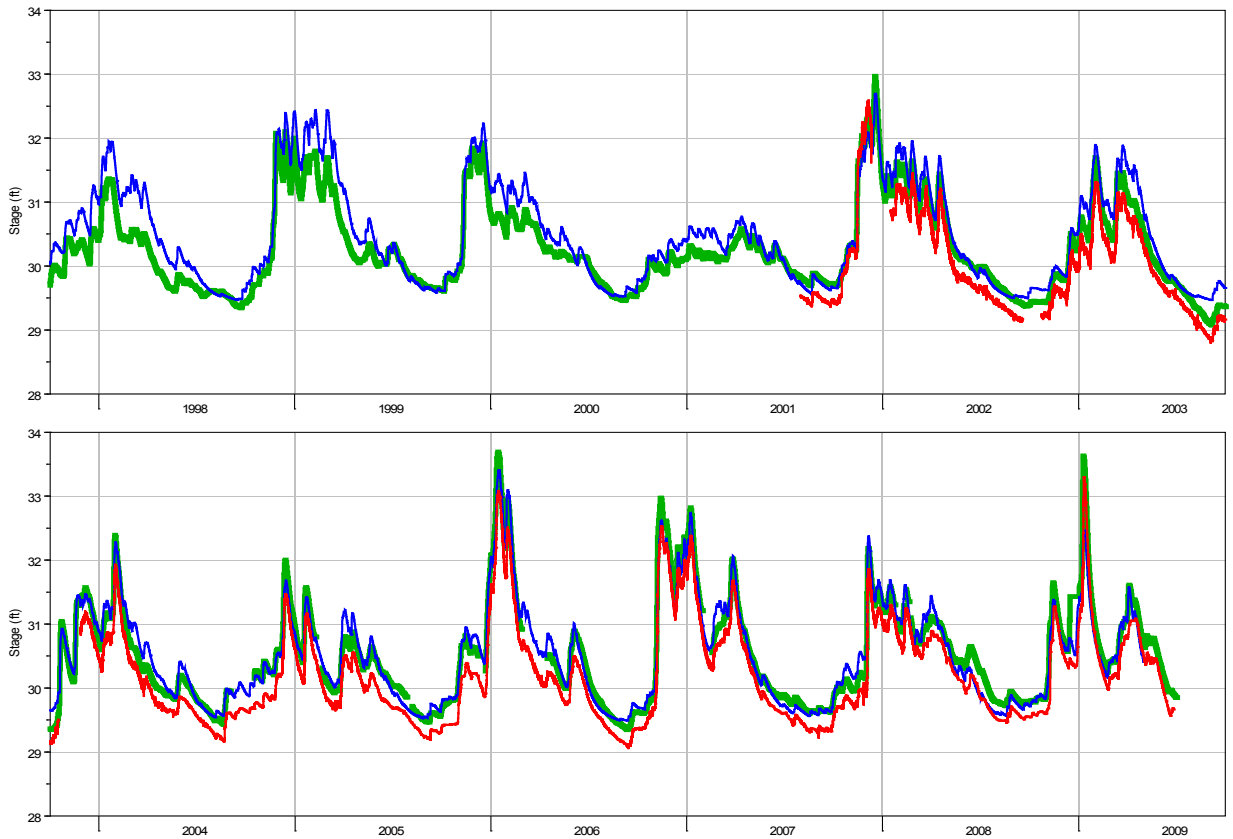


Figure 2. Water levels simulated at the Marymoor weir in blue, recorded at King County 51m in red, and observed USGS Lake Sammamish gage 12122000 in green.

Simulated results are generally within a couple of tenths of a foot of the observed weir stage from WY 2004 through WY 2009, though there are some simulated excursions of close to a foot. The existing model uses one static set of model parameters (e.g., channel vegetation and weir conditions) to represent a range of flows while ensuring that peak stages are reasonably matched for the entire 60 year period. When specifying this set of model parameters during WY 2003 and earlier, the model tends to simulate stage slightly higher than that in Lake Sammamish as the physical conditions of the TZ vary from that represented in the model. During this earlier time period, the hydrologic simulation of inflows tends to overpredict observed flows (when compared at downstream gage 51t), possibly further contributing to the higher-than-observed weir stage.

The TZ is a relatively complex section to simulate. Vegetation conditions have changed over time both naturally (e.g., growth of willows over the channel and grasses in the overbanks, seasonal growth and die-back) as well as through TZ maintenance (e.g., mowing). Channel roughness, both horizontally and vertically, can be altered in the model to match the changing TZ conditions. In addition, the weir has a narrow notch for low flow conditions and a much wider crest for high flows. Vegetation affects the efficiency of the weir. Preliminary indications show that by adding additional weir details to the model and adjusting roughness values to represent the specific conditions during a period of interest, the model can simulate results generally closer than the existing model. The model simulation also shows that Bear Creek can cause a backwater through the TZ. If model refinements are made, the accuracy of the modeled backwater effect could be investigated.

The purpose of the HEC-RAS modeling for the FIS was to simulate stage and flow well along the entire Sammamish River from Lake Sammamish to Lake Washington. For purposes of the Willowmoor project, model refinements could focus on more closely replicating the reach between Bear Creek and Lake Sammamish.

3 Statistical Analysis

NHC performed statistical analysis on currently available observed and simulated data to establish a current hydrologic context, to compare against the original design flows, to evaluate coincidence of high flows and high lake levels, and to identify trends in hydrology that could affect project function. This work builds on the statistical analysis already performed by the County and documented in the *Findings on Lake Sammamish Outflow* (2012a) report. The analyses focus on annual data and trends, rather than just the spring season, because winter flooding has become a greater concern with development of the formerly agricultural Sammamish River valley.

3.1 Corps Design Flows

As discussed in Section 2.1, the TZ was originally designed to contain a 1,500 cfs spring flow with lake levels not to exceed 29.0 feet NGVD (32.6 feet NAVD). The design conditions were based on the March 1950 event, which was characterized as having a 10-year annual and 40-year spring (after March 1) recurrence interval. As mentioned previously, the Corps' original frequency analysis was not available for review. It seems likely that it would have been based on the flow record for the Sammamish River near Redmond gage (USGS 12125000), which extends from 1940 through 1957. Annual frequency analysis of that dataset using the methods of Bulletin 17B (USGS, 1981) produces a 10-year annual peak flow estimate of 1,250 cfs. The 1,500 cfs design flow is within the 95-percent confidence limits, as is the 1,360 cfs peak flow from March 1950.

Based on post-1966 observed data for the Sammamish River near Woodinville (USGS 12125200 and King County 51t), the statistical 10-year annual flow and 40-year spring flow are substantially higher than the Corps design flow (Table 7). The 1,500 cfs design flow for the Sammamish River below Bear Creek equates to approximately a 3-year annual flow and just over a 10-year spring flow based on observed peak flows since 1966. HSPF-simulated flows for this location (NHC, 2010) show similar results to the observed. Table 7 shows frequency analysis results for the common period for simulated and observed data from water year 1966 through 2009. Extension of the analysis to the full period available for each dataset (1966 through 2013 for observed, 1949 through 2009 for simulated) affects 10-year flow estimates by less than two percent.

Table 7. Flow frequency analysis for Sammamish River near Woodinville (1966-2009)

	Location	10-Yr Annual Flow (cfs)	40-Yr Spring Flow (cfs)	1,500 cfs Recurrence Interval (yrs)	
				Annual	Spring
Observed	12125200/51t	2,150	1,990	2.9	11
Simulated	RAS XS 50090	1,970	2,090	2.9	11

A number of factors could contribute to the substantial increase in Sammamish River flows since the original design analysis, but it seems most likely that the project itself is the major cause. As King County has demonstrated in previous studies (e.g., King County, 2010 and 2012b), there have been no significant climate trends affecting precipitation or streamflow over this period. Increased flows due to watershed development (particularly in Bear Creek) do not appear to have had a significant impact on the Sammamish River peak flow record, as there is no apparent increasing trend over time since 1966. A relatively short record at the time of the Corps analysis could affect frequency estimates, particularly if that period lacked very large events. However, analysis of various 15 to 20 year periods in the Sammamish River near Woodinville record, including comparing the wettest and driest periods, produced differences in the 10-year flow on the order of five to ten percent, compared to a 33 percent increase over the Corps design flow. Thus, it seems likely that increases in the capacity of the lake outlet and downstream channel due to construction of the Sammamish River project are responsible for increased peak flows.

The Corps design documents do not specify a frequency for the design flow on Bear Creek (690 cfs), and because of lake storage effects, frequency of a particular event is likely to be different on the Sammamish River and Bear Creek. For purposes of comparison, however, frequency analysis was conducted on the continuous record of observed data for Bear Creek (King County 02a; WY 1989-2013) and indicated a 10-year annual flow of 1,150 cfs and a 40-year spring flow of 730 cfs. Both of these are higher than the March 1950 peak of 650 cfs. Adding the six peaks from the USGS record for Bear Creek (station 12124500) between 1946 and 1958 to the annual frequency analysis decreases the 10-year flow by about 35 cfs. On this augmented frequency curve, the March 1950 event has an annual exceedance probability of about 0.25 (i.e., a four-year recurrence interval). It should be noted that the Bear Creek design flow is not equivalent to the Bear Creek contribution to the Sammamish River design flow, as the latter[7] represents Bear Creek inflow coincident with the lake outflow peak and would typically be less than the peak flow for a given event.

It appears that the Corps project has had the effect of increasing high flows in the Sammamish River due to increased lake outlet and channel capacity. Despite a substantial increase in the 10-year flow since construction of the weir and TZ, however, prior modeling (NHC, 2010) indicates that the TZ and downstream Sammamish River channel have sufficient capacity to contain the current 10-year event, with the possible exception of the area between approximately NE 90th Street and NE 145th Street. In many areas, the currently estimated 50-year and even 100-year flows remain within the channel.

3.2 Lake Level Analysis

The other objective of the Sammamish River project was to keep Lake Sammamish levels below 29.0 feet (NGVD) for the project design event while maintaining minimum (summer) levels. In recent years, however, lakeside homeowners have expressed concerns about higher lake levels and more frequent flooding. This study examined the post-project lake level record and analyzed trends in high and low lake

[7] Assumed to be 300 cfs in previous work by the Corps and King County

levels relative to other hydrologic and hydraulic influences. NHC also assessed correspondence between inflows, downstream channel conditions, and lake levels during extreme events to characterize the factors contributing to the highest lake levels.

The full record (1939 through 2013) of Sammamish River lake levels is shown in Figure 3. Vertical lines indicate completion of the Sammamish River project in 1964 and modification of the weir in 1998. The impact of the original project on the annual range of lake levels is immediately apparent. Also notable is the apparent shift in annual minimum lake levels since the 1998 weir modifications. The post-project trends are explored further in the following sections.

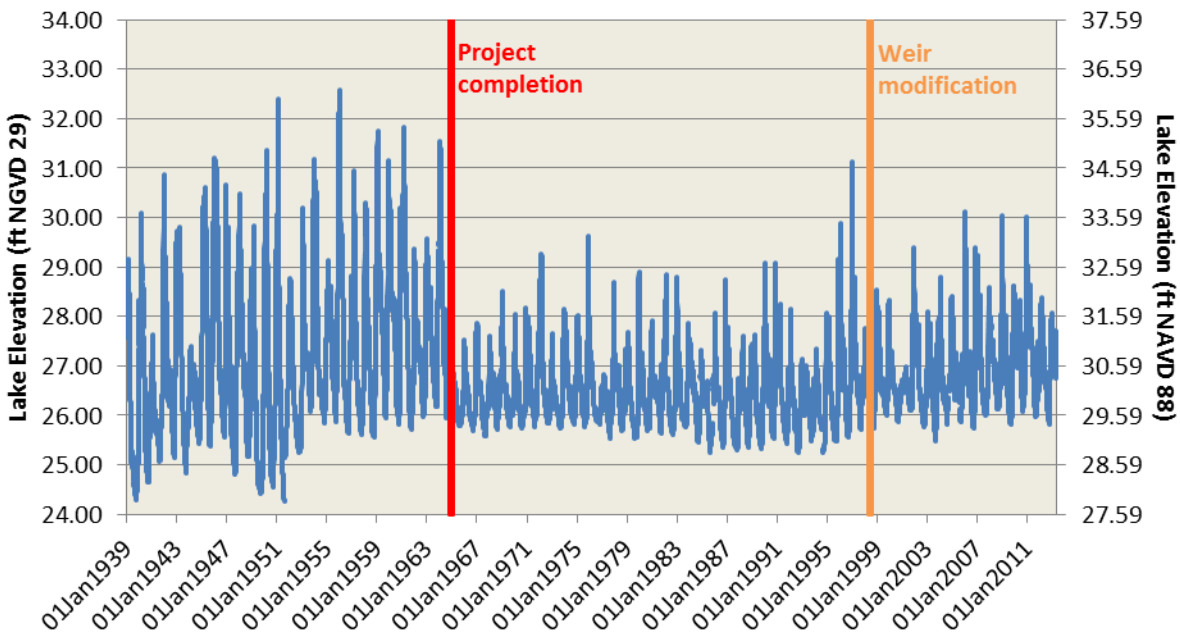


Figure 3. Time series of daily Lake Sammamish elevations.

The post-project (1965 through 2013) daily records for Lake Sammamish elevation and Issaquah Creek streamflows are displayed in Figure 4. In this figure, the horizontal axis shows the day of the water year, while the vertical axis shows the water year. Colors indicate streamflow or stage values measured on each day, while white indicates missing values. The color thresholds for the two plots, which are based on lake levels of interest, reflect the same duration exceedance levels for both records from 1965 through 2013. For example, lake level exceeds 26 feet NGVD (29.6 feet NAVD) approximately 76 percent of the time since 1965, so the corresponding Issaquah Creek threshold (38 cfs) was determined by finding the daily flow that was exceeded 76 percent of the time over the same period.

We see that, in general, the relative magnitudes of lake level and Issaquah Creek flow are consistent, at least through the mid-1990s, which is expected since Issaquah Creek accounts for over half of the drainage area to the lake. For example, the period from 1965 through 1976 appears as wetter (more blues on both plots), while 1985 through 1996 is drier (more greens). Lake levels are notably more sustained than streamflows at a given level, indicated by the longer stretches of continuous color, which is indicative of the longer response time of the relatively large storage provided by the lake.

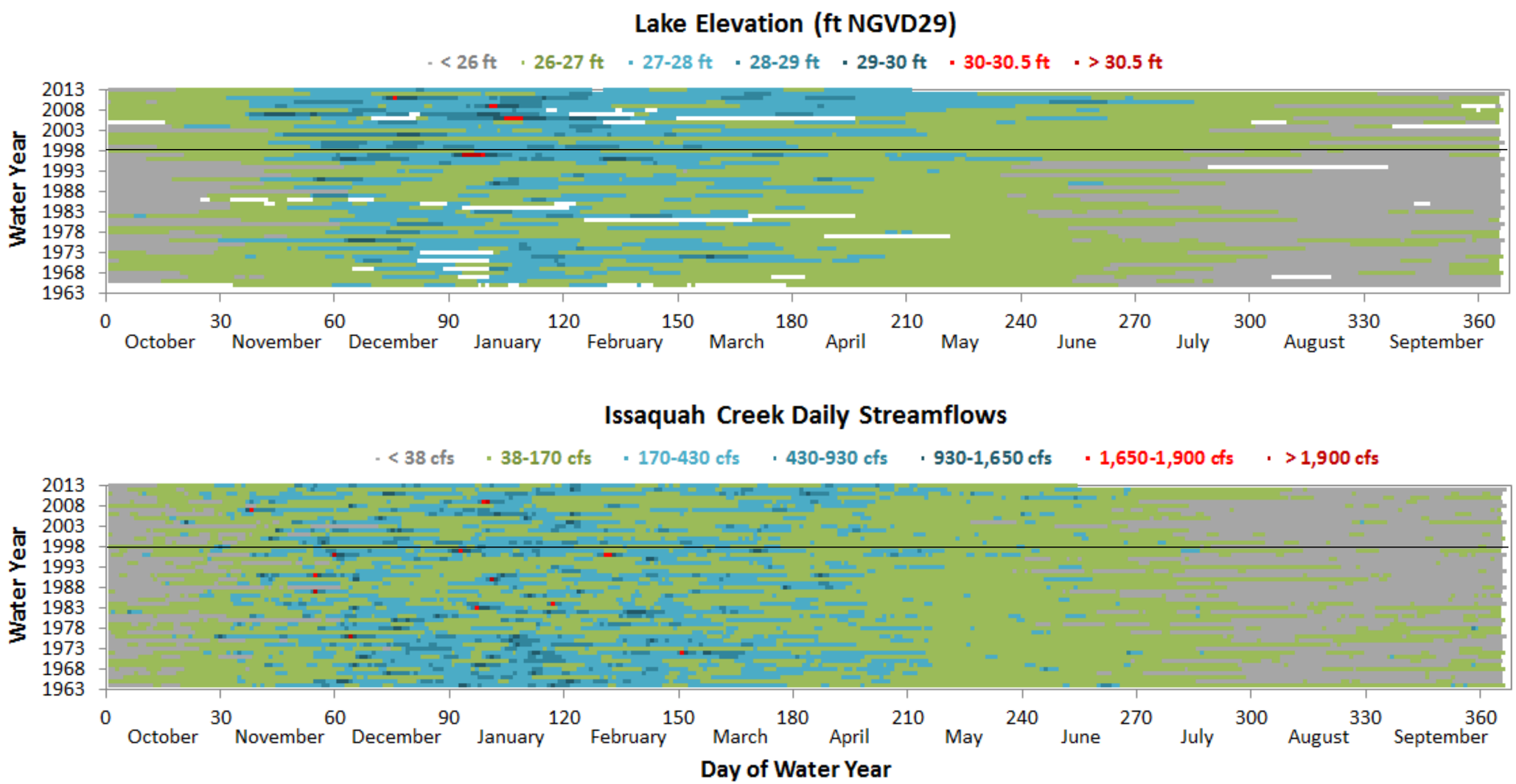


Figure 4. Daily records of lake elevation (feet NGVD) and Issaquah Creek flow. The values on the horizontal axis are day of the water year (October through September). Colors indicate streamflow or stage values. White indicates missing values.

The most notable difference between the two records in Figure 4 is the distinctly higher lake levels, relative to streamflows, since the late 1990s or early 2000s, indicated by the higher concentration of "blue" lake levels. Note that the threshold for the light blue lake level in Figure 4 corresponds to the regulatory OHW level of 27 feet NGVD (30.6 feet NAVD), so the record indicates much more frequent excursions above that level in the past ten to fifteen years. It is likely not a coincidence that the shift in lake levels relative to Issaquah Creek streamflows appears to correspond to the modifications to the lake outlet weir in 1998 (see the horizontal black line on Figure 4 plots). Since that time, lake level has exceeded 27 feet approximately 37 percent of the time, compared to approximately 24 percent over the entire post-project period (1965 through 2013). In contrast, Issaquah Creek has exceeded the corresponding 170 cfs threshold 23 percent of the time since 1998, consistent with the historical average. If the lake level change was driven by wetter conditions in general, we would expect to see a similar signal in the Issaquah Creek streamflows.

Absent additional data or further investigation, we believe it is reasonable to consider Issaquah Creek flows as representative of inflow volumes to the lake and thus inflow contributions to lake levels. Flow increases have likely occurred on smaller tributaries with increased development over the past 20 to 30 years, particularly on the Sammamish Plateau. However, given the relatively small size of affected areas compared to the entire lake drainage basin and the tendency for peak flow increases to be larger than storm volume increases (e.g., Hartley and Funke, 2001), it seems unlikely that this effect would have a significant impact on lake volumes during large events.

3.2.1 Exceedance Analysis

In a previous analysis, King County (2012a) found no evidence of increasing trends in mean or peak streamflows for Issaquah Creek (see Section 2.2.2). However, the same study noted an increasing trend in high lake level exceedances, i.e., the number of days the lake level exceeded a given threshold, for Lake Sammamish between 27 and 28 feet NGVD (Figure 5). The study noted that there were no significant trends in lake level exceedances from 1965 through 1991, when changes to the TZ maintenance protocols were implemented. In this study, NHC confirmed that there is a similar lack of statistically significant exceedance trends through 1998, when weir modifications occurred. The period of record since 1998 is too short for statistical trend analysis, but we hypothesize that trends may be similarly absent in the post-1998 period, indicating a shift in lake levels rather than an increasing trend.

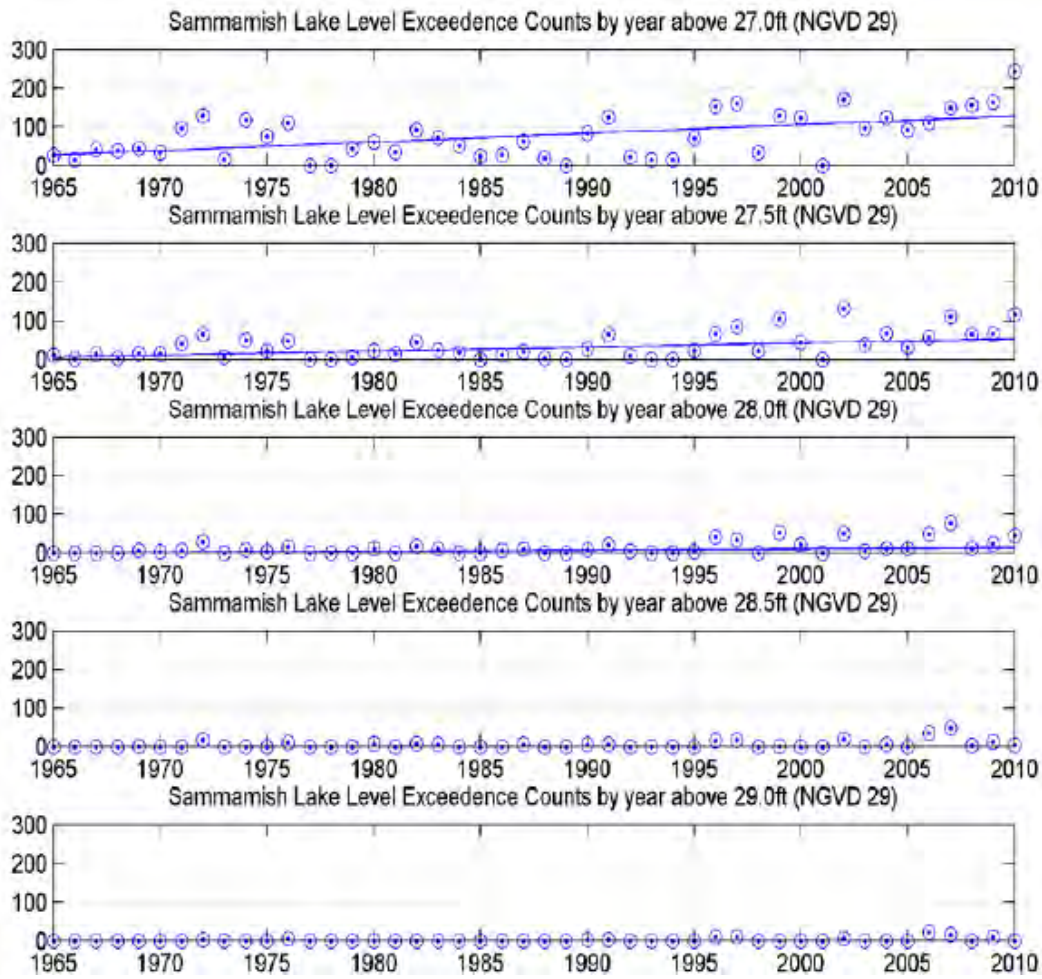


Figure 5. Number of days each year that Lake Sammamish elevation exceeded a given lake level for WY 1965 through 2010 (Figure 4-1 in King County, 2012a).

For this study, NHC conducted a similar daily exceedance analysis on the daily streamflow record for Issaquah Creek to look for trends in the frequency of high flows. To correspond with the thresholds in Figure 4, NHC determined the number of days exceeding flow thresholds of 170 cfs, 430 cfs, and 930 cfs in each water year of the record. Results, shown in Figure 6, reveal no apparent trends in these metrics over time. With no apparent climatic trend corresponding to increasing periods of high lake levels, it seems likely that changing hydraulics through the weir and TZ are playing a significant role.

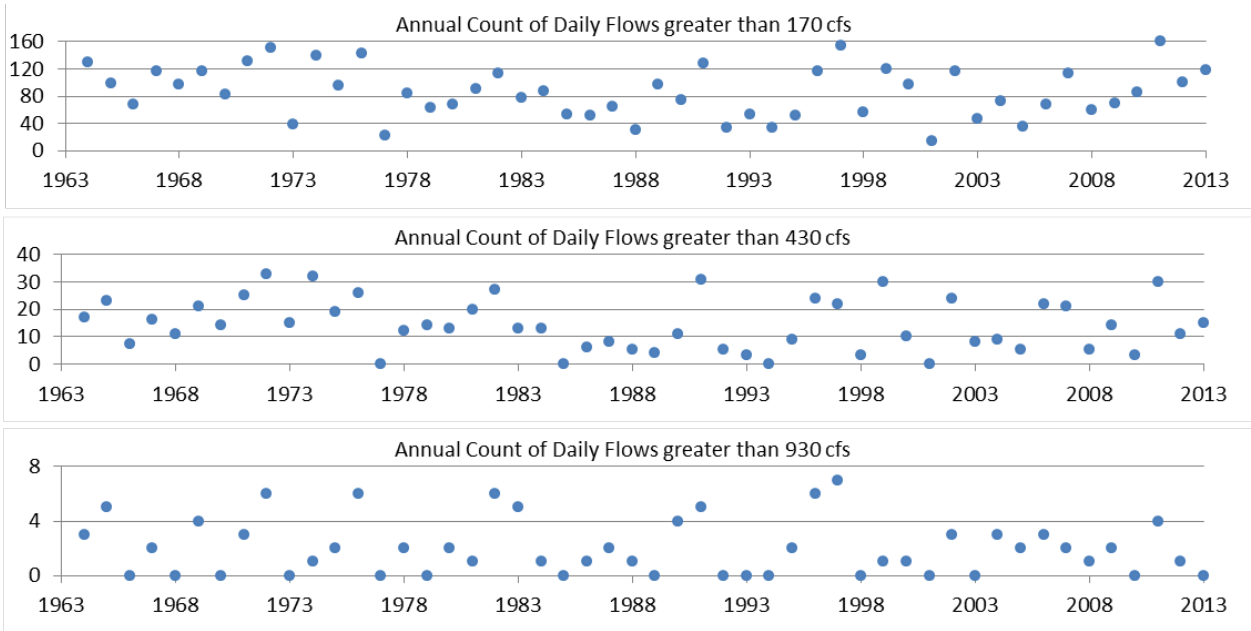


Figure 6. Number of days each year that Issaquah Creek daily flows exceeded a given flow level for WY 1964 through 2013.

3.2.2 Lake Level Trends

To further explore how various lake levels have changed over time, NHC examined a range of statistical annual lake levels, including the annual maximum, mean, and minimum levels, for the period from 1965 through 2013 (Figure 7).

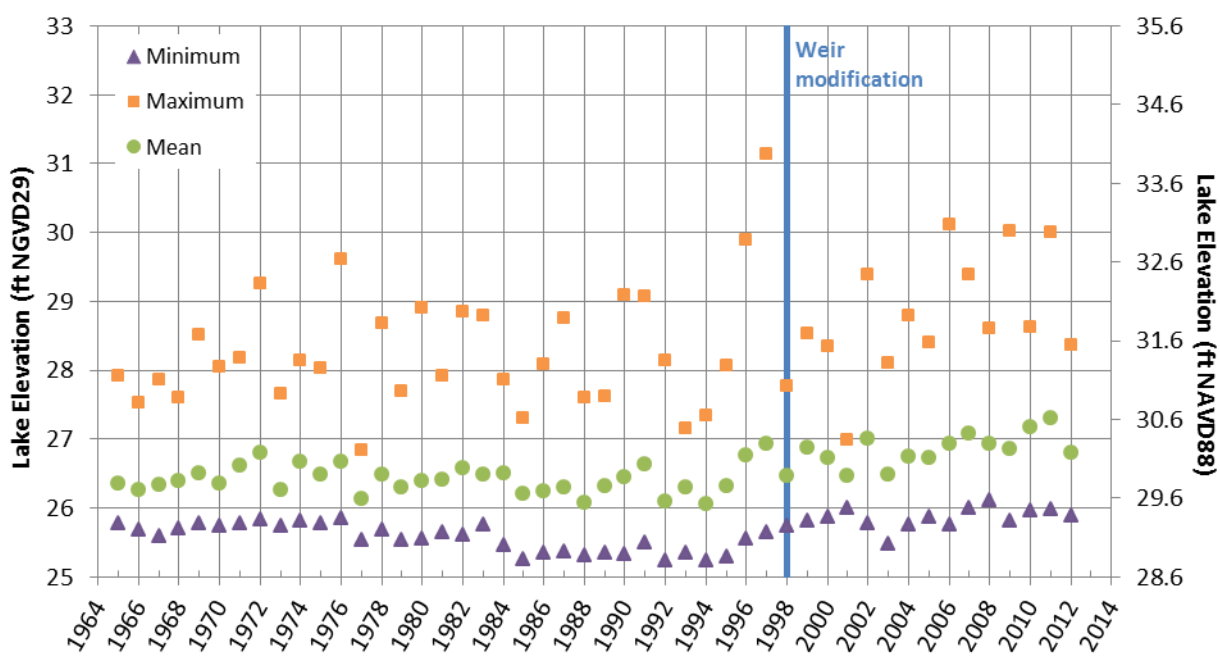


Figure 7. Annual distribution of daily lake stage. Minimum, mean, and maximum daily values are plotted for each water year.

Statistical trend analyses (using the Mann-Kendall test) indicate significant decreasing trends from the annual minimum (99.9 percent confidence) up to the 25th percentile[8] (99 percent confidence) lake levels from 1965 through 1997. No statistically significant trends were detected at the 90 percent confidence level for median and higher lake levels over the same period. The low lake level trends correspond with significant decreases in late summer flows on Issaquah Creek, reported previously by King County (2012b) and confirmed in this study. The observed decline in low lake levels appears to have been counteracted by the weir modifications in 1998, as minimum lake elevations have increased while late summer streamflows have remained at lower levels.

Statistical tests of data homogeneity were also conducted on the multiple lake level quantiles. The purpose of these tests is to determine whether a series of data belong to the same statistical population (i.e., they are homogeneous) or at what point there is a statistical break (or inhomogeneity) in the data, which would suggest a change in external influences. Results from three different tests were not entirely consistent across the various lake level quantiles, but all indicated significant breaks (at the 95 percent confidence level) in the mean and median levels between 1995 and 1997. Two of the three tests found significant breaks in the other quantiles as well. In all three tests, results for maximum flows had the lowest significance but consistently showed similar patterns of results.

Initially, it is somewhat counterintuitive that the homogeneity tests tend to identify 1995 or 1996 as the break point in most of the lake level quantiles, as we are not aware of any significant changes to the system at that time. However, water years 1996 and 1997 were exceptionally wet and produced two of the largest events, for both lake level and streamflow volume, in the record (February 1996 and January 1997). Figure 8 shows the daily lake elevations for water years 1996 and 1997 compared to long-term daily average elevations from 1965 through 1995 and 1998 through 2013. The intent of Figure 8 is to illustrate the annual pattern of flows. The difference in the two long-term daily averages is notable but not necessarily a reliable indicator of the magnitude of change between the two periods.

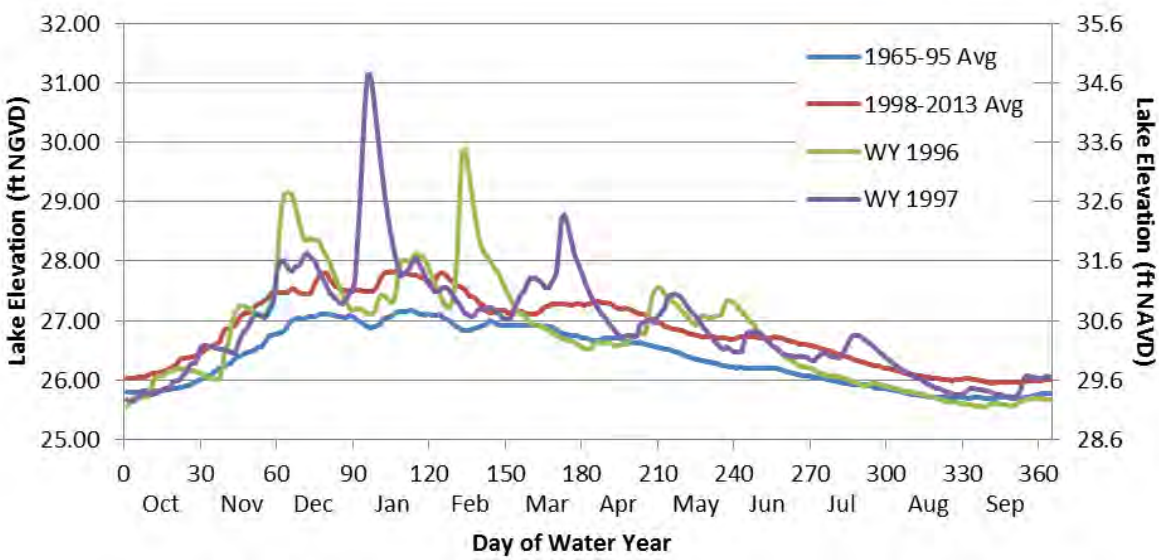


Figure 8. Comparison of 1996 and 1997 lake levels to long-term daily average levels. Horizontal axis is day of water year (October through September).

[8] The "x" percentile level is determined by ranking the daily lake levels for each water year in order of magnitude and selecting the value for each year that corresponds to the lowest "x" percent of the days, i.e. lake levels were below the 25th percentile value on 25 percent of the days in a given year (and exceeded it on 75 percent of the days).

Figure 8 shows that the 1996 and 1997 water levels are clearly well above the 1965 through 1995 average in general, but inter-event levels still tend to drop to the earlier (i.e., pre-weir modification) pattern. Given this, it seems likely that it is an accident of timing—with two wet years preceding the weir modifications—rather than a systematic shift that places the break prior to the weir modifications. Indeed, if we move water years 1996 and 1997 earlier in the record (to separate them from the changes in 1998) the homogeneity tests do not indicate a significant break in any lake level quantiles at that point (i.e., those years fall within the acceptable variability) and uniformly identify the most significant break at 1997/1998. In any case, the results of these tests certainly support the idea that lake levels since the mid-1990s are distinctly different than 1965 through 1995 levels, especially at low to moderate elevations.

Detailed documentation and results from the trend analyses performed for this study are provided in Appendix A to this report.

3.3 Extreme Lake Level Events

Lake Sammamish elevation has surpassed the benchmark of 29 feet NGVD (32.6 feet NAVD)—the flood control elevation specified in the original design objective—in 16 separate events (with dates ranging from November through March) since construction of the Sammamish River project. Since 1965, the chance of exceeding 29 feet NGVD in a given year is approximately 20 percent (or a five-year annual recurrence). Fourteen of the sixteen events occurred since 1989, and nine since 1998. The lake has surpassed 30 feet NGVD (33.6 feet NAVD) four times, all in the most recent half of the record with the earliest in water year 1997. Three of the four occurred in the month of January and one in December. The January 1997 event produced the highest lake level on record, 31.14 feet NGVD (34.73 feet NAVD) in the daily record. This was a large rain-on-snow event in the Puget Sound lowlands that produced peaks of record on many streams in the region.

To explore likely causes for the highest lake level events, we examine the records of the top seven events. Table 8 presents these seven events, ordered by rank. The Issaquah Creek daily hydrograph and the daily lake elevation values are plotted. Fifteen-minute hydrographs are available for four of these events and are plotted as well. The fifth and sixth columns of Table 8 show the rank of each event with respect to one-day and three-day peak inflows from Issaquah Creek. The last column shows the associated peak inflow from Bear Creek and its rank; ranks reflect only the Bear Creek period of record from 1988 through 2013.

Although several of these seven lake level events coincide with some of the highest recorded peak inflow events, others are coincident with rather unremarkable inflow peaks. For example, the third highest recorded elevation event (January 11-21, 2006) was associated with a peak inflow that ranked only eighteenth. While they are necessary to cause a high lake level, neither peak daily inflow nor total inflow volume is sufficient, on its own, to account for the most extreme lake level events.

Based on the individual event characteristics (column 4 of Table 8), differing explanations are proposed as likely for the extreme lake elevations.

1. January 1-9, 1997. The most extreme lake level event is explained by an exceptionally prolonged intense event, lasting over six days, which produced the highest Bear Creek discharge on record (reaching 1,500 cfs on December 31, 1996). None of those days had a comparably extreme inflow from Issaquah Creek (the event ranked ninth for its peak daily inflow).
2. December 13-19, 2010. The second highest lake level event was neither exceptionally prolonged nor had a comparably extreme inflow. The likely explanation for that event is a

reduced discharge rate from the lake again caused by exceptionally high discharge from Bear Creek (approaching 1,400 cfs).

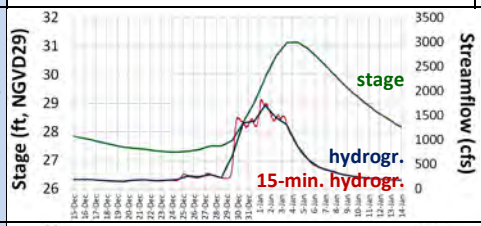
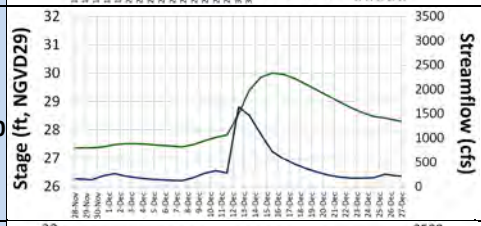
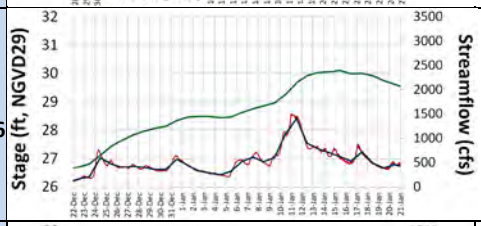
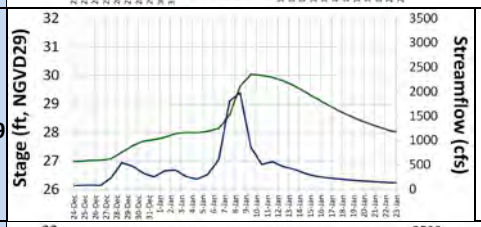
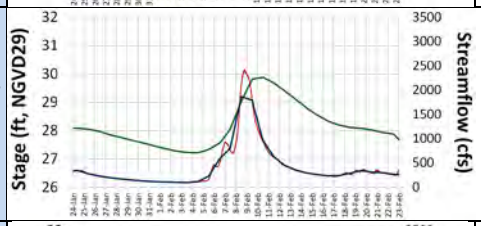
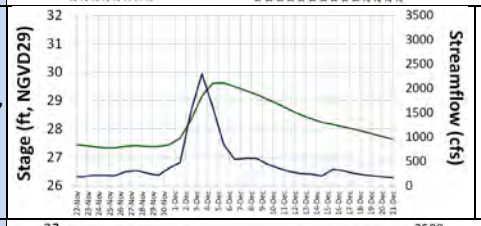
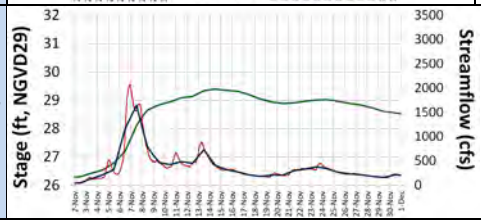
3. January 11-21, 2006. For the third-ranking lake level event, the likely explanation is yet a different one. It appears that a series of smaller events built up lake levels, which already approached 29 feet NGVD (32.6 feet NAVD) when the relatively moderate peak streamflow arrived and filled the lake beyond the 30-foot (NGVD) level.

4. January 8-14, 2009. The fourth ranking lake level event is likely explained by the occurrence of an extremely high peak daily inflow at a time when a series of smaller events, including melt from an unusually high lowland snowpack, had built up lake levels past the 28-foot (NGVD) mark.

5 & 6. February 8-12, 1996 and December 4-6, 1975. The fifth and sixth ranking lake stage events both had a combination of extremely high peak inflows and a prolonged duration of high inflows.

7. November 14, 2006. Neither Issaquah nor Bear Creek inflows were remarkable for the seventh ranking lake stage event. Combined with the sustained very high lake levels, which remained in the vicinity of 29 feet NGVD (32.6 feet NAVD) for about three weeks, this suggests reduced outlet capacity, perhaps due to heavy vegetation in the TZ.

Table 8. High Lake Sammamish events ordered by rank of peak lake elevation, indicated in the first column. Columns 5 and 6 give the event's rank with respect to peak daily and 3-day flows on Issaquah Creek (for 1976-2013). The last column gives the associated Bear Creek peak flow and rank in the Bear Creek record (1988-2013).

Lake Level Rank	Date	Lake Sammamish Stage at Weir and Issaquah Creek Hydrograph	Event Characteristics	Daily Inflow Ranks		Bear Cr Peak Q (Rank)
				Peak	3-day	
1	Jan 1-9, 1997		This event generated the highest of all recorded lake stage values (31.14 ft). The peak daily flow from incoming Issaquah Creek was not as exceptional but the event was **prolonged**, lasting over 6 days. **Bear Ck discharge** was highest in record, impairing lake rating curve.	8	4	1572 cfs (2)
2	Dec 13-19, 2010		Daily peak flow from incoming Issaquah Creek was not as extreme, though 3-day inflows were high, and the event was not exceptionally prolonged (about 4 days long). **Backwater due to high Bear Ck discharge** is suspected as the cause for the exceptionally high stage.	12	7	1068 cfs (3)
3	Jan 11-21, 2006		Daily peak flow from incoming Issaquah Creek was unremarkable but the event followed a **series of smaller events that built up lake levels** over the preceding weeks.	18	13	587 cfs (13)
4	Jan 8-14, 2009		This event had **extremely high inflows from Issaquah Creek** and the event followed a **series of smaller events that built up lake levels** over the preceding 10 days.	5	2	619 cfs (11)
5	Feb 8-12, 1996		This event had **extremely high inflows from Issaquah Creek** and was **prolonged**, lasting about 7 days.	6	3	941 cfs (5)
6	Dec 4-6, 1975		This event had the **second highest peak inflow from Issaquah Creek** and was **prolonged**, lasting over 5 days.	2	1	n/a
7	Nov 14, 2006		This event had **moderately high inflow from Issaquah Creek**, and was **followed by several smaller events that kept lake stage at a high level** for about 3 weeks.	11	11	329 cfs (73)

It is apparent from the above discussion that inflow volume is not the sole driver for extreme lake level events (i.e., events where lake level exceeds 29 feet NGVD), or we would expect to see much closer correspondence between the highest inflow volumes and highest lake levels. The magnitude and timing of Bear Creek flows, in particular, have a demonstrated impact on lake outflows and elevations (e.g., King County, 2012a). Figure 9, below, shows a time series of lake elevations (in feet NGVD); peak flows on Bear Creek and the Sammamish River near Woodinville exceeding the respective 300 cfs and 1,500 cfs design values; and three-day mean flows on Issaquah Creek exceeding 1,000 cfs. The Issaquah Creek flows are included as a proxy for lake inflow volume, and the 1,000 cfs threshold corresponds with the approximately 2.5-year return period of the 1,500 cfs Sammamish River flow (Table 7).

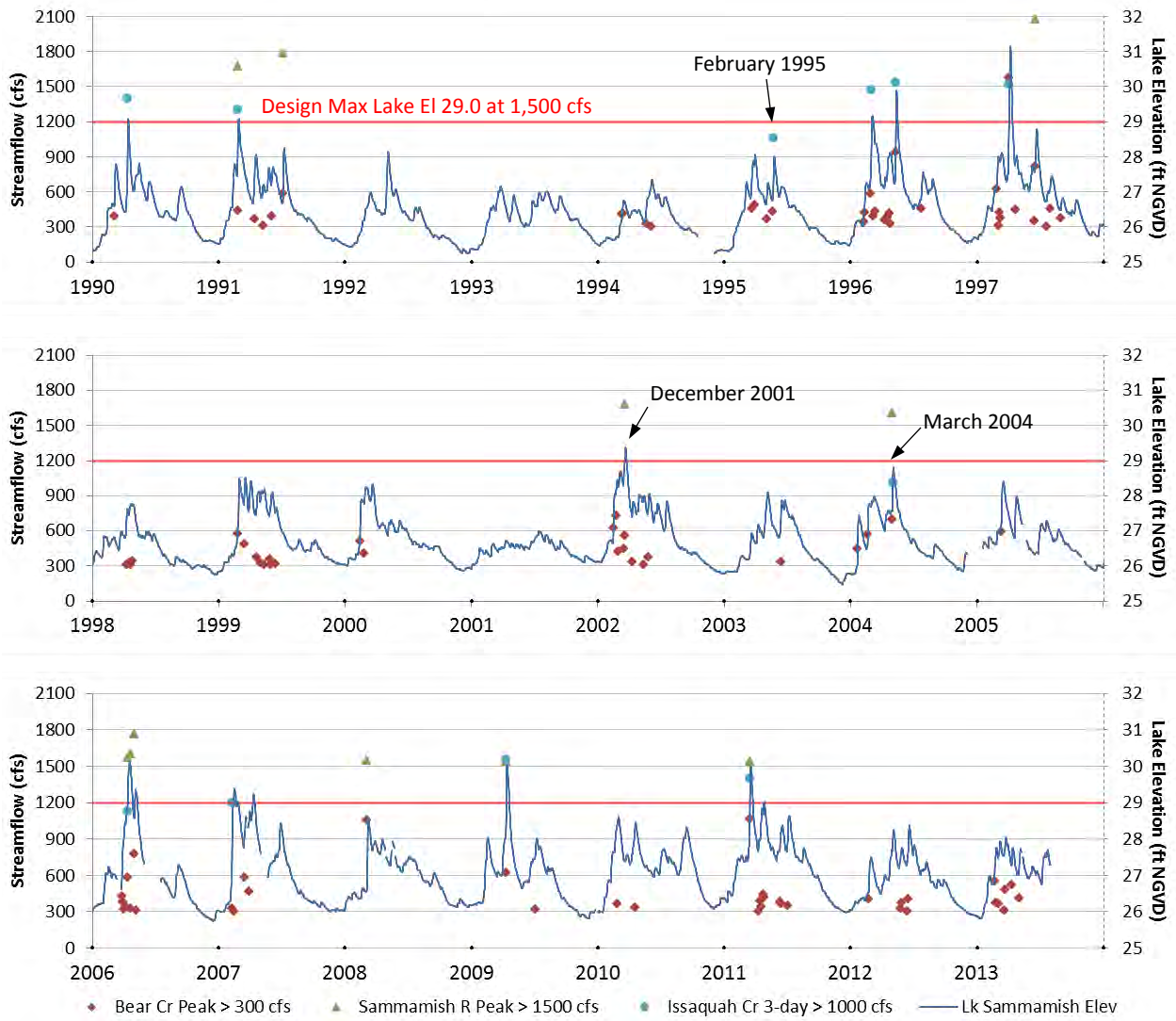


Figure 9. Time series plot of lake elevations, Bear Creek and Sammamish River peaks above design values, and maximum Issaquah Creek three-day mean flows representing inflow volume to the lake. Horizontal axis labels are water years (October through September).

We can see that inflow volume does, indeed, have the strongest correspondence with extreme lake levels—all extreme lake level events except December 2001 correspond to a high three-day Issaquah Creek flow. However, it is not as strong a predictor of relative magnitude of the peak lake level; i.e., the highest three-day Issaquah Creek flows do not correspond with the highest lake levels. This agrees with

the information presented in Table 8. Most of the extreme lake level events also coincide with high flows from Bear Creek, which is not unexpected since the same storms generally affect the Issaquah and Bear Creek basins. High Sammamish River flows occur almost exclusively in events with high Bear Creek flows and about equally with lake levels above and below 29 feet NGVD (32.6 NAVD) (though exclusively above OHW levels—between 27 and 28 feet NGVD).

As shown in Figure 9, February 1995 and January 2004 are the only high inflow events in the past 25 years that did not correspond with extreme lake levels. January 2004 also exceeded the Bear Creek and Sammamish River thresholds. Notably, both of these events followed mowing of the TZ (Table 2). Lake level also has not exceeded 29 feet NGVD since mowing in 2011—despite more than a dozen high Bear Creek flows—though there have been no high Issaquah Creek events during that period. This suggests that vegetation management in the TZ has a role in maintaining hydraulic capacity of the lake outlet to maintain lake elevations within target levels (see Figure 1).

It is notable that nearly 90 percent of the highest (at least 29 feet NGVD) post-project lake level events have occurred since 1990, while only about half of the highest Issaquah Creek events have occurred in that time, as shown in Figure 10. Since that time, we see close to a one-to-one correspondence of high Issaquah Creek events with high lake events, suggesting that there has been a change in the relationship between lake level and Issaquah Creek flow volume for large events.

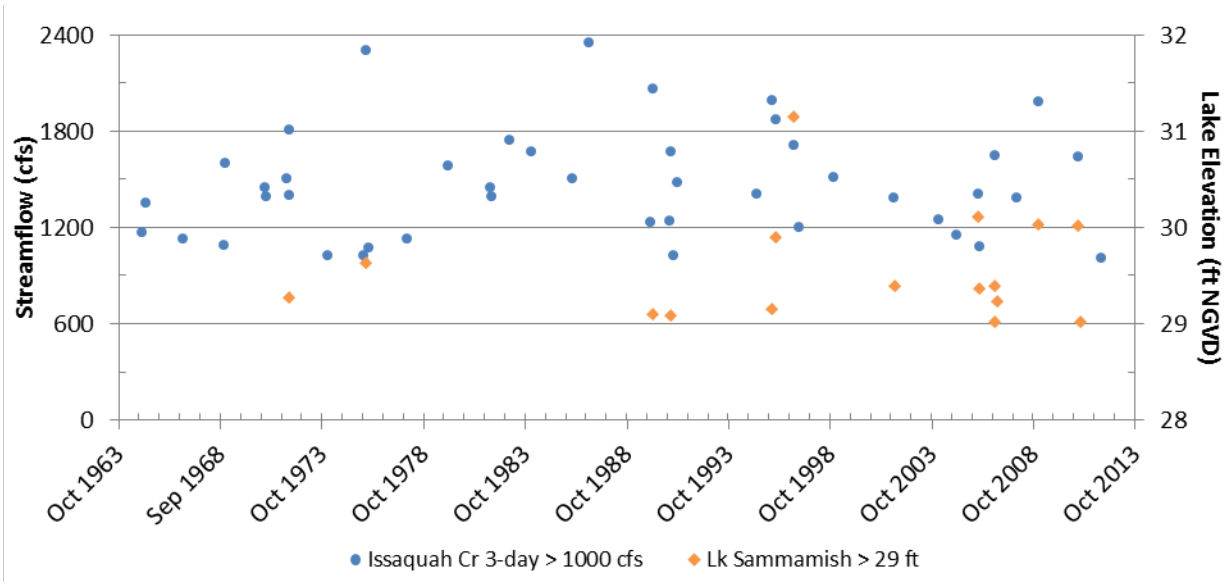


Figure 10. Comparison of high Issaquah Creek flow events and high Lake Sammamish stage events (1965-2013)

Since we don't think that potential flow increases from other tributaries are likely to have significantly affected inflow volumes in large events (requiring relatively more storage than in the past), this points to reductions in lake outlet capacity as a cause for relatively more frequent high lake levels. We have already identified several potential causes of reduced lake outflows, including weir modifications, vegetation in the TZ, and backwater from Bear Creek. Interestingly, the original annual maintenance regime for the TZ was discontinued in 1989. The Bear Creek backwater effect is discussed further in the following section.

3.3.1 Lake Elevation-Discharge

As discussed in the previous section, two of the top seven extreme lake level events (January 1-9, 1997 and December 13-19, 2010) appear to have been partly explained by a somewhat impaired stage-

discharge curve caused by high discharges from Bear Creek. This section takes a closer look at the evolution of the lake's stage-discharge relationship over time, in recent decades.

Figure 11 shows the relationship between mean daily lake discharge and mean daily lake elevation since 1988. The daily time scale is used, rather than hourly, because the daily datasets cover longer periods of record and the daily scale is sufficiently detailed for the purposes of the present analysis. Lake discharges were estimated indirectly to make discharge independent of stage at the weir to facilitate exploration of variability in stage-discharge over time. Lake discharge was estimated from daily streamflow records for the Sammamish River and Bear Creek using a relationship developed by King County (2012a, page 26):

$$Q_{Lake\ outflow} = Q_{Woodinville} - 1.2\ Q_{Bear\ Creek,\ Redmond}$$

The Sammamish River streamflow record comes from USGS gage 12125200 and from King County gage 51t, which replaced the USGS station in 2005. The Bear Creek streamflow record is that for King County 02a gage. In Figure 11, marker color is used to differentiate between sub-periods generally corresponding to the rating curve periods shown in Figure 1, as well as a pre-weir modification period.

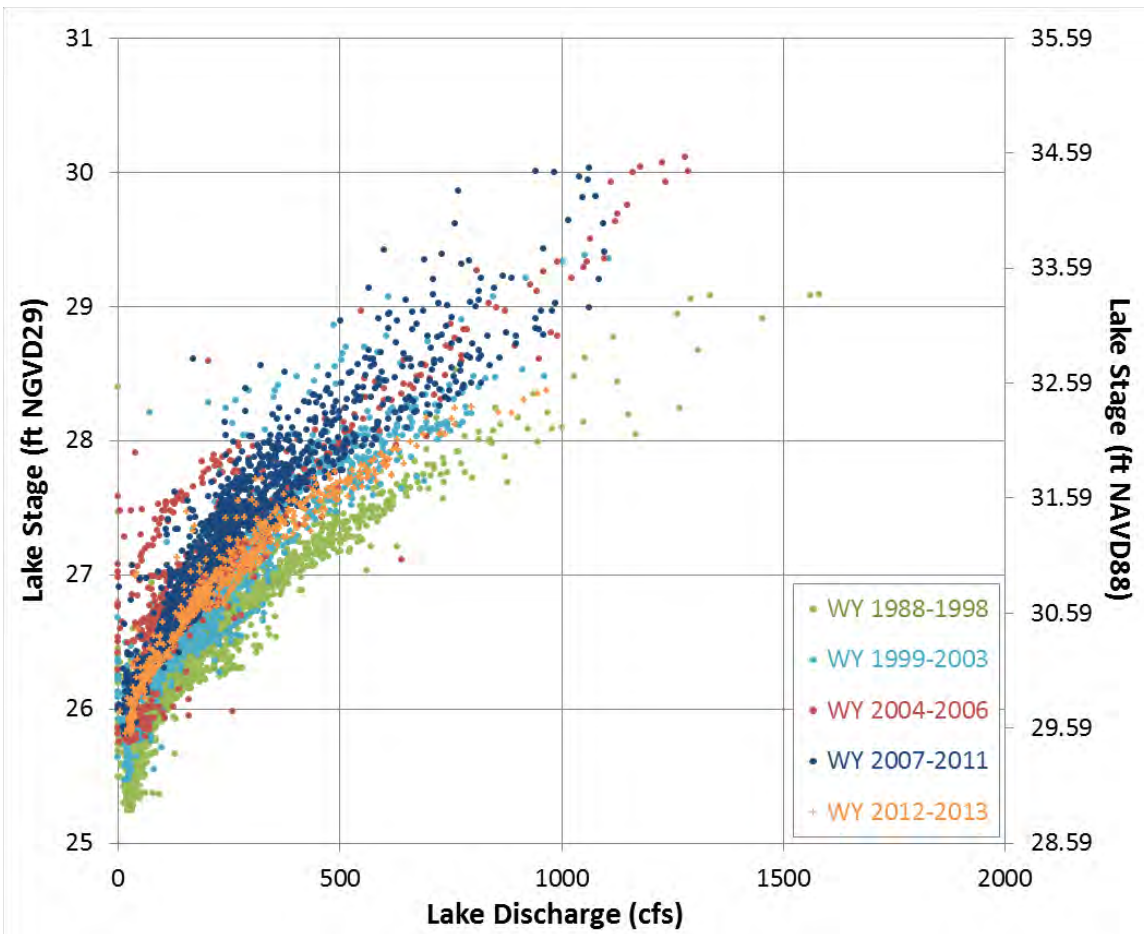


Figure 11. Relationship between lake discharge and lake elevation for five sub-periods of record. Lake discharge was estimated indirectly, on the basis of streamflow records for Sammamish River and Bear Creek.

Readily apparent from Figure 11 is the presence of multiple shifts over time in the lake elevation-discharge relationship. The plot shows a clear upward shift in elevation-discharge after 1998, meaning that the lake level associated with a particular discharge increased. The weir modifications, which included raising the weir level across most of the weir section (see Section 2.1), are consistent with such

an impact. There seems to be more scatter in the post-1998 data, but the period from 2004 to 2006 is generally the highest while the last two years are the lowest since the weir was modified. These periods correspond to, respectively, very limited TZ vegetation maintenance (2004 to 2006) and intensive annual mowing (2012 to 2013), supporting the idea that TZ vegetation has a measurable impact on lake discharges.

It is also well-recognized (e.g., King County, 2012a) that backwater effects from high Bear Creek discharge can diminish the lake's discharge capacity for a given stage, creating an impairment in the lake's weir rating curve during large events. During events with high Bear Creek flows, Bear Creek inflows raise the water surface in the channel downstream of the TZ, which in turn raises the water surface through the TZ and even back to the weir. This reduces discharge capacity over the weir (which depends on the difference in water surface elevation over the weir), and if lake inflows exceed discharge capacity, the lake continues to fill. As Bear Creek flows recede, water levels downstream of the weir decrease, increasing discharge capacity. Thus as the lake peaks and begins to subside, the discharge as lake level decreases is higher than it was on the rising limb (i.e., as lake level went up) for the equivalent lake level. This effect, referred to as a hysteresis, is illustrated in Figure 12.

It is informative to contrast lake discharge capacity during two of the largest events in the record: the event of January 1-9, 1997, during which the highest ever lake levels were recorded, and the event of February 8-12, 1996, which ranked fifth with regard to lake elevation. The daily elevation and discharge values during these two events are shown in Figure 12, showing the hysteresis loop habitually seen in large events (King County, 2012a). While the two events have the same starting and end points in Figure 12, they take disparate courses in between.

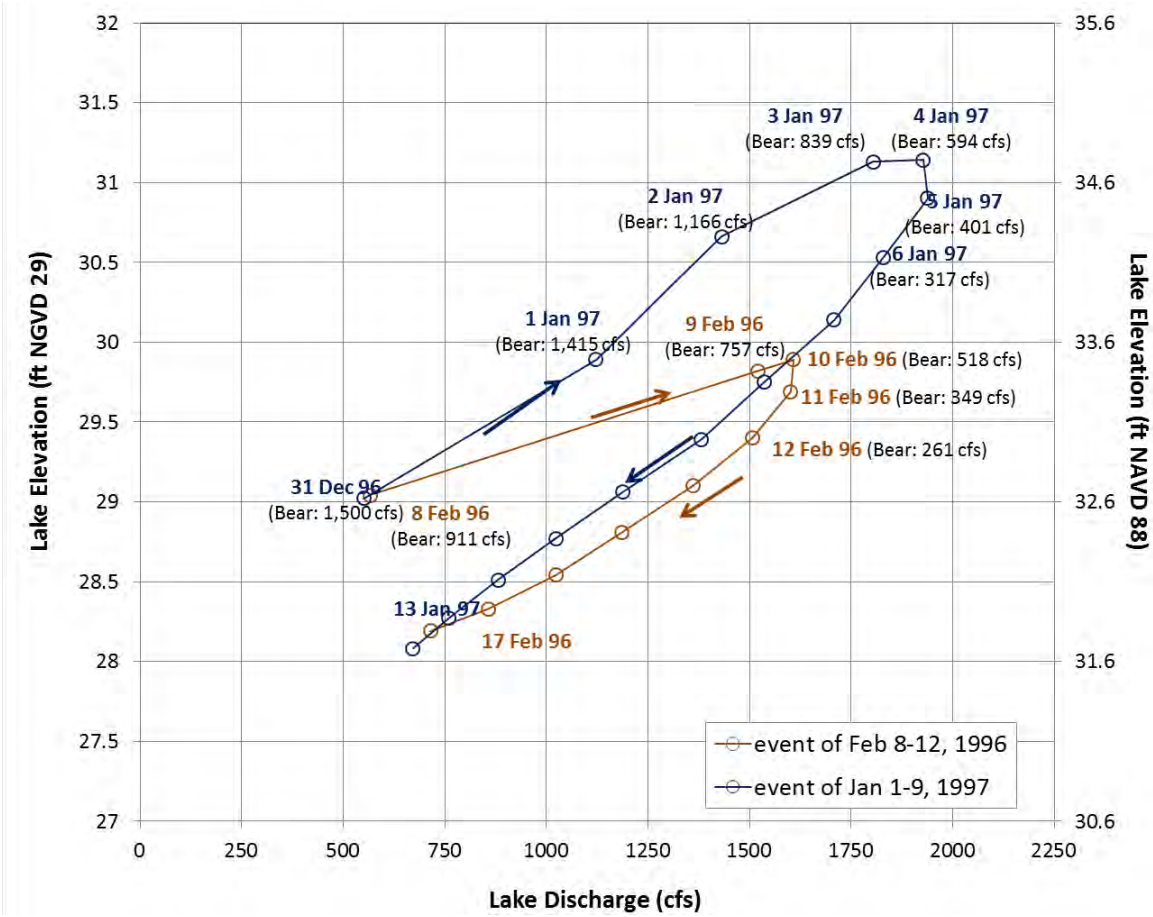


Figure 12. Elevation-discharge comparison for two extreme events. The February 1996 event achieves higher discharge for similar elevations compared to the January 1997 event.

For each date label in Figure 12, the mean daily discharge recorded at Bear Creek is also provided. The much higher Bear Creek discharge values during the January 1997 event compared to February 1996 are the likely explanation for the higher lake elevations in the 1997 event for comparable outflows. Both events occurred under similar TZ vegetation conditions and prior to the 1998 weir modification. The January 1997 event, which gave rise to the highest estimated lake discharge in the period of record, saw exceptional discharges coming from Bear Creek. Only after January 2 did the daily discharge from Bear Creek drop below the discharge from the lake itself.

3.4 Summary of Results

Data analyses conducted for this study point to significant changes in hydrologic conditions through the lake and TZ since construction of the Sammamish River flood control project in 1964. Annual peak flows on the Sammamish River downstream of Bear Creek have increased considerably. The 10-year annual flow, which the Corps equated to the 1,500 cfs design flow, is roughly 2,000 cfs based on streamflow data since 1965. Although Bear Creek flows have also likely increased somewhat, the downstream increase is probably mostly attributable to the project itself.

Inflows to Lake Sammamish, as represented by Issaquah Creek, have shown no significant increases, but late summer low flows have decreased significantly. This led to a corresponding decrease in summer lake levels until the outlet weir was modified in 1998. The weir modifications are consistent with an observed post-1998 upward shift in minimum lake levels, and there has been a coincident increase in

moderate lake levels as well. The duration of lake levels exceeding 27 feet NGVD (30.6 feet NAVD) since 1998 is about 50 percent higher than the long-term average, and statistical tests indicate that post-1998 lake levels are distinctly different from pre-1998 levels. This may account for the higher OHW level determined in a 2004 study (roughly 28 feet NGVD compared to the accepted 27 feet NGVD level). It is not clear whether impacts extend to peak lake levels.

The highest lake levels on Lake Sammamish are concentrated in the past 25 years, with nearly 90 percent occurring since 1990. Based on examination of the data, a number of factors have been identified as contributing to extreme lake levels, including:

- High or prolonged inflows to Lake Sammamish
- High antecedent lake levels (i.e. lake levels prior to a storm event)
- Vegetation condition in the TZ
- Backwater from high Bear Creek flows

Examination of discharges determined independently from the weir rating curve (direct measurements and computed estimates) clearly indicates a dynamic elevation-discharge relationship at the weir. The relationship varies both within large events, primarily due to backwater effects from high Bear Creek flows, and over periods of months to years, apparently reflecting changes in vegetation (i.e. hydraulic roughness) in the TZ.

4 Design Considerations for Future Hydrology

Past experience and current scientific evidence suggest that there is a potential for systematic hydrologic changes—notably increases in peak flows and storm volumes—over the life of the Willowmoor project due to land use and/or climate change. To assure a robust design under future conditions, the County would like to identify and account for realistic future hydrologic conditions in the design hydrology.

4.1 Land Use Change

Based on rates and type of development in the Lake Sammamish and Bear Creek basins, we know that streamflows have been affected by land use change since the original project construction. Since few of the available gage records extend back before the late 1980s, a hydrologic modeling analysis would likely be needed to estimate the extent of that change and its effects on lake levels. While it would be interesting to quantify the land use impacts to date, it is probably not particularly important to establishing design hydrologic conditions for the Willowmoor project.

In terms of land use, current conditions are likely to be critical in terms of peak flows and storm volumes. Remaining undeveloped portions of the watershed, primarily in the Issaquah and Bear/Evans Creek basins, are outside of designated urban growth areas and would not expect to see significant development over the life of the project. Furthermore, under current Washington State stormwater management standards, redevelopment and new development require flow control mitigation to essentially match forested condition flows for most significant storm events. In the case of redevelopment of existing impervious surfaces, the required mitigation would actually reduce peak flows, as well as volumes through the peak of the hydrograph. For these reasons, *significant* flow increases due to further land use change are judged to be unlikely.

4.2 Climate Change

The following sections explore the types of storms that have historically produced large events in the Sammamish watershed and how current research suggests these may change as a result of projected climate change. These results suggest how we might use such projections to develop realistic estimates of frequency and intensity of future extreme events in the Sammamish basin.

4.2.1 Atmospheric Circulation Patterns Associated with Extreme Streamflows

Atmospheric rivers (ARs) are long (greater than 2,000 km) and narrow (less than 1,000 km) plumes of water vapor in the lower troposphere (e.g., Bao et al., 2006; Ralph et al., 2004) that are associated with extreme precipitation intensity and volume. ARs are associated with many significant flooding events in western Washington (e.g., Neiman et al., 2011) and throughout the North American west coast, where they produce roughly twice as much precipitation as non-AR storms (Neiman et al., 2008). Their impact on California hydrologic extremes has been most widely studied (e.g., Dettinger, 2004; Ralph et al., 2006).

Table 9 shows the hydrographs and satellite imagery of atmospheric water vapor (vertically-integrated water vapor, or IWV) observed on the dates of the highest streamflows in the Issaquah Creek record and establishes the connection between extreme flows and landfall of ARs seen on each of the images. The event of December 3, 1975, which ranked second for daily streamflow, predates available satellite imagery. Its hydrograph is shown in Table 8. Even in the absence of imagery, it is nevertheless clear that this extreme event was very large in spatial scale, affecting vast areas of western Washington, and was particularly devastating in Snohomish County[9]. For the case of November 24, 1986, the satellite image for the preceding date is also shown in Table 9, and the magnitude of the downpour that occurred in the interim 24 hours can be judged by comparing the two images.

In their analysis of flooding in four watersheds from different western Washington locations (the Queets, Satsop, Sauk, and Green watersheds), Neiman et al (2011) noted that the Green River has the most marked inter-annual variability, with its peak annual daily streamflows varying by an order of magnitude from year to year. Issaquah Creek, the main tributary of Lake Sammamish, neighbors the Green River at slightly lower elevation, and its inter-annual variability is also marked. Neiman et al (2011) attributed this wide variability to the fact that only a small subset of ARs reach the Green River basin, namely those that enter from the narrow window between the Olympic Mountains and Mount Rainier. Given the proximity of the Lake Sammamish watershed to the Green River basin, and the former's lower altitude, it appears likely that this same phenomenon, which selects for a subset of ARs, explains the high inter-annual variability of peak annual streamflow in Issaquah Creek, Bear Creek, and the Sammamish River, and, by implication, a high inter-annual variability of peak lake levels. The images in Table 9 are all within this narrow window of AR directions.

From their analysis of the four watersheds' streamflow records, Neiman et al (2011) concluded that landfalling ARs were responsible for nearly all annual peak daily streamflows in western Washington (the exceptions being events of rapid snowmelt, a factor largely absent in the case of Issaquah Creek, given its low elevation) during the 30 water years studied (1980-2009). They found the same to be true for all peak daily flows exceeding the five-year return period.

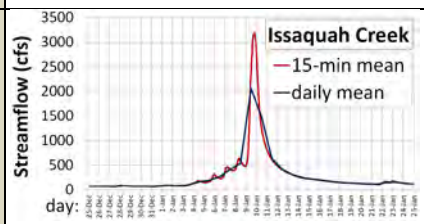
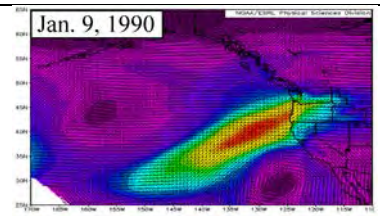
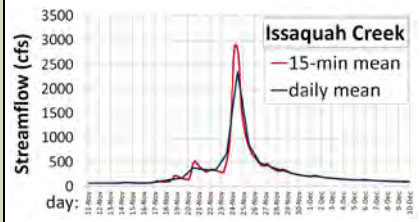
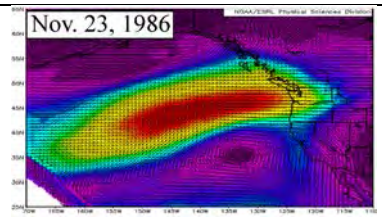
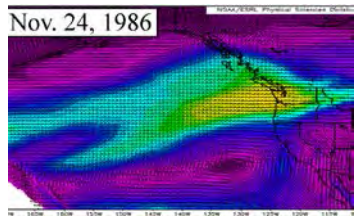
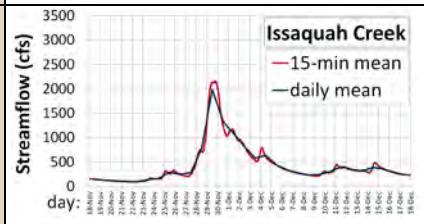
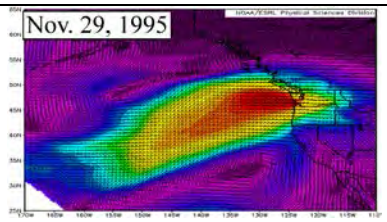
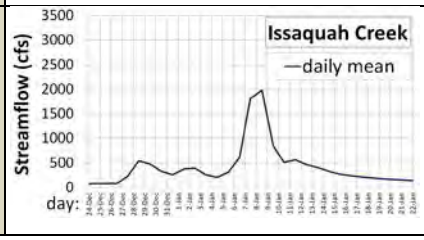
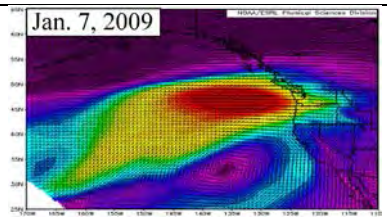
Neiman et al. (2011) concluded as follows:

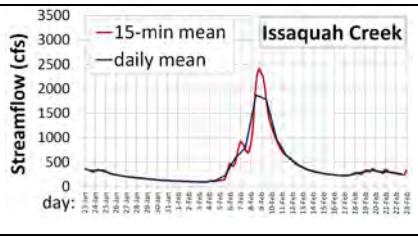
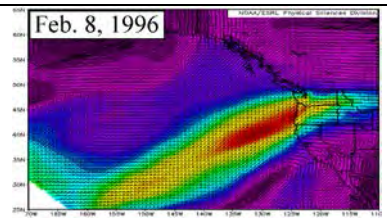
> Those ARs that produced flooding typically exhibited two or more of the following attributes:

[9] http://www.historylink.org/index.cfm?DisplayPage=output.cfm&file_id=8504

(i) the AR was optimally oriented for orographic precipitation enhancement in a given basin,
(ii) the low-level onshore water vapor fluxes into the basin were quite strong,
(iii) the AR stalled over the basin,
(iv) the melting level was especially high, and/or
(v) basin soils were already saturated prior to AR landfall.

Table 9. Hydrographs and atmospheric vapor transport for extreme events. For second ranked event (3 December 1975), which precedes satellite imagery, see Table 8. Satellite imagery from Neiman et al. (2011, suppl. mat.).

Rank	Date	Issaquah Creek Hydrograph	Atmos. Integrated Vapor Transport ($km\ s^{-1}\ m^{-1}$)
1	Jan. 9, 1990		
3	Nov. 24, 1986		 
4	Nov. 29, 1995		
5	Jan.7-8, 2009		

Rank	Date	Issaquah Creek Hydrograph	Atmos. Integrated Vapor Transport (km s^{-1} m^{-1})
6	Feb.8-9, 1996		

These results demonstrate that the largest recorded streamflow events in Issaquah Creek, the principal tributary to Lake Sammamish, have been associated with the landfall of atmospheric rivers, and are therefore explained by large-scale atmospheric circulation patterns over the Northern Pacific Ocean, as they interact with the regional and local topography.

4.2.2 Future Projections and Suggested Approach

The location of the North Pacific low-pressure center known as the Aleutian Low, which fluctuates from year to year, has been shown to determine the path of the storm track (e.g., Hartmann and Wendler, 2005). Simulations by several global climate models (GCMs) are capable of adequately reproducing the North Pacific storm track that brings ARs and intense storms to western Washington and elsewhere on North America's Pacific coast (e.g., Yin, 2005). GCM simulations for future periods show that associated with global warming is an increase in the frequency with which the Aleutian Low takes more northerly positions and an intensification of its low pressure strength (Yin, 2005; Kushner et al., 2001). As a result, the North Pacific storm track moves northward, favoring more frequent and intense storms in the Pacific Northwest. Downscaled GCM results indicate that precipitation in western Washington will be more intense not only due to the increased frequency of large-scale storms entering the coast, but also due to changes in the intensity of these storms as they interact with the region's topography, phenomena that are simulated by regional climate models and statistical downscaling (Salathé, 2006). Some of these and other published results were reviewed in the King County (2010) document.

For purposes of project design, the future hydrology should reflect a realistic representation of the increased frequency and intensity of these AR events that cause extreme streamflows in the Sammamish River basin. The frequency with which ARs (including those approaching from directions effective at producing high streamflows in the Lake Sammamish watershed) are projected to make landfall in this region can be directly derived from multiple GCM results, without prior downscaling. Alternatively, Dulière et al (2011) showed that fine-resolution regional climate model (RCM) simulations (12-km grid spacing), used to downscale from GCM projections, are capable of adequately representing precipitation extremes. The availability of simulations of future climate downscaled to such fine scale is very limited, however (see Salathé et al., 2010), so direct analysis of GCM results is the preferred approach.

At the scale of the Sammamish River basin, even RCM simulations are unlikely to reliably represent precipitation intensities. Given the projected intensification of ARs, and the prospect of extreme high-intensity and long-lasting precipitation that can result from an AR moving slowly or stalling over a region (see e.g., Ralph et al., 2011), we can expect that runoff generated in extreme events is likely to increase. As a fairly simple way to represent this effect, large events from the historical record could be concatenated to represent a particularly severe storm with quite realistic possibility of occurring. This

approach is similar to the one suggested as the basis for an emergency preparedness scenario for California, by Dettinger et al. (2012).

Precipitation records used as input to the hydrologic models can be modified, replacing the largest historical storm events with the composite storms. The number of composite storms in the precipitation record would be based on the estimated frequency of AR events (compared to the historic record) to produce what we estimate to be a realistic frequency distribution of more typical and severe storms. The resulting composite climatology can then be used to drive our hydrologic and hydraulic models to evaluate streamflows and lake elevations for project alternatives under potential future conditions.

5 Conclusions and Recommendations

One of the key findings of this study is the confirmation of the impact of the TZ and Bear Creek on peak lake levels. Reduced lake outflows can be clearly linked to vegetation conditions in the TZ and high outflow from Bear Creek, and appear to have contributed to some of the highest observed lake levels. Both of these factors have been previously recognized but need to be explicitly and collectively considered in design of modifications to the TZ.

This study also demonstrated significant changes in low to moderate lake levels, up to at least the OHW level. Exceedances and durations above the 27- to 28-foot NGVD levels (30.6 feet to 31.6 feet NAVD) have increased significantly in the past 15 years compared to prior levels, and it seems likely that these changes result from the weir modifications in 1998. Statistical analyses indicate that increasing occurrences of high lake levels are not accompanied by corresponding inflow or precipitation trends (which would suggest a climatic origin).

Based on the review and analyses conducted in this work and other recent studies (e.g. King County, 2012a), we conclude that several of the hydrologic assumptions used by the Corps of Engineers for the design of the Sammamish River Flood Control project in the mid-1960s are outdated. Using updated records and analysis, the 1,500 cfs project design flow is now substantially less than the 40-year spring flow/10-year annual flow to which it was equated in the design documents. Even with higher flows, the project continues to meet its primary objective of eliminating spring flooding while keeping lake levels below 29 feet NGVD (32.6 feet NAVD). The Willowmoor project design should also consider whether spring flooding remains the most critical flood protection scenario, with development of much of the downstream agricultural area.

Recommended next steps for determining design hydrology for the Willowmoor project include:

1. Definition of goals and constraints. These include determination of desired level of downstream flood protection, target lake level(s) and exceedance frequencies, and potential seasonal target flows and duration (e.g. to meet fish and recreation needs), as well as definition of a realistic vegetation management scenario or scenarios. It may be useful to consider minimum project targets (i.e. equivalent to existing) and “optimal” project targets (e.g. enhanced lake level protection).
2. HSPF model updates. This would include updating the Issaquah Creek, Bear/Evans Creek, Lake Sammamish tributaries, and Sammamish River models to current land use[10] (if necessary) and recalibrating the Issaquah Creek and Bear/Evans Creek models to available gage data. General calibration adjustments common to both models would also be applied to the uncalibrated

[10] Snohomish County models (Swamp, North, and Little Bear Creeks) have been more recently updated and calibrated than King County models and are less critical to analysis of the TZ.

models, as appropriate.

3. HEC-RAS model refinement focusing on the reach between Bear Creek and Lake Sammamish. This would include a period-of-record simulation using the existing HEC-RAS model with updated hydrologic inputs and comparison to appropriate observed data. Calibration of TZ vegetation conditions for the top lake level events could also be included.
4. Future conditions analysis. This could include climate analysis and development of future conditions precipitation records (as discussed in Section 4.2) and HSPF simulations (for all tributary models) with the modified precipitation inputs. Flow outputs would then be used as input for a period-of record HEC-RAS simulation to determine downstream (Lake Sammamish and Sammamish River) conditions under future hydrology. In lieu of this detailed analysis, a targeted sensitivity analysis could be used to encompass a range of uncertainties.
5. Selection of design events. Design events appropriate to the project targets would be selected from both the existing and future conditions modeling. Because of the time-varying influence of Bear Creek on the lake outlet, unsteady hydraulic model simulations will be important for project design. Thoughtful selection of design events and initial conditions from the continuous hydrologic modeling should obviate the need for extended hydraulic simulations to evaluate design concepts, however.

Going forward, it seems likely that revised design hydrology and flood protection objectives can be developed that will maintain at least an equivalent level of protection to the project's original objectives while reflecting changes in flood management priorities and project maintenance constraints and incorporating evolving management goals, such as habitat enhancement, recreational use, and lake level regulation.

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Appendix A – Trend Analysis Results

1 Homogeneity tests for lake stage time series

Here we apply three classical homogeneity tests to each of the following annual time series:

- The **minimum** daily value in each water year
- The **10th percentile** of daily values in each water year
- The **25th percentile** of daily values in each water year
- The **50th percentile** (median) of daily values in each water year
- The **mean** of the daily values in each water year
- The **90th percentile** of daily values in each water year
- The **maximum** daily value in each water year

1.1 Standard Normal Homogeneity Test

This test was introduced by Alexandersson (1986).

Consider n years i and the corresponding annual values y_i. The mean and standard deviation of the n annual values y_i are $\bar{y}$ and s, respectively.

We compare the means of the normalized values for the first k years with those of the rest of the years, from k+1 to n. We do this multiple times, for all values of k, from k =1 through k =n-1.

The mean of the normalized values in the set of the first k years, and in the set of the remainder n -1 years is

$$\bar{z}_1 = \frac{1}{k} \cdot \sum_{i=1}^{k} \frac{(y_i - \bar{y})}{s} \quad and \quad \bar{z}_2 = \frac{1}{n-k} \cdot \sum_{i=k+1}^{n} \frac{(y_i - \bar{y})}{s} \qquad , k = 1, \dots, n-1 \qquad \textbf{Eq. 1}$$

The test statistic is $T(k)$, defined as

$$T(k) = k \cdot \bar{z}_1^2 + (n-k) \cdot \bar{z}_2^2 \qquad , k = 1, \dots, n-1 \qquad \textbf{Eq. 2}$$

The maximum value of $T(k)$ over all k is T_0:

$$T_0 = max_{1 \le k \le n-1} T(k)$$

Eq. 3

The series is inhomogeneous at year k if T_0 is above a critical value, which depends on sample size. Table A-1 reproduced from Khaliq and Ouarda (2007), provide critical values.

Table A-1. Critical values for statistic T_0, from Khaliq and Ouarda (2007).

Table I. Critical values of the SNHT statistic T for various sample sizes and corresponding to six selected critical levels.

Sample size	Critical level (%)						Sample size	Critical level (%)					
	90	92	94	95	97.5	99		90	92	94	95	97.5	99
10	4.964	5.197	5.473	5.637	6.188	6.769	145	8.063	8.529	9.120	9.490	10.877	12.660
12	5.288	5.554	5.876	6.068	6.729	7.459	150	8.086	8.554	9.147	9.519	10.906	12.694
14	5.540	5.831	6.187	6.402	7.152	8.001	155	8.111	8.578	9.172	9.543	10.933	12.725
16	5.749	6.059	6.441	6.674	7.492	8.440	160	8.133	8.601	9.195	9.569	10.966	12.759
18	5.922	6.248	6.652	6.899	7.775	8.807	165	8.155	8.625	9.222	9.596	10.992	12.793
20	6.070	6.410	6.830	7.089	8.013	9.113	170	8.174	8.643	9.241	9.615	11.016	12.820
22	6.200	6.551	6.988	7.257	8.220	9.380	175	8.195	8.666	9.265	9.641	11.046	12.851
24	6.315	6.675	7.123	7.400	8.400	9.609	180	8.214	8.685	9.283	9.658	11.062	12.872
26	6.417	6.785	7.246	7.529	8.558	9.812	185	8.233	8.706	9.307	9.683	11.089	12.904
28	6.509	6.884	7.353	7.643	8.697	9.993	190	8.252	8.725	9.325	9.701	11.110	12.930
30	6.592	6.973	7.451	7.747	8.825	10.153	195	8.268	8.741	9.343	9.720	11.132	12.956
32	6.669	7.056	7.541	7.841	8.941	10.300	200	8.286	8.761	9.364	9.741	11.156	12.982
34	6.741	7.132	7.625	7.930	9.050	10.434	225	8.361	8.838	9.446	9.826	11.247	13.083
36	6.803	7.201	7.699	8.009	9.143	10.552	250	8.429	8.908	9.516	9.898	11.329	13.175
38	6.864	7.263	7.768	8.081	9.230	10.663	275	8.489	8.970	9.581	9.966	11.399	13.248
40	6.921	7.324	7.835	8.151	9.317	10.771	300	8.540	9.022	9.635	10.020	11.460	13.326
42	6.972	7.380	7.894	8.214	9.390	10.865	325	8.587	9.070	9.685	10.071	11.517	13.389
44	7.022	7.433	7.951	8.273	9.463	10.957	350	8.633	9.117	9.732	10.118	11.565	13.440
46	7.071	7.484	8.007	8.331	9.530	11.040	375	8.670	9.157	9.775	10.161	11.613	13.494
48	7.112	7.529	8.054	8.382	9.592	11.116	400	8.706	9.193	9.814	10.202	11.654	13.542
50	7.154	7.573	8.103	8.432	9.653	11.193	425	8.738	9.224	9.844	10.234	11.692	13.580
52	7.194	7.616	8.149	8.480	9.711	11.259	450	8.771	9.260	9.882	10.272	11.730	13.623
54	7.229	7.654	8.190	8.524	9.760	11.324	475	8.798	9.288	9.912	10.302	11.761	13.655
56	7.264	7.690	8.230	8.566	9.810	11.382	500	8.828	9.317	9.939	10.330	11.795	13.690
58	7.299	7.727	8.268	8.606	9.859	11.446	525	8.854	9.344	9.967	10.360	11.827	13.730
60	7.333	7.764	8.308	8.647	9.906	11.498	550	8.878	9.369	9.995	10.386	11.854	13.751
62	7.363	7.796	8.343	8.683	9.947	11.548	575	8.901	9.391	10.016	10.408	11.878	13.782
64	7.392	7.827	8.375	8.717	9.985	11.599	600	8.923	9.414	10.040	10.431	11.904	13.813
66	7.421	7.857	8.408	8.752	10.026	11.648	650	8.963	9.455	10.083	10.476	11.949	13.856
68	7.449	7.886	8.439	8.784	10.067	11.692	700	9.001	9.493	10.119	10.511	11.986	13.904
70	7.475	7.913	8.467	8.814	10.099	11.737	750	9.033	9.524	10.152	10.547	12.026	13.947
72	7.499	7.938	8.496	8.844	10.134	11.776	800	9.063	9.557	10.187	10.580	12.059	13.975
74	7.525	7.965	8.523	8.873	10.171	11.822	850	9.093	9.587	10.216	10.612	12.096	14.023
76	7.547	7.989	8.548	8.898	10.200	11.858	900	9.119	9.614	10.244	10.640	12.120	14.041
78	7.570	8.013	8.575	8.926	10.230	11.895	950	9.143	9.638	10.269	10.665	12.149	14.070
80	7.591	8.035	8.599	8.951	10.259	11.928	1000	9.168	9.664	10.295	10.692	12.176	14.105
82	7.613	8.059	8.623	8.976	10.290	11.966	1100	9.211	9.708	10.339	10.736	12.220	14.150
84	7.634	8.079	8.647	9.001	10.315	11.995	1200	9.246	9.745	10.377	10.775	12.263	14.197
86	7.655	8.102	8.670	9.026	10.347	12.033	1300	9.283	9.781	10.415	10.812	12.304	14.235
88	7.673	8.121	8.691	9.047	10.370	12.059	1400	9.313	9.812	10.446	10.845	12.340	14.271
90	7.692	8.140	8.710	9.067	10.394	12.089	1500	9.347	9.846	10.481	10.880	12.374	14.312
92	7.711	8.160	8.732	9.090	10.417	12.120	1600	9.372	9.871	10.506	10.904	12.396	14.339
94	7.730	8.181	8.752	9.110	10.447	12.153	2000	9.464	9.965	10.603	11.002	12.500	14.443
96	7.745	8.196	8.770	9.127	10.465	12.175	2500	9.551	10.052	10.690	11.089	12.591	14.540
98	7.762	8.214	8.788	9.147	10.484	12.196	3000	9.618	10.121	10.760	11.161	12.664	14.619
100	7.778	8.231	8.807	9.167	10.507	12.228	3500	9.675	10.178	10.818	11.219	12.727	14.683
105	7.819	8.273	8.851	9.214	10.562	12.291	4000	9.727	10.229	10.869	11.271	12.779	14.734
110	7.856	8.312	8.892	9.255	10.608	12.343	4500	9.766	10.269	10.911	11.313	12.820	14.777
115	7.891	8.350	8.931	9.296	10.656	12.401	5000	9.803	10.307	10.948	11.349	12.859	14.817
120	7.921	8.380	8.963	9.330	10.694	12.446	7500	9.938	10.442	11.085	11.487	12.997	14.959
125	7.952	8.413	8.999	9.365	10.735	12.488	10 000	10.031	10.537	11.180	11.584	13.095	15.063
130	7.983	8.446	9.032	9.400	10.772	12.538	15 000	10.152	10.658	11.302	11.707	13.221	15.186
135	8.010	8.474	9.063	9.431	10.808	12.579	20 000	10.236	10.743	11.388	11.791	13.305	15.271
140	8.038	8.501	9.092	9.462	10.845	12.621	50 000	10.480	10.988	11.634	12.039	13.556	15.523

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Results

Our sample size (water years 1965-2012) is n=48. The values in Table A-1 are 7.112 and 8.382 for test significance of 10% (90% confidence level) and 5% (95% confidence level), respectively. We therefore conclude on the basis of this test, at the 90% certainty level, that all of these time series are inhomogeneous, excepting the minimum and maximum time series. The most likely break point is centered roughly about 1995 in most cases, and 1996 in the case of the 10th percentile series.

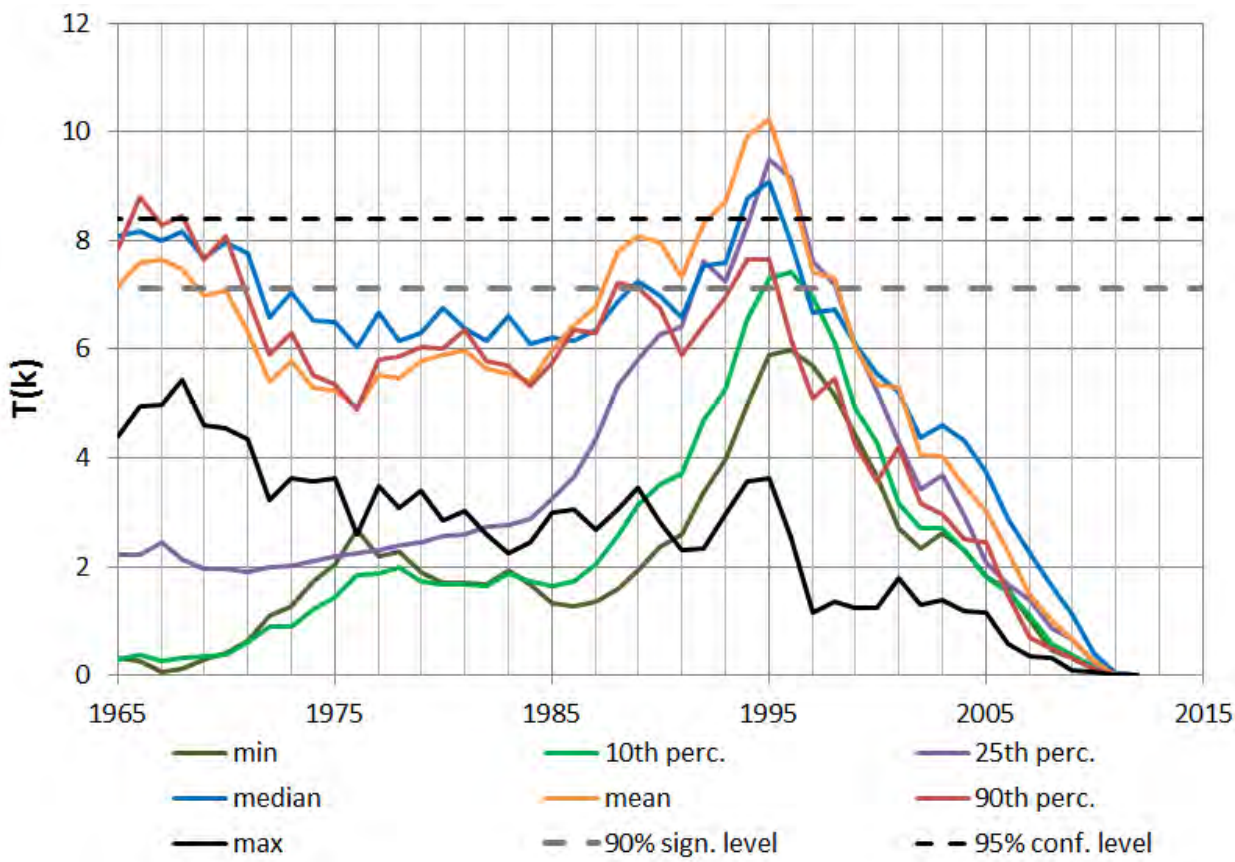


Figure A-1. Values of the T_0 statistic for the Standard Normal Homogeneity Test

1.2 Buishand Range Test

This test was introduced by Buishand (1982).

Consider n years i and the corresponding annual values y_i. The mean and standard deviation of the n annual values y_i are $\bar{y}$ and s, respectively. The adjusted partial sum over the series formed by the first k years, S_k* is

$$\boldsymbol{S_k^* = \sum_{i=1}^{k}(y_i - \bar{y}) \quad , \quad k = 1, \dots, n-1} \qquad \textbf{Eq. 4}$$

The range covered by Sk* over all k, divided by the standard deviation of the complete series of n years (s) is designated the rescaled adjusted range, R.

$$\boldsymbol{R = \frac{1}{s} \cdot (\max_{1 \le k \le n-1} S_k^* - \min_{1 \le k \le n-1} S_k^*)} \qquad \textbf{Eq. 5}$$

The test statistic is given by T_0:

$$T_0 = \frac{R}{\sqrt{n}} \qquad \textbf{Eq. 6}$$

The series is inhomogeneous at year k if T_0 is above a critical value, which depends on sample size, according to Table A-2 (reproduced from Winjgaard *et al.*, 2003).

Table A-2. Critical values of statistic T_0 for sample size n and two statistical significance levels.

n	20	30	40	50	70	100
1%	1.60	1.70	1.74	1.78	1.81	1.86
5%	1.43	1.50	1.53	1.55	1.59	1.62

Results

The values in Table A-2 follow an approximately linear relationship between n=40 and n=70, and we used linear interpolation between n=40 and n=50 to obtain for n=48 the value 1.55 for the 5% significance level and 1.77 for the 1% significance level. Values of test statistic T_0 are shown in Figure A-2 for all values of k (indicated by the corresponding year). The most likely break point is centered around 1997 or 1996, depending on the series.

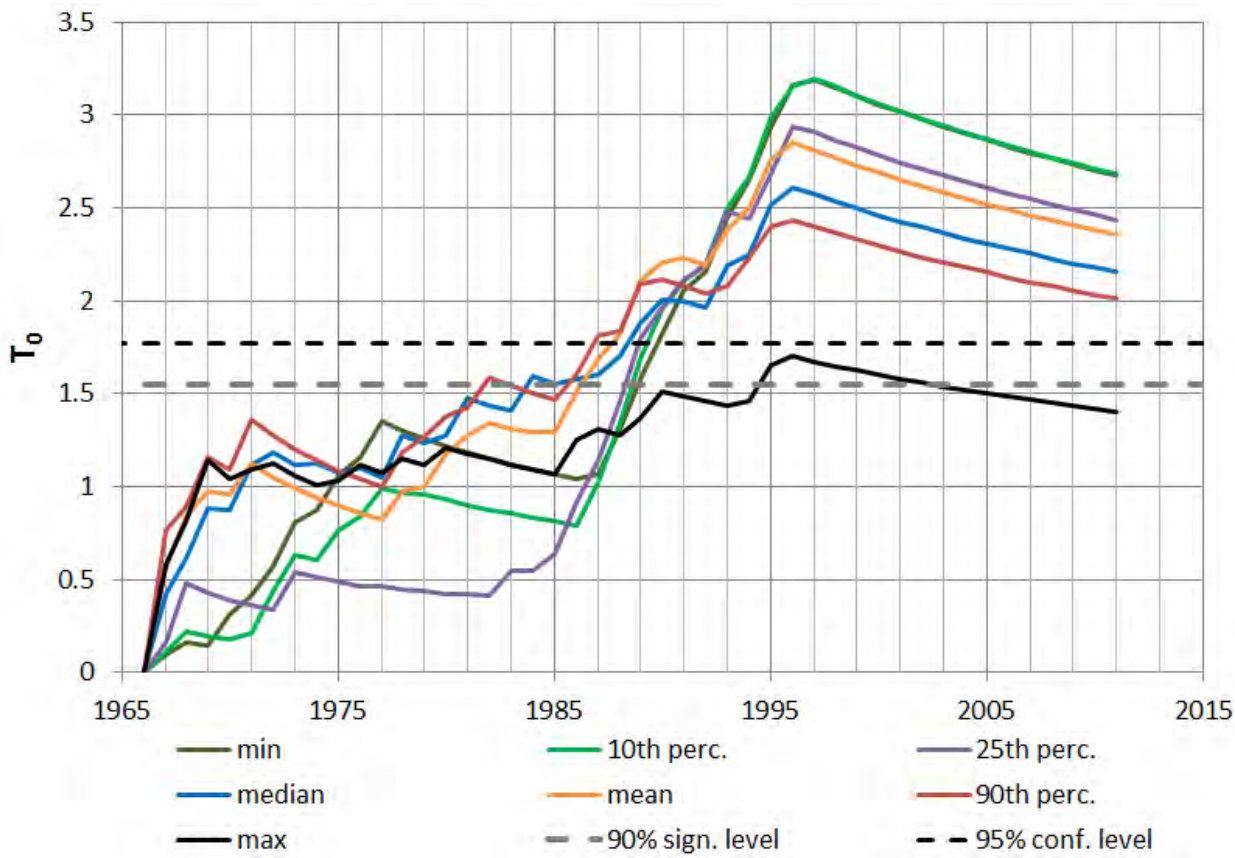


Figure A-2. Values of test statistic T_0 for our time series.

1.3 Pettitt Rank Test

This test was introduced by Pettitt (1979).

This is a non-parametric rank test. The annual values $y_i, \ldots, y_n$ and their respective ranks $r_i, \ldots, r_n$ are used to calculate the statistics X_k:

$$X_k = 2 \cdot \sum_{i=1}^{k} r_i - k \cdot (n+1) \quad , \quad k = 1, \dots, n-1 \qquad \textbf{Eq. 7}$$

The test statistic X_E is defined as

$$X_E = \max_{1 \le k \le n-1} |X_k| \qquad \textbf{Eq. 8}$$

The series is inhomogeneous at year k if X_E is above a critical value, which depends on sample size, according to Table A-3 (reproduced from Winjgaard *et al.*, 2003).

Table A-3. Critical values of statistic X_E for sample size n and two statistical significance levels.

n	20	30	40	50	70	100
1%	71	133	208	293	488	841
5%	57	107	167	235	393	677

Results

The values in Table 3 follow an approximately linear relationship between n=40 and n=70, and we used linear interpolation between n=40 and n=50 to obtain the values 221.4 and 276 for the 5% and 1% confidence levels, respectively. Values of test statistic $X(k)$ are shown in Figure A-3 for all values of k (indicated by the corresponding year), for each of our series. On the basis of this test, the most likely breakpoint is centered about 1995.

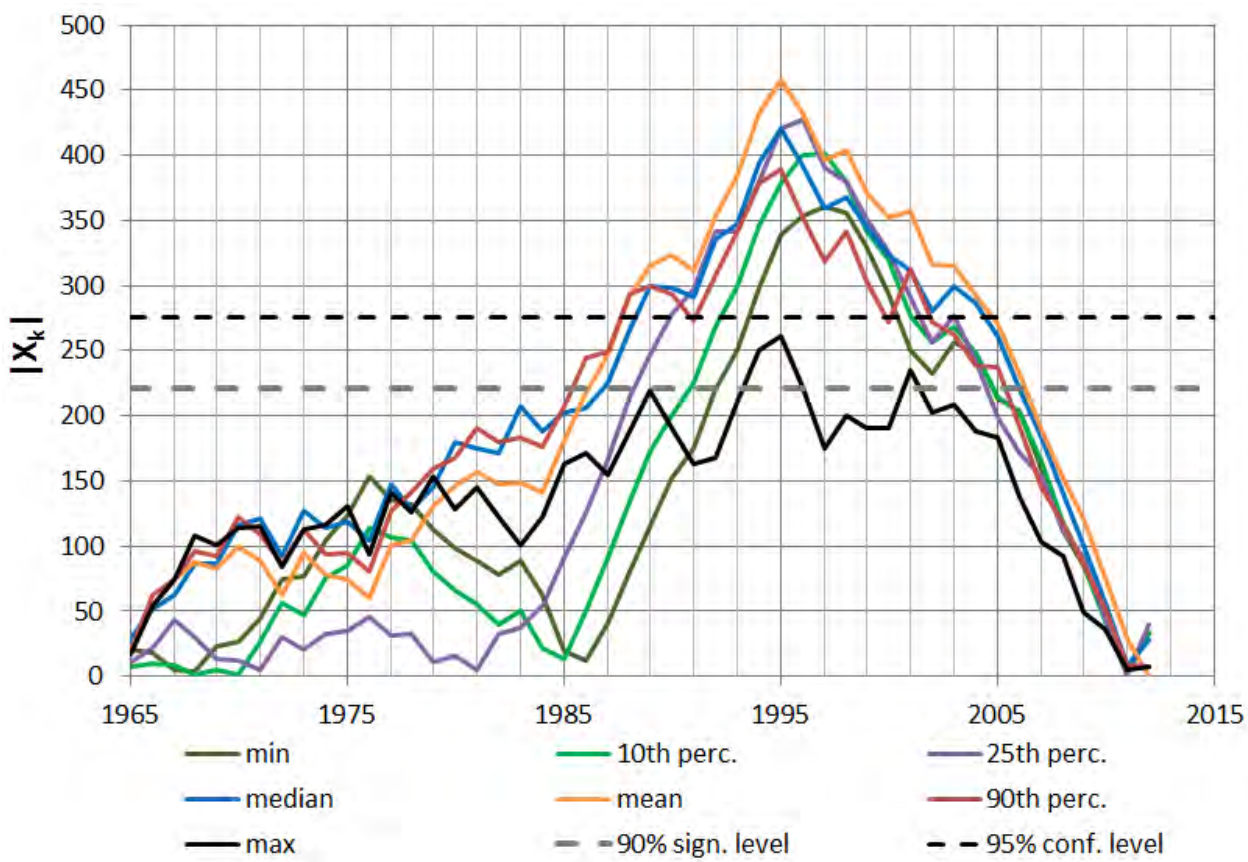


Figure A-3. Values of test statistic $|X_k|$ for our time series.

1.4 Effect of Shifting Water Years 1996-1997

We suspect that test statistics peak prior to modifications to the Lake Sammamish outlet weir in 1998 because of the presence of two prior wet years (water years 1996 and 1997) immediately preceding the weir modifications that appear to have generally increased lake levels. Here we apply the same homogeneity tests with water years 1996-1997 relocated in the lake level record to 1980-1981. The sequence of 1980-1995 was shifted forward two years, so the same data are still present but water years reordered. Results of the tests on the modified time series are shown in Figures A-4 through A-6. As expected, the most likely breakpoint shifts to 1997/1998, though significance of the results is affected in some cases.

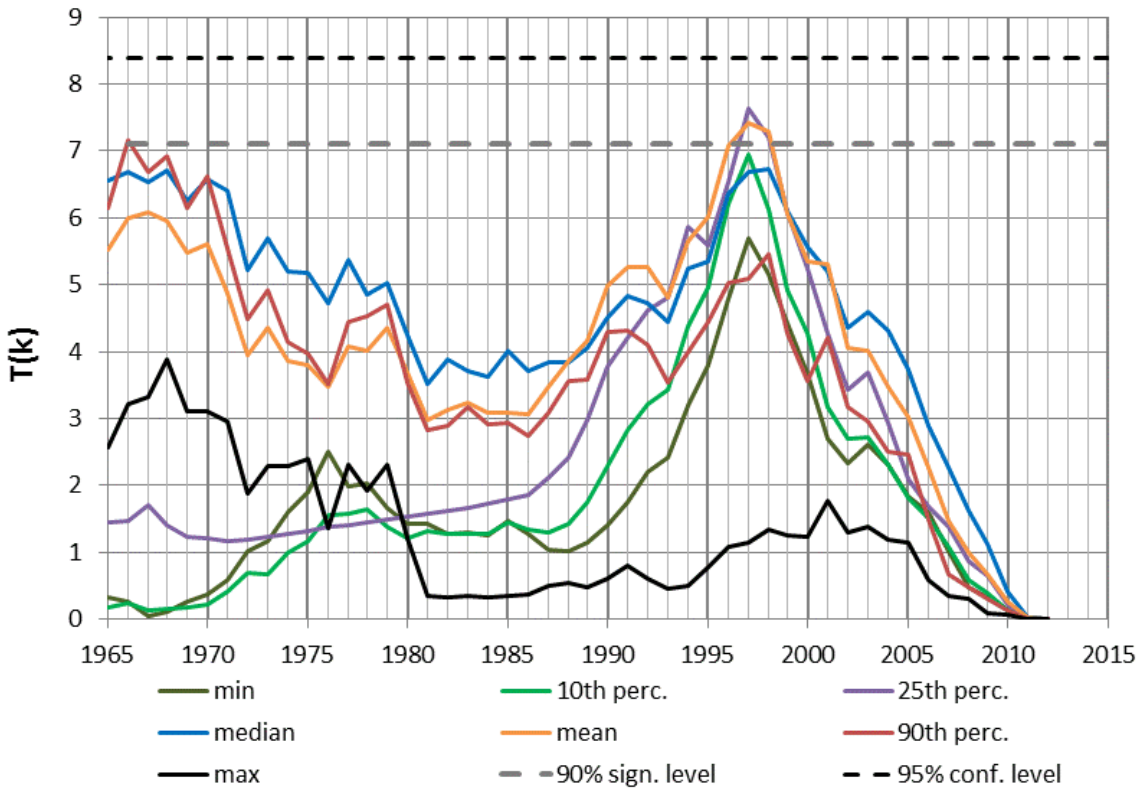


Figure A-4. Values of the Standard Normal test statistic for modified time series.

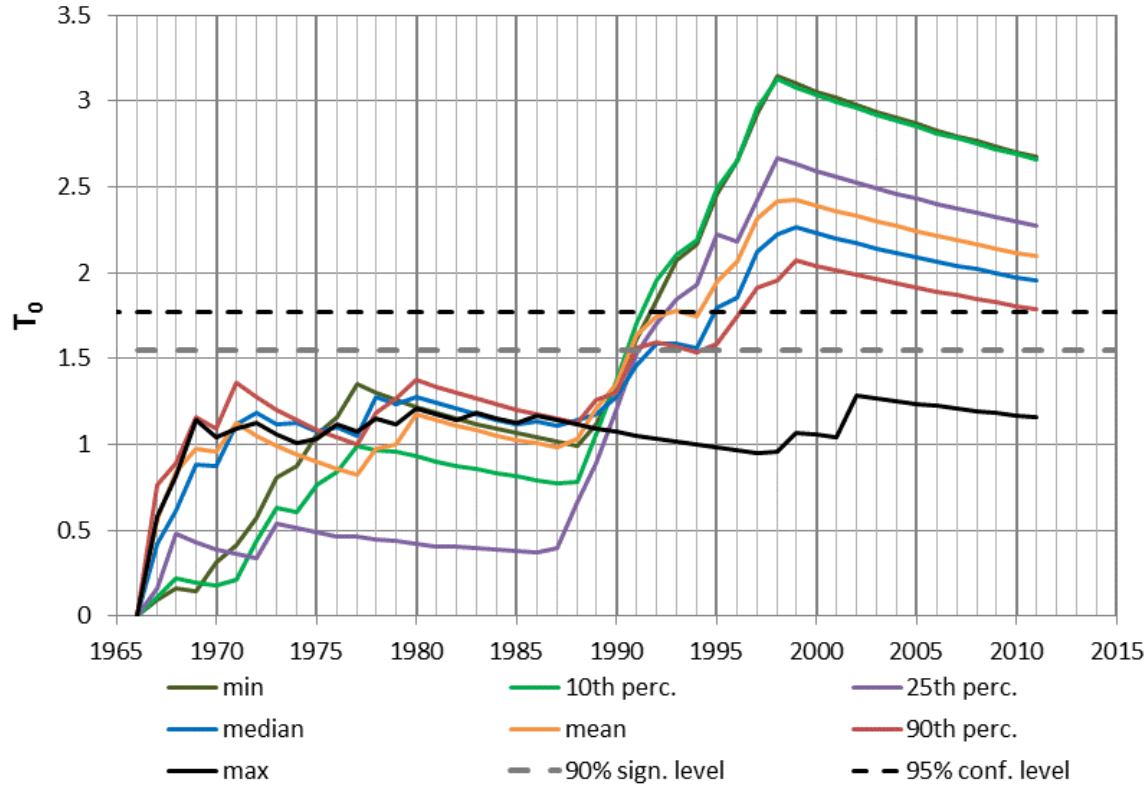


Figure A-5. Values of the Buishland Range test statistic for modified time series.

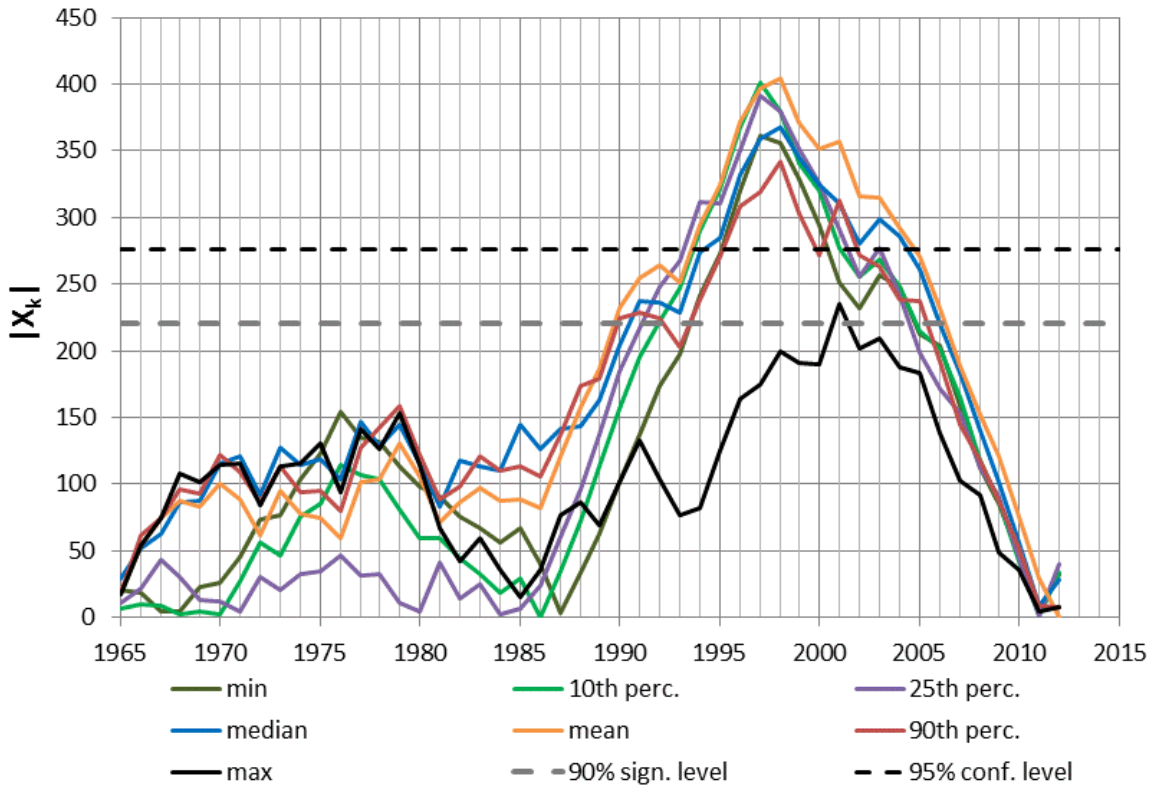


Figure A-6. Values of the Pettitt Rank test statistic for modified time series.

2 Study of trends in the period 1965-1997

In 1998, a notch was introduced to the weir to enhance low flows and facilitate fish access to the lake. These changes modified the lake's discharge rating curve, representing a discontinuity in the time series of lake stage.

It was shown in Figure 10 that the lake's rating curve was subject to numerous changes in the period from 1988 to present; and Figure 1, prepared by King County, documents this phenomenon from 2001 to present. Hence, the time series of lake stage, even prior to 1998's weir modifications, cannot be considered statistically homogenous.

Here, we investigate whether any specific monotonic trends can be detected as statistically significant, in the pre-1998 time series of daily lake stage data. We perform the following tests for trends:

a) An analysis of trends in the frequency of high lake levels, performed by counting the number of days where stage exceeded fixed threshold values.
b) An analysis of trends in the minimum, mean and maximum, and in specific annual quantiles of daily stage values.

The results of these tests, which are summarized below, are highly significant declining trends in the low end of the daily stage values, i.e., the annual minimum, the 10th percentile and the 25th percentile. But no trends were detected in the median (50th percentile) or higher quantiles, or the maxima.

The rate of linear decline in the minimum annual value of daily stage, estimated from the Sen slope, is 0.016 ft per year, or over half a foot (0.528 ft) in the 33 years of this record. The rate of decline in the 10th percentile of the distribution of daily stages is 0.014 ft per year, or 0.462 ft in the 33 years. The rate of decline in the 25th percentile is 0.011 ft per year, or 0.363 ft in the 33 years.

Searching for an explanation for the declining trends in low lake elevations, we also studied the trends in monthly streamflows in Issaquah Creek, the largest tributary to the lake, and the only tributary for which streamflow records are available for this period. We find declining monthly flows for August and September, the two lowest flow months of the year, for 1965-1997. We also find declining monthly flows for December and January for this period. When the entire period of record for Issaquah Creek streamflows (1964-2012) is considered, the detected trends acquire increased statistical significance, and a trend is detected for February as well.

The strong and highly statistically significant declining trend in the mean inflows in the driest months, August and September, is a likely explanation for the observed pre-1997 declining trend in lake stage.

2.1 Trends in the frequency of high lake stage

Figure A-7 shows the annual counts of lake stage greater than specified high thresholds. No linear trends are immediately apparent, and to be sure, we show in Figure A-8 the results of the Mann-Kendall test for trends on each of these series (except for the highest threshold, 29 ft NGVD, for which the number of observed exceedances was too small). For each threshold in Figure A-8, we cannot reject at the 90% confidence level that the Sen slope is different from zero. Hence, no significant trends in lake level exceedances are detected for this period.

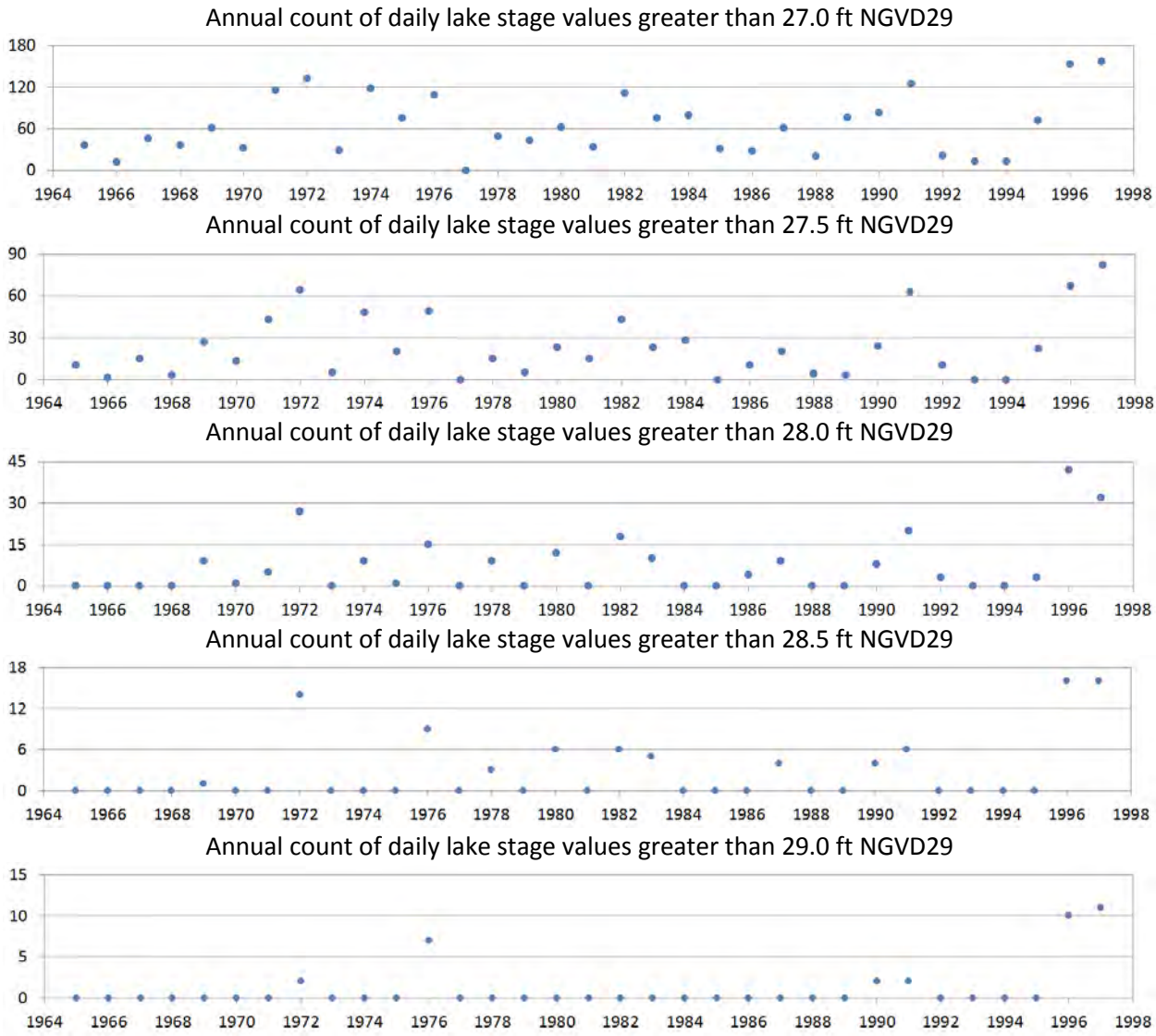


Figure A-7. Lake Sammamish stage exceedance counts by year (1965-1997). Note the different y axis scale among panels.

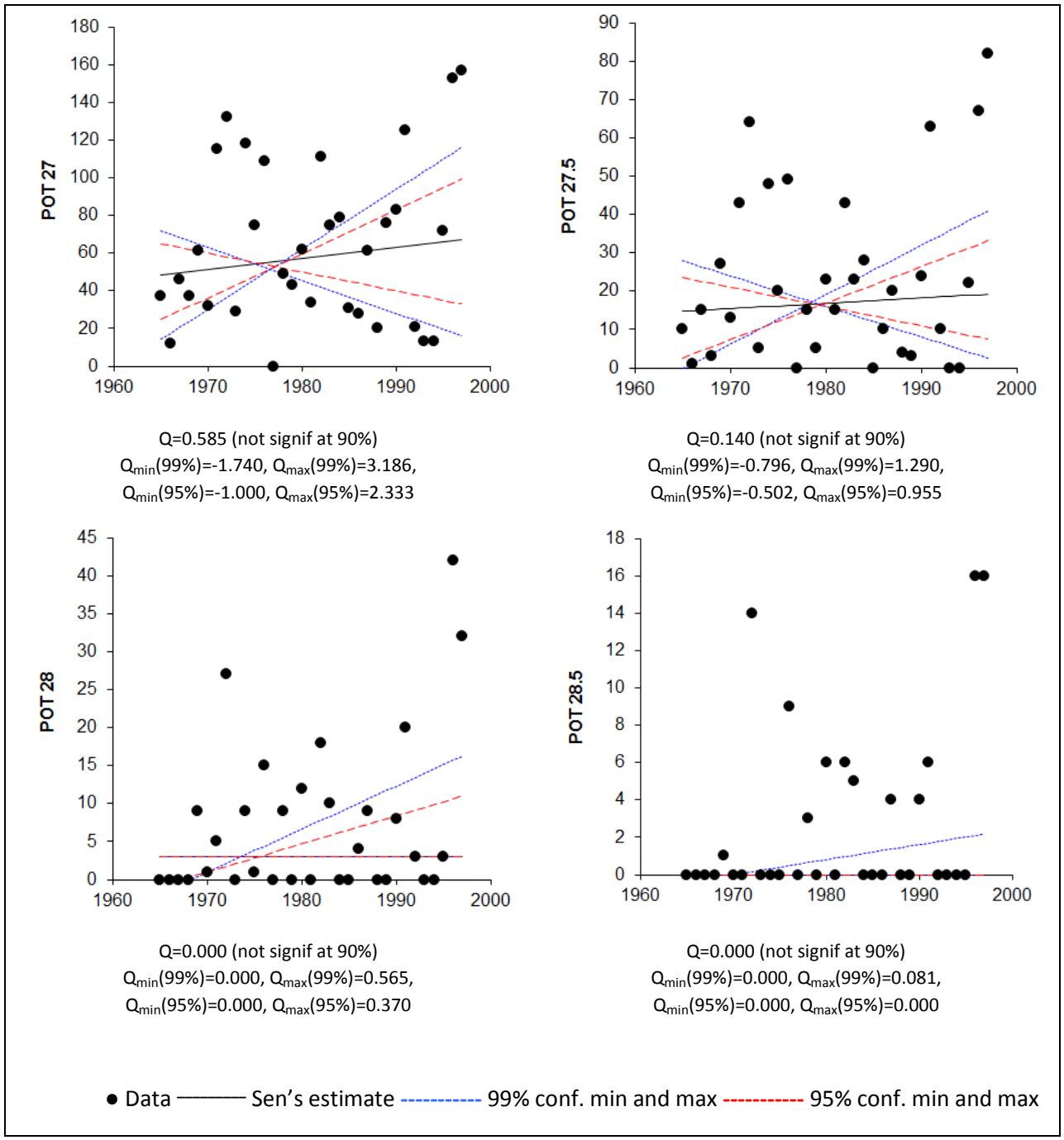


Figure A-8. Mann-Kendall test for trends for lake stage thresholds 27, 27.5, 28 and 28.5 ft NGVD29.

2.2 Trends in the quantiles of daily lake stage

Figure A-9 (same as report Figure 7) shows the annual distribution of daily lake stage, in the form of its minimum, mean, maximum, and the 10th, 50th and 90th percentiles. Figure A-10 shows the results of the Mann-Kendall test for trends for each of these series, and for the series of 25th percentiles, for the period 1965-1997. Declining trends are highly significant (at 99.9% confidence, i.e. α=0.001) for the time series of daily minima and the 10th percentile, and were very significant (at the 99% confidence level, i.e.

α=0.01) for the time series of the 25th percentile. No trends were detected at the 90% confidence level for any of the other series.

The observed decline in low stage values in the lake appears to have been counteracted by the changes implemented in 1998 (Figure A-9).

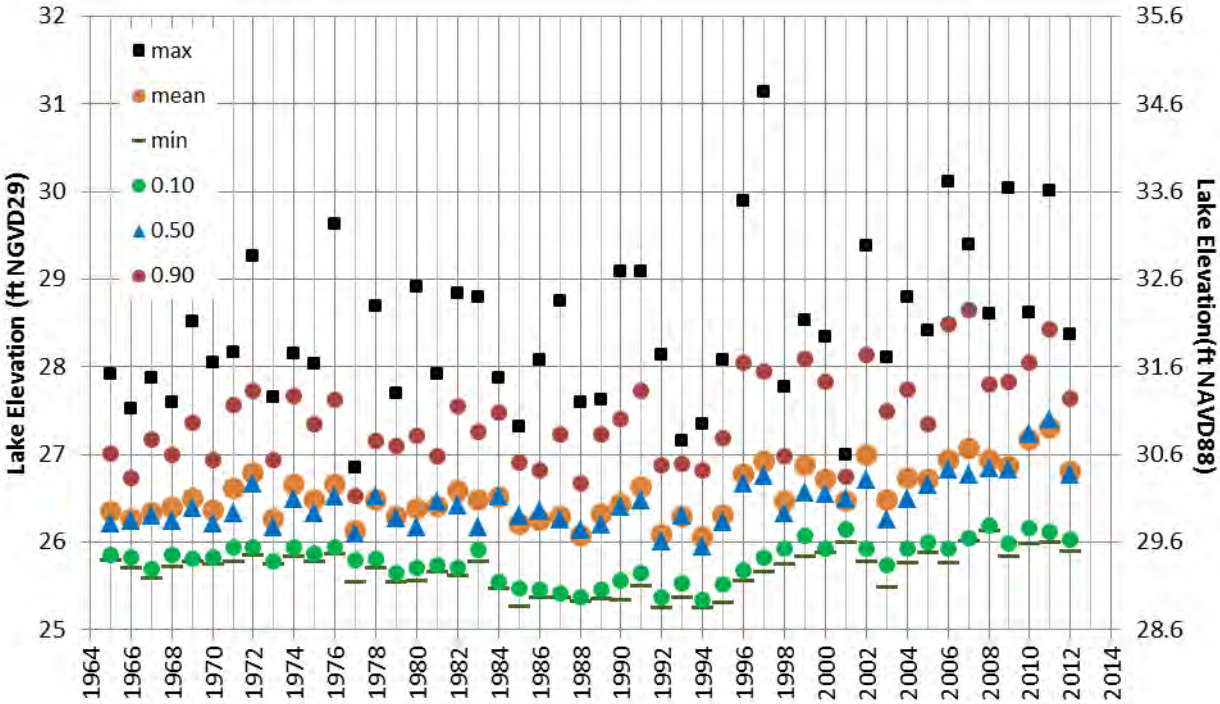


Figure A-9. Annual distribution of daily lake stage. For each water year, we plot the minimum (green dashes), mean (orange dots), and maximum (black squares) of the daily values. We also plot the 10th percentile (green dots), 50th percentile (the median, blue triangles), and the 90th percentile (red dots).

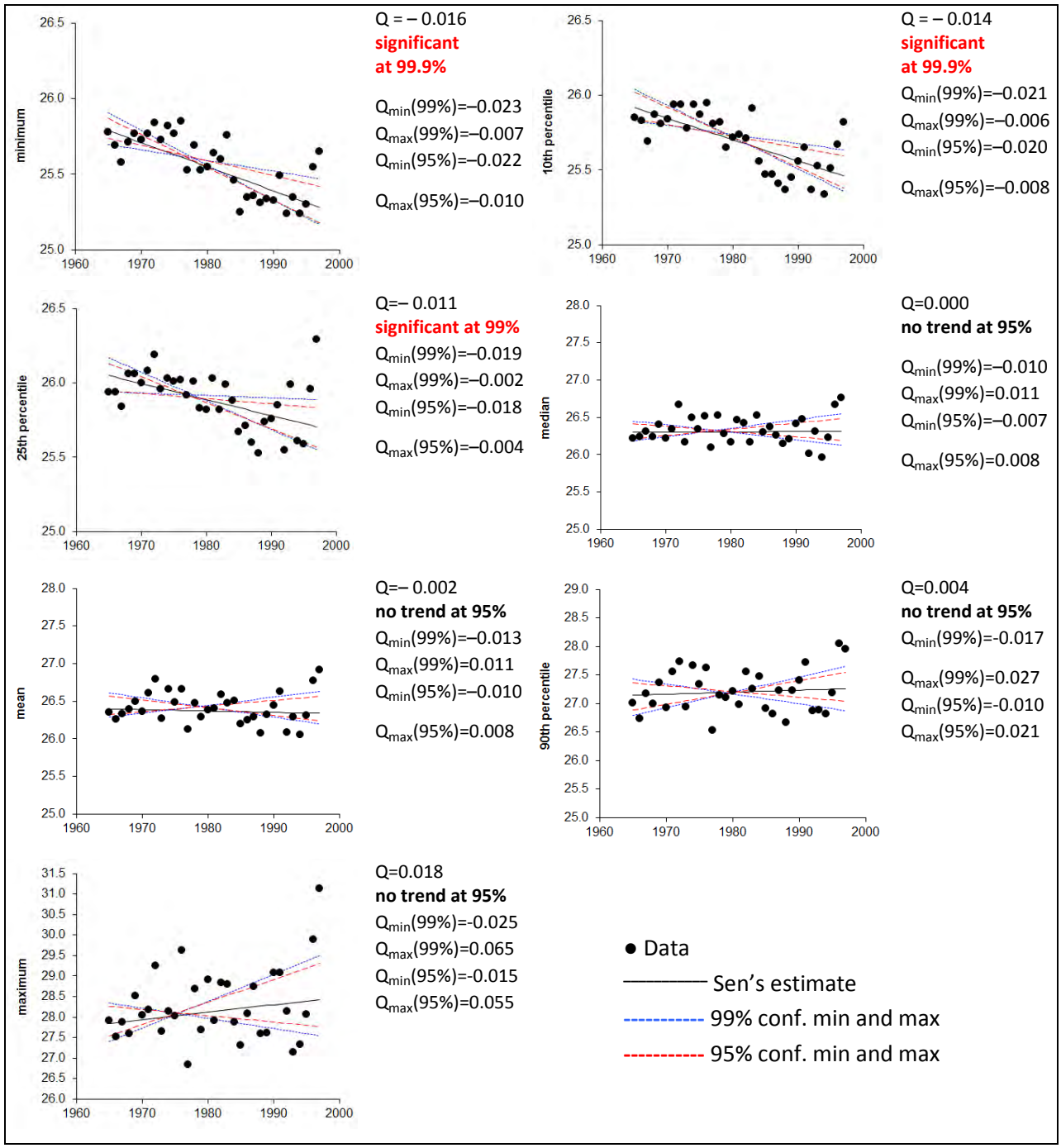


Figure A-10. Mann-Kendall test for trends for the annual time series of daily lake stage minima, mean and maxima, and distribution quantiles, for period 1965-1997. Significant trends are established at 99% level or greater for the minima and the 10th and 25th percentiles. No trends are detected for the other series, at the 90% confidence level.

2.3 Trends in the quantiles of daily discharge from Issaquah Creek

To investigate inflows to the lake as a possible cause for the declining trends in the minimum and lower quantiles of lake stage, we studied the daily quantiles of Issaquah Creek discharge over the same period, 1965-1979.

Figure A-11 shows the results of the Mann-Kendall test for the four months where significant trends were identified.

Figure A-12 shows the results of the Mann-Kendall test when the entire 49-year period of record for Issaquah Creek is included, i.e., for 1964-2012. Now, a declining trend for the month of February is also identified as statistically significant. The significance of the September trend is also higher, 99.9%, when the entire period is considered.

The magnitude of the September linear trend is -1.021 million cubic feet (lost) per year (see Figure A-12). Thus, in the 49-year period, the trend originated a decline of about 50 million cubic feet, which represents 55% of the 49-year average streamflow for September (90.3 million cubic feet). For August, the linear declining trend is -0.696 (from Figure A-12), subtracting 34.1 million cubic feet in the 49-year period, which represents 41% of the average August streamflow (83.1 million cubic feet).

The strong correlation between minimum daily stage in September and Issaquah Creek discharge for August and September is shown in Figure A-13. The strong and highly statistically significant declining trend in the mean inflows in the driest months, August and September, is a likely explanation for the observed pre-1997 declining trend in lake stage.

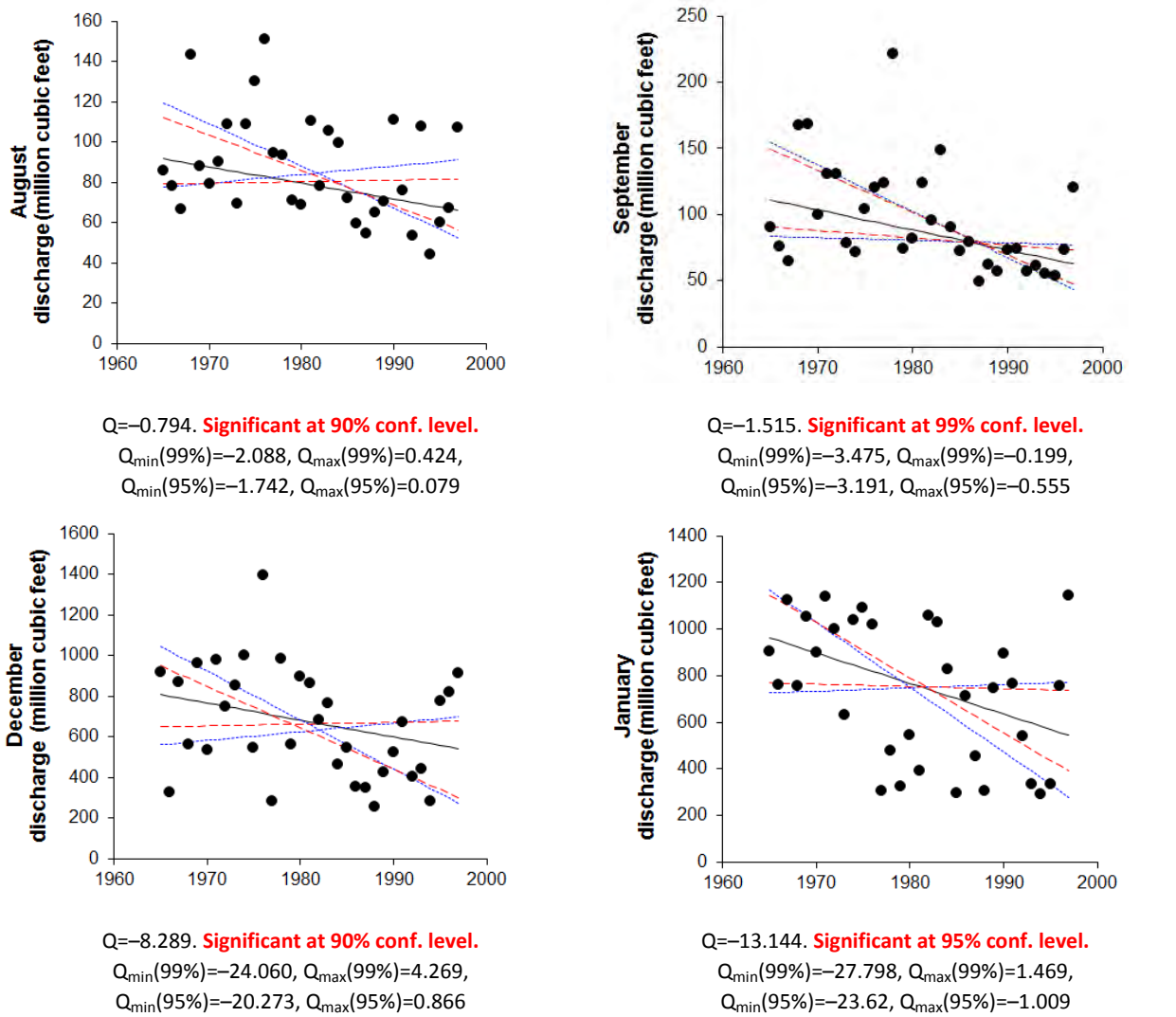
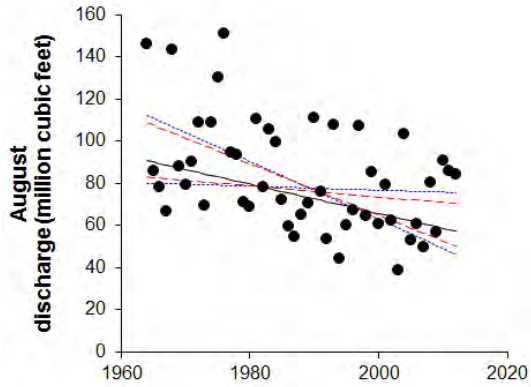
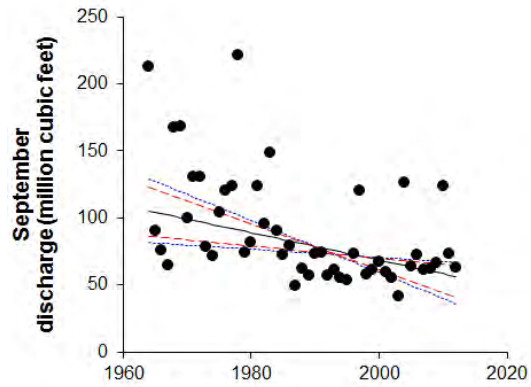


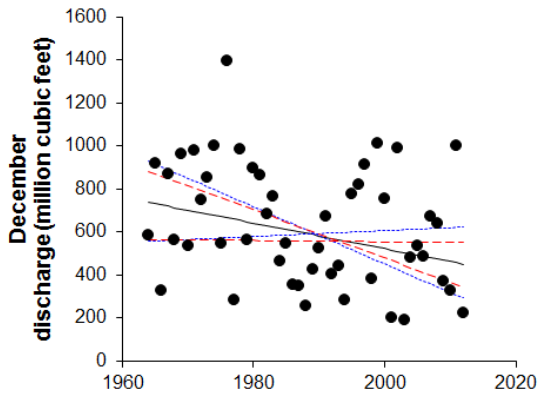
Figure A-11. Mann-Kendall test for trends for Issaquah Creek monthly discharge, for the period 1965-1997. Results are shown only for the four months of the year where the test identified statistically significant trends.



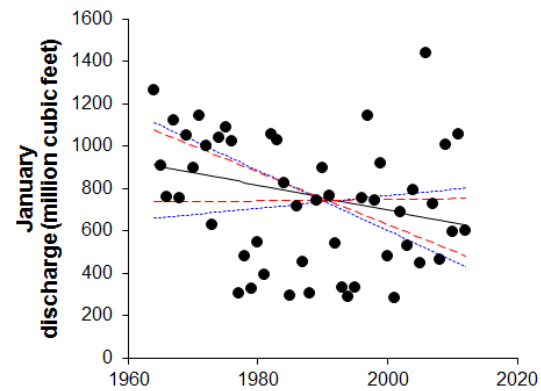
Q=–0.696. **Significant at 99% conf. level.**
Q_{min}(99%)=–1.372, Q_{max}(99%)=–0.093,
Q_{min}(95%)=–1.220, Q_{max}(95%)=–0.264



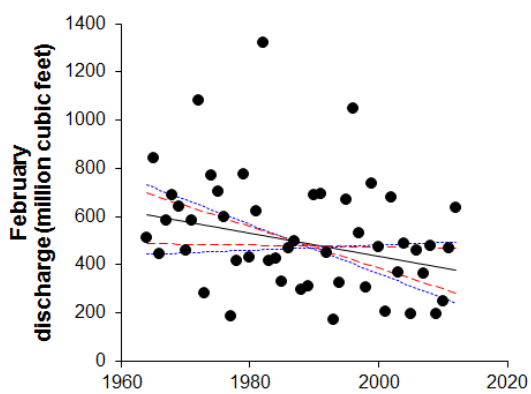
Q=–1.021. **Significant at 99.9% conf. level.**
Q_{min}(99%)=–1.940, Q_{max}(99%)=–0.305,
Q_{min}(95%)=–1.717, Q_{max}(95%)=–0.459



Q=–5.976. **Significant at 95% conf. level.**
Q_{min}(99%)=–13.275, Q_{max}(99%)=1.378,
Q_{min}(95%)=–11.230, Q_{max}(95%)=–0.313



Q=–5.921. **Significant at 90% conf. level.**
Q_{min}(99%)=–14.147, Q_{max}(99%)=2.962,
Q_{min}(95%)=–12.340, Q_{max}(95%)=0.359



Q=–4.752. **Significant at 95% conf. level.**
Q_{min}(99%)=–10.203, Q_{max}(99%)=1.095,
Q_{min}(95%)=–8.606, Q_{max}(95%)=–0.373

● Data
——— Sen's estimate
- - - - - 99% conf. min and max
- - - - - 95% conf. min and max

Figure A-12. Mann-Kendall test for trends for Issaquah Creek monthly discharge, for the complete period of record, 1964-2012. Results are shown only for the five months of the year where the test identified statistically significant trends.

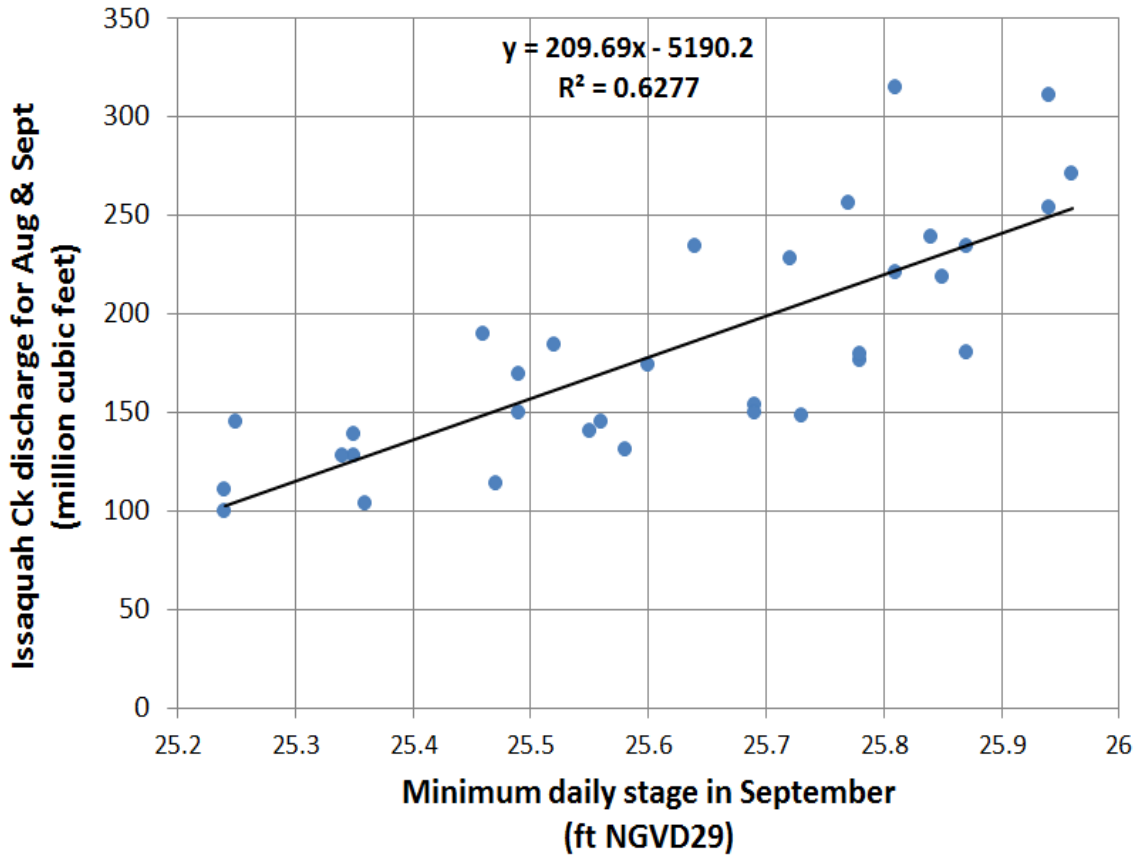


Figure A-13. Effect of Issaquah Creek discharge in the two months of August and September, on the minimum daily stage observed in September.

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Appendix B – Existing Habitat, Fish and Wildlife Report, Tetra Tech 2014

WILLOWMOOR EXISTING HABITAT, FISH AND WILDLIFE REPORT

FINAL

JUNE 2014

Department of Natural Resources and Parks
Water and Land Resources Division
King Street Center, KSC-NR-0600
201 South Jackson Street, Suite 600
Seattle, Washington 98104
www.kingcounty.gov

WILLOWMOOR EXISTING HABITAT, FISH AND WILDLIFE REPORT

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King County

KING COUNTY FLOOD CONTROL DISTRICT

Department of Natural Resources and Parks
Water and Land Resources Division

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Executive Summary

King County and the King County Flood Control District seek to improve flood control and habitat conditions in the upper Sammamish River in Marymoor Park. The river channel was constructed as part of the overall Sammamish River Improvement Project in 1964 by the U.S. Army Corps of Engineers (Corps) in cooperation with King County. King County conducts maintenance including regular mowing, trimming and removal of vegetation and sediment in the channel. These actions adversely affect water quality and habitat and conflict with Federal, state and local efforts to protect and enhance riverine habitat and recover ESA listed salmon species. Additionally, property owners around Lake Sammamish have expressed concerns about lake water levels and are interested in solutions to reduce high lake levels. Consequently, the County is undertaking the Willowmoor Floodplain Restoration Project to further the following goals:

- Provide necessary lake level control, flow conveyance, and downstream flood control;
- Reduce costs, complexity and ecological impacts of maintenance;
- Enhance habitat conditions in the river channel and adjacent tributaries and wetlands to benefit ESA listed Chinook and other species.

This report includes the results of a literature review of existing fish data, a summary of the fish populations present in the project area, upper Sammamish River and tributary aquatic habitat conditions, upper Sammamish River hydrology and water quality, a wetland delineation and functional assessment, vegetation community mapping, wildlife habitat, and recommendations for enhancing aquatic and terrestrial habitat in the project area. The purpose of this report is to briefly summarize existing habitat conditions and identify opportunities and constraints for aquatic and terrestrial habitat restoration in the project area.

1. Introduction

1.1 Overview

King County and the King County Flood Control District seek to improve flood control and habitat conditions in the Sammamish River Transition Zone in Marymoor Park. The Transition Zone is located in the upper portion of the Sammamish River immediately downstream of the Sammamish Weir structure that controls the minimum elevation of Lake Sammamish (Figures 1 and 2). The Transition Zone was constructed as part of the overall Sammamish River Improvement Project in 1964 by the U.S. Army Corps of Engineers (USACE) in cooperation with King County. The Transition Zone as currently constructed has required increasingly intensive and costly maintenance including regular mowing, trimming and removal of the vegetation and accumulated sediments in the channel. These actions adversely affect water quality and habitat and conflict with Federal, state and local efforts to protect and enhance riverine habitat and recover ESA listed salmon species. Additionally, property owners around Lake Sammamish have expressed concerns about lake water levels and are interested in solutions to reduce high lake levels. Consequently, reconfiguration of the river channel and the adjacent floodplain is desirable to further the following goals:

- Provide necessary lake level control, flow conveyance, and downstream flood control;
- Reduce costs, complexity and ecological impacts of maintenance;
- Enhance habitat conditions in the river channel and adjacent tributaries and wetlands to benefit ESA listed Chinook and other species.

1.2 Project Area

The Sammamish River begins at the outlet of Lake Sammamish and flows north and west approximately 13.5 miles to Lake Washington (Figure 1). Four major tributaries enter the Sammamish River including Bear, Little Bear, North and Swamp Creeks. Several smaller tributaries also enter the river. The Sammamish River is the second largest tributary to Lake Washington and provides a migratory corridor for fish and wildlife between Lakes Washington and Sammamish.

The project area includes the outlet of Lake Sammamish down to the end of the Transition Zone and King County owned property within the floodplain to the south of the river (Figure 2). This includes the channel from Lake Sammamish to the end of the Transition Zone (approximately 4,500 feet of channel) and approximately 90 acres south of the channel. Two small tributaries enter the river in the project area: Tosh and Country Creeks. Of interest, although outside of the project area is the Sammamish River downstream to the confluence with Bear Creek, an additional distance of 2,200 feet of river channel.

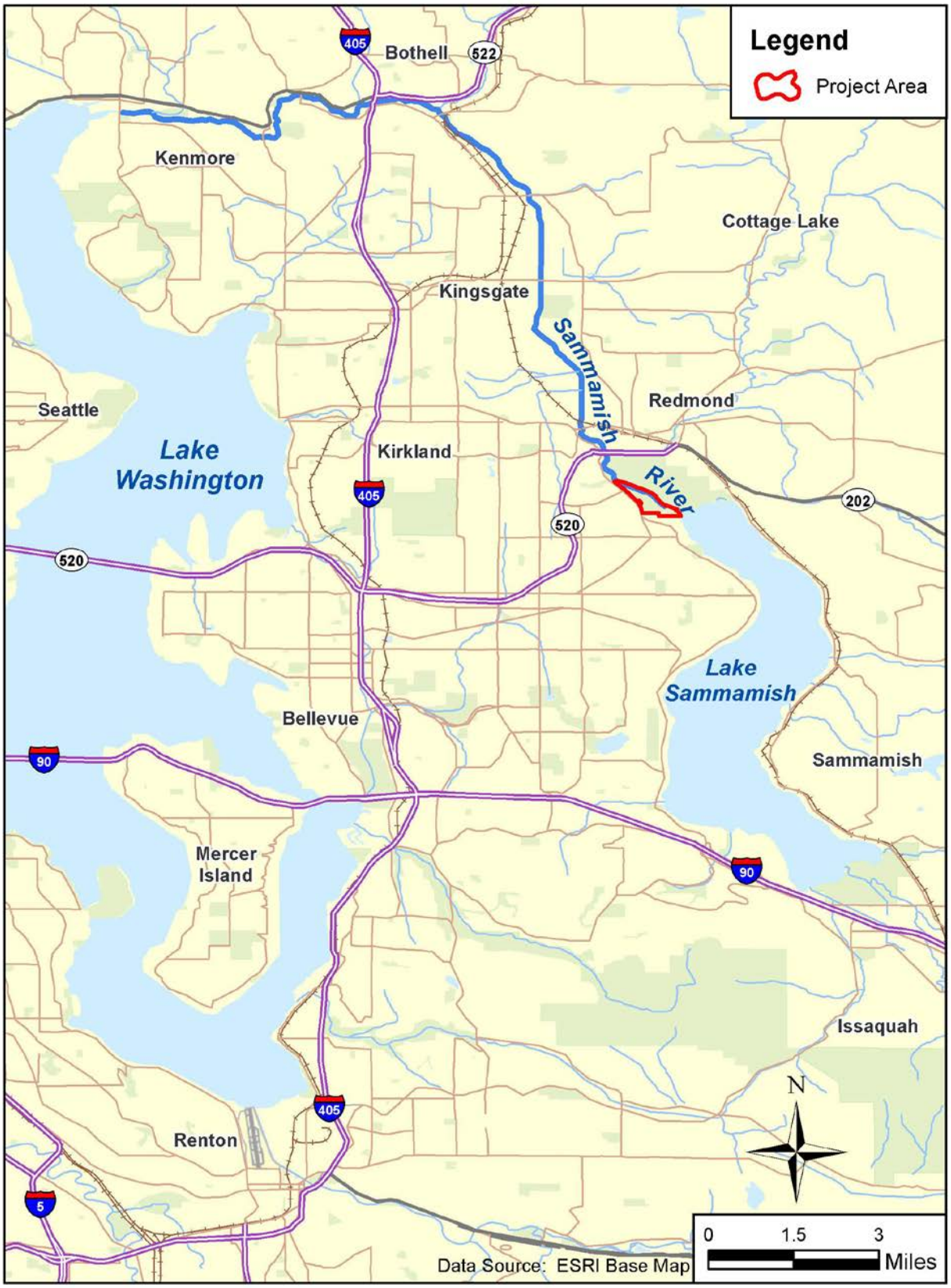

Figure 1. Vicinity Map.

Figure 2. Project Area

2. Aquatic Habitat in the Upper Sammamish River

The Sammamish River is a low gradient (0.01%) and low velocity channel that drops only 13 feet between Lakes Sammamish and Washington over 13.5 miles (King County 2009). Historically, the Sammamish River was characterized as a slow-moving slough with multiple channels and extensive wetlands throughout the floodplain (USACE and King County 2002). The river was navigated by steam powered vessels during the early European settlement period (late 1800s) and it was reportedly difficult to identify the main channel from the numerous blind channels. Large woody debris (LWD) was also abundant, likely from the extensively forested conditions that existed along the river. (Stickney & McDonald 1977) Figure 3 shows the current river alignment in orange overlaid on the 1871 General Land Office survey map of the project area (BLM 2013) and Figure 4 shows the current river alignment on a 1936 aerial photo. The upper reach of the Sammamish River was likely historically seasonally inundated by Lake Sammamish or comprised of lake fringing wetlands.

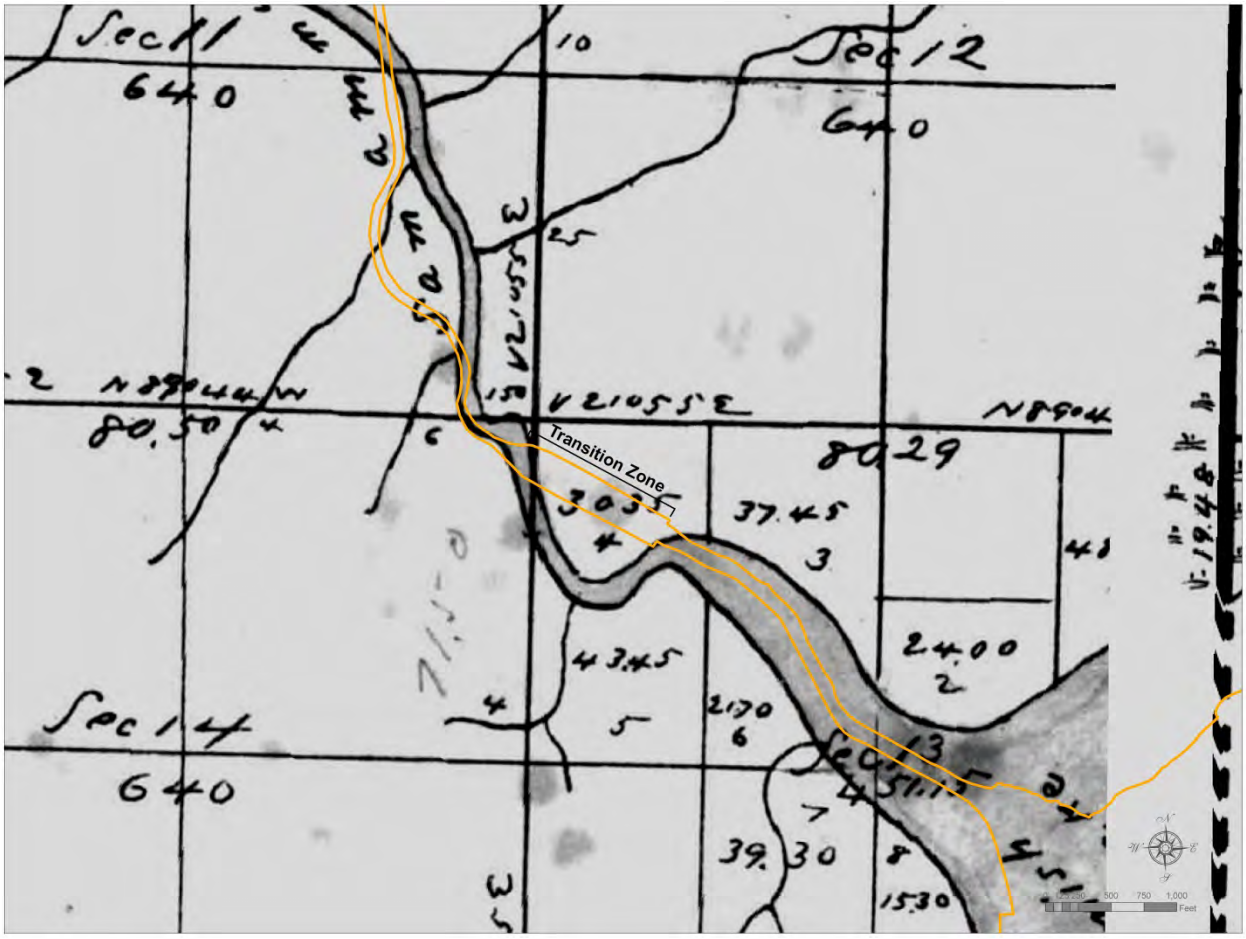

Figure 3. 1871 General Land Office Survey Map with Current River Alignment (in orange).

The Sammamish River is highly modified from historic conditions, primarily as a result of three major projects: 1) the lowering of Lake Washington and the Sammamish River resulting from the construction of the Lake Washington Ship Canal/Locks in 1917; 2) straightening of the river in 1938; and, 3)

construction of the Sammamish River Improvement Project in 1964. These three projects plus agricultural, residential, and commercial development over the past nearly 150 years have changed the Sammamish River and floodplain from a forested swamp valley with a multi-threaded channel to a single-thread trapezoidal channel surrounded by development. Figure 5 is reproduced from USACE and King County (2002) and shows the changes to the river alignment and floodplain from pre-1938 conditions to present day.

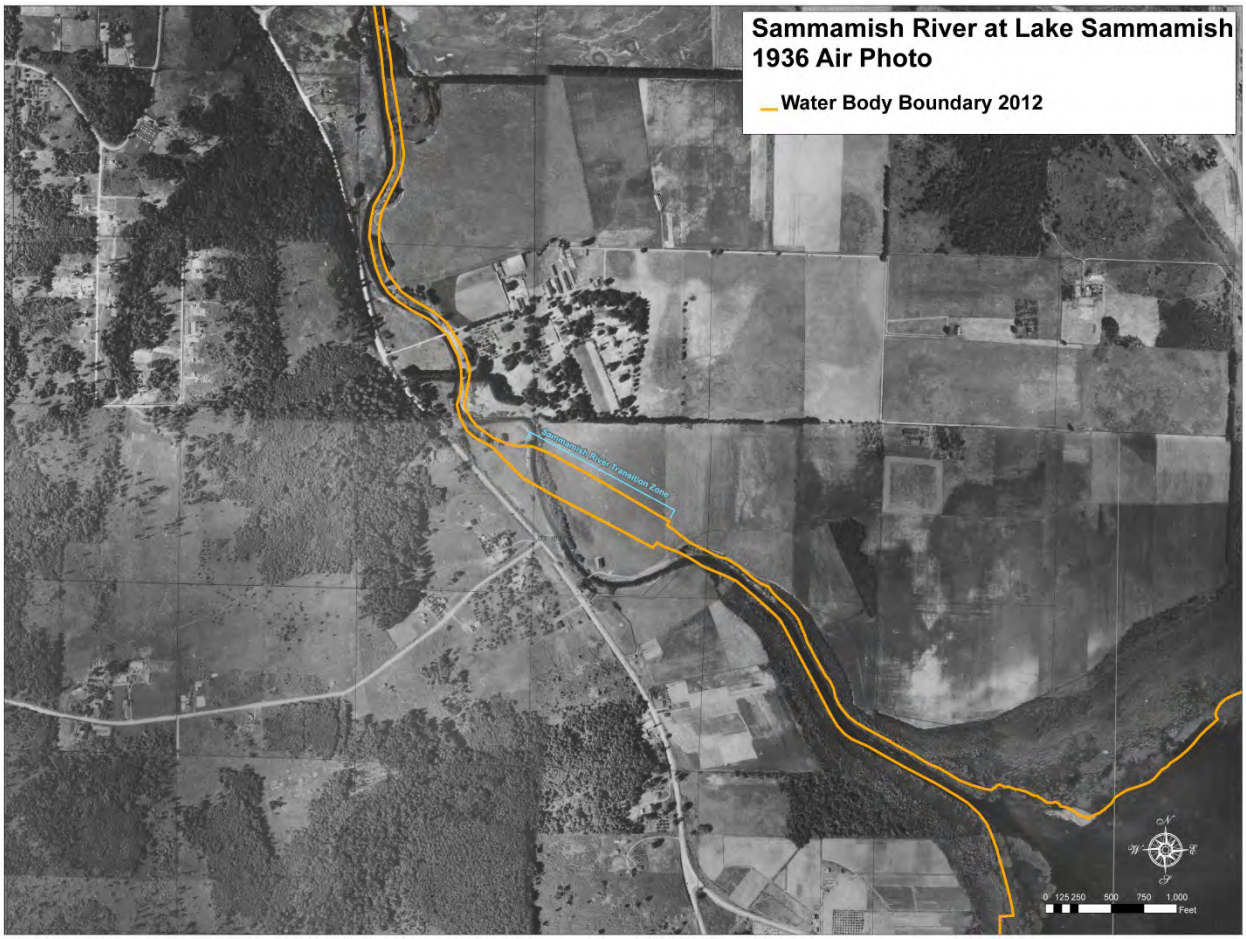

Figure 4. 1936 Aerial Photo with Current River Alignment (shown in orange).

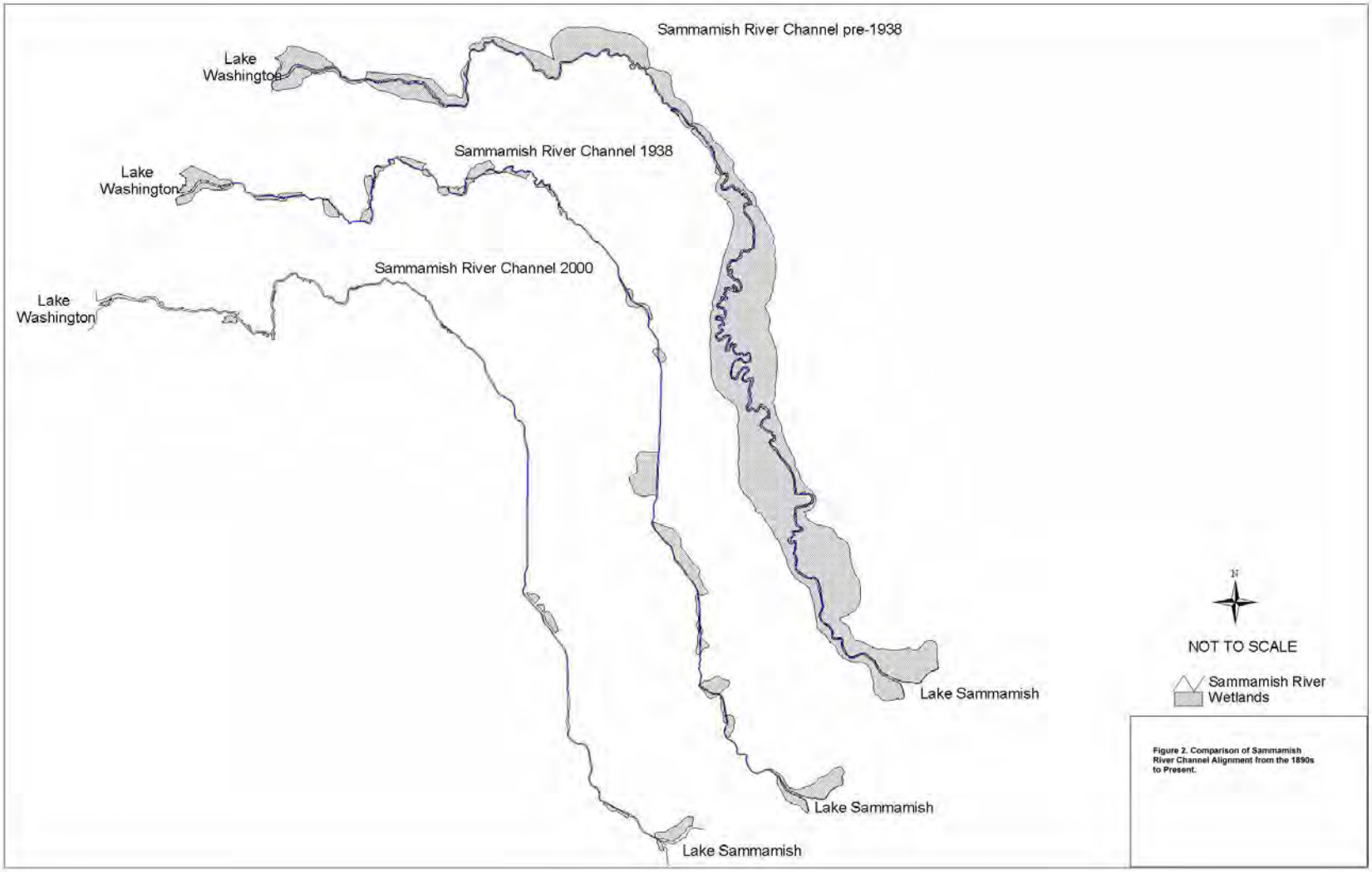

Figure 5. Comparison of Sammamish River alignment and wetlands from pre-1938 to present.

The project area includes two primary constructed features from the 1964 work including the Sammamish Weir and the Transition Zone. The weir was designed to maintain the minimum Lake Sammamish elevation and the transition zone was designed to convey the design flood of 1,500 cfs without exceeding a lake elevation of 29 feet National Geodetic Vertical Datum 1929 (NGVD29; 32.6 feet North American Vertical Datum 1988; NAVD88; NHC 2013). The Transition Zone is a constructed channel with an approximate 12-foot low flow channel in the center and a 200-foot wide high flow channel and then banks sloping up to grade. The Transition Zone was lined with angular rock and intended to be a grass-lined channel in order to maintain effective conveyance.

The weir was reconfigured in 1998 by the USACE to replace the aging grouted riprap weir that had shallow sheet flow with a concrete weir with a defined low-flow notch to provide 12-18 inches of water for fish passage during low flows. The weir is suitable for adult salmon and trout passage. It is not known if juvenile salmon or other species have difficulty passing the weir. For lamprey species it is difficult to pass velocities that may be suitable for adult salmon, and they will often attach to structures and manually climb the structure. Sharp angles and corners on concrete fishways are difficult for lamprey to hang onto and pass over.

A stream habitat survey of the Sammamish River was conducted by R2 Resource Consultants in 1999, and the upper reach from Lake Sammamish to the Bear Creek confluence was classified as consisting of 22 percent riffles[1], 3 percent pools[2], and 75 percent glide[3] habitat (see Figure 6). What was defined as riffle habitat is the Transition Zone, which has shallow turbulent flow, but is not all that similar to natural riffles because of the constructed channel with angular rock. Downstream of the transition zone, the river is predominantly glide habitat with three pools mapped in 1999 (R2 Resource Consultants 1999) between the transition zone and Bear Creek. These pools were noted as providing holding habitat for adult Chinook salmon in 1998 (Fresh, et al. 1999) and having slightly cooler water temperatures at depth, although the residual depth[4] of these pools was only about 2 feet. A more recent survey of pools in the project area was conducted by King County in 2013 and three pools were also mapped, but did not correspond to the same pools mapped in 1999 (see Figure 5). The pools mapped in 1999 no longer exist. Depending on what maintenance has been undertaken by King County in the transition zone, riparian conditions vary. Currently, the low flow channel (riffle) in the Transition Zone is bordered on both sides by a narrow (approximately 30 foot wide canopy) willow (*Salix* sp.) and shrub zone that provides 30 to 40 percent canopy cover over the low flow channel. The river banks and high flow channel area were cleared in 2013, so only re-sprouting herbaceous vegetation occurs here.

[1] Riffles are shallow water habitats with less than a 3.5 percent gradient and may have surface turbulence from increased velocity and shallow depth over coarse substrate (i.e. gravel and cobble; NWIFC 1994)

[2] Pools are deeper water habitats with very low surface water gradient and low velocity (NWIFC 1994).

[3] Glides are deeper water habitats with moderate velocity and no surface turbulence.

[4] Residual pool depth is the additional depth of the pool below the depth of the river channel bed adjacent to the pool.

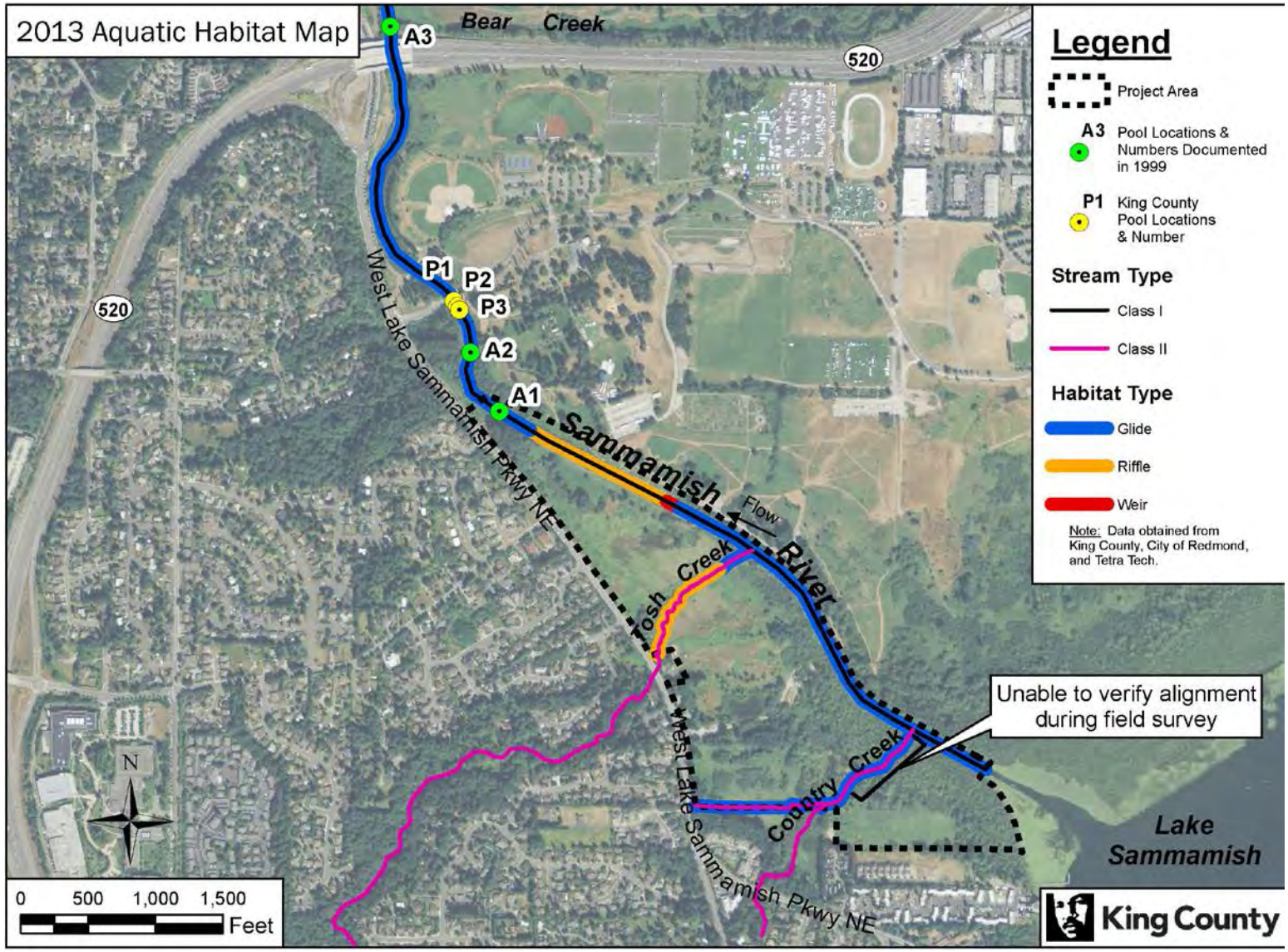

Figure 6. Existing aquatic habitat types in the project area

The upper reach of the river actually provides the most diverse aquatic habitat in the entire Sammamish River; however, the habitat is still far from meeting standards for high quality stream habitat (see Table 1 below; NOAA 1996); although the unique geomorphic setting of the Sammamish River (low gradient lowland river between two large lakes) renders many of the stream habitat ratings in the NOAA (1996) guidelines not entirely applicable.[5] However, as a general guideline to what is considered good salmon habitat, the NOAA guidance provides important information.

Two tributaries enter the Sammamish River in the project area (Tributaries 0141 - Tosh Creek and Tributary 0142 - Country Creek). The City of Redmond recently completed a culvert replacement and stream restoration project on Tosh Creek to improve fish habitat and provide fish passage upstream of West Lake Sammamish Parkway. Approximately 700 feet of the creek was restored into a meandering alignment with large wood placed in the bed and on the banks; the stream habitat through this reach is largely riffle and a wide buffer has been planted with a diverse mix of native trees and shrubs (TT field data 2013). The lower 300 feet of the creek still occupies a ditch along a former property line down to the Sammamish River. The lower 300 feet of creek is glide habitat with dense reed canary grass (*Phalaris arundinaceae*), blackberry (*Rubus armeniacus*), and red alder (*Alnus rubra*) along the banks (TT field data 2013). This lower reach was left unrestored so that restoration could be performed in concert with the goals and objectives of this Willowmoor project.

Country Creek is located in a ditch with glide habitat for about 600 feet downstream from West Lake Sammamish Parkway. The creek then disappears into a large wetland fringing Lake Sammamish and the creek channel becomes indistinguishable from the wetland. Figure 6 shows the existing creek alignments and existing aquatic habitat types in the project area.

Where the lake narrows into the channel upstream of the weir, a significant amount of wetland area is still present on both riverbanks, approximately 250 acres. Emergent, forested, and scrub-shrub wetlands provide a mosaic of habitats within the open space. These habitats are most representative of the historic Sammamish River conditions, although now primarily deciduous forested wetlands and with substantial presence of non-native plant species. However, the interconnected lake, riverine, and wetland habitats provide refuge for fish during high flows and opportunities for enhancement for greater connectivity and restoration of diverse native plant communities such as existed historically.

The following table compares NOAA's identified properly functioning conditions and the existing condition in the project area. As previously stated, not all properly functioning conditions as defined by NOAA are necessarily relevant to the Sammamish River – those indicators of most relevance are highlighted in bold in Table 1.

[5] The NOAA 1996 "Matrix of Pathways and Indicators" and the definitions of "Properly Functioning Conditions" which is used to help determine potential effects of actions on listed species was developed to implement the Aquatic Conservation Strategy and to evaluate effects of the Northwest Forest Plan, the Recovery Plan for Snake River Salmon and management of eight National Forests in Idaho and Oregon. Thus, the research and baseline data used to define Properly Functioning Conditions is necessarily primarily derived from information on streams located in National Forests that have steeper gradients, coarser substrate, and heavily forested canopy as compared to a low gradient lowland river such as the Sammamish River.

Table 1. Comparison of project area existing conditions to properly functioning conditions.

Indicators	Properly Functioning Condition	Existing Condition in Project Reach
Water temperature	50-57° F (10-14° C)	Regularly exceeds 77° F (25° C)
Sediment/Turbidity	<12% fines, turbidity low	>12% fines, turbidity low due to lake outlet
Chemical Contamination Nutrients	No 303(d) listings, low levels of contaminants and nutrients	Four Category 5 303(d) listings in project reach; multiple upstream
Physical Barriers to Habitat	Any man-made structures allow upstream and downstream passage at all flows	Weir allows fish passage at all flows; tbd if could be improved
Substrate Quality	Dominant substrate is gravel or cobble or embeddedness <20%	Dominant substrate sand, gravel, quarry spalls; embeddedness >20%
Large Woody Debris	>80 pieces/mile at>24" diameter and >50 feet long	Less than 10 per mile, do not meet size categories
Pool Frequency	~18 pools/mile	3 pools/mile
Pool Quality	Pools >1 meter deep with cover and cool water, minor reduction of pool volume by fine sediment	All pools less than 1 meter deep, limited cover, slightly cooler water
Off-Channel Habitat	Backwaters with cover and low energy	No off-channel habitats
Refugia	Habitat refugia exist and are adequately buffered; existing refugia are sufficient in size, number and connectivity	Wetland refugia in Lake Sammamish fringing forested/shrub wetlands[6]
Channel Width/Depth Ratio	<10	~100
Streambank Condition	>90% stable	>90% stable, but due to engineering and low velocities
Floodplain Connectivity	Off-channel areas are frequently hydrological linked to main channel; overbank flows occur and maintain wetland functions, riparian vegetation and succession	Off-channel areas not frequently connected; wetlands maintained by lake and upslope surface and groundwater
Change in Peak/Base Flows	Peak flow, base flow, and flow timing comparable to undisturbed watershed of similar size, geology and geography	Peak flow and base flow modified due to upstream development; flow timing altered due to locks
Increase in Drainage Network	Zero or minimum increases in drainage network density due to roads	Substantial increases in drainage network density due to roads and development
Road Density and Location	<2 miles/mi^2; no valley bottom roads	Substantial miles of road per mi^2, multiple valley bottom roads
Disturbance History	Less than 15% disturbance in watershed	Close to 100% disturbance in watershed
Riparian Reserves	Riparian system provides adequate shade, large wood recruitment, habitat protection, and connectivity	Riparian system provides only minimal shade, limited large wood recruitment, limited habitat protection and connectivity

Essential Fish Habitat (EFH) is a concept defined by the Magnuson-Stevens Fishery Conservation and Management Act (50 CFR 600.905-930) as "…those waters and substrate necessary to fish for spawning,

[6] No data available on fish use of these wetlands within Marymoor Park fringing Lake Sammamish, but would be accessible to fish during winter/spring season.

breeding, feeding, or growth to maturity." EFH is another way of identifying if existing conditions provide suitable conditions for fish survival. EFH for Pacific salmon refers to those waters and substrate necessary to support a long-term, sustainable salmon fishery and salmon contributions to a healthy ecosystem. Key elements of EFH that would be appropriate in the project area (as summarized from PFMC 1999) include rearing areas for juvenile Chinook including pools and shallow stream margins, undercut banks, woody debris accumulations, and other areas with cover and low velocity. Adult Chinook require large, deep, low velocity pools with abundant large wood and other cover. Coho smolt production is often limited by freshwater rearing habitat availability. Coho typically rear in smaller streams, but larger lakes, sloughs, and wetlands can all be productive habitats. Complex habitats in streams with a mix of pools, riffles, glides, large woody, undercut banks and overhanging vegetation provide good feeding opportunities for coho.

3. Fish Occurrence and Populations

Six species of salmon are known to be present in the Sammamish River watershed: Chinook, coho, pink (H. Berge, King County, Pers. comm. 2013), and sockeye salmon/kokanee, and steelhead/rainbow and cutthroat trout. The presence of bull trout has not been confirmed. Chum salmon may occasionally stray into the watershed, but are not known to be a sustaining population. All information provided below is summarized from the Washington Department of Fish and Wildlife (WDFW 2013a and 2013b), unless otherwise noted.

In addition to salmon species, other fish species known or likely to occur in the Sammamish River watershed include native species such as Pacific lamprey, river lamprey, Western brook lamprey, mountain whitefish, longfin smelt, northern pike minnow, peamouth chub, three-spine stickleback, large-scale sucker, redside shiner, longnose dace, speckled dace, Olympic mudminnow, and several species of sculpin, and non-native species such as yellow perch, smallmouth bass, largemouth bass, brown bullhead, bluegill, pumpkinseed sunfish, green sunfish, tench, black crappie, grass carp and common carp (Wydoski & Whitney 2003; USACE and King County 2002).

Chinook Salmon. Chinook salmon occur throughout the greater Lake Washington watershed and two stocks have been identified by WDFW: Cedar River and Sammamish. There are also the Issaquah Hatchery produced Chinook salmon and natural spawners in Issaquah Creek. The Lake Washington populations are part of the Puget Sound Chinook salmon Evolutionary Significant Unit (ESU) listed as a threatened species under the federal Endangered Species Act in 2005 (NOAA 2005). All naturally spawned and Issaquah Hatchery-produced Chinook salmon in the watershed are included in the Puget Sound ESU, with hatchery production representing an indistinguishable component of the population.

A genetic study conducted in 2003 and 2004 (Warheit and Bettles 2005) indicates that Chinook salmon in the watershed may be a single genetic population. There was a lack of consistent genetic differentiation between the populations, which may be a function of common ancestry or could also result from hatchery strays into all areas of the watershed (Issaquah Creek Hatchery). There is a large amount of genetic variance within each of the stocks. While naturally spawning fish from both the Cedar

River and the Bear/Cottage Lake Creek system show some genetic differences from Issaquah Creek Hatchery fish (and three other hatcheries evaluated), this was only a weak difference.

Chinook spawn in all four major tributaries to the Sammamish River (Bear, Little Bear, North and Swamp Creeks) and tributaries to Lake Sammamish, although the majority of fish spawn in Bear and Issaquah Creeks (WRIA8 Steering Committee 2005). WDFW collects spawner data for the Sammamish population of Chinook and adult escapement (natural spawners) has ranged from 33 to 544 in the Bear/Cottage Lake system and from 311 to 7,314 in Issaquah Creek[7] since 1980. Figure 7 shows the Chinook escapement estimates since 1976, based on index counts of live spawners and carcasses. The Issaquah Hatchery operates under a Hatchery Genetic Management Plan (WDFW 2002) with the goal of releasing 2,000,000 fingerling fall Chinook per year into Issaquah Creek with 18,000 to 19,000 adults produced. The broodstock return goal is 1,600 adult Chinook, with current goals to reach 10 to 20 percent natural origin fish, ultimately to reach the integrated genetic goal of 50 percent natural origin fish for broodstock. In recent years, natural origin return fish have ranged from 7 to 22 percent of the broodstock (average 12 percent). The overall smolt to adult return rate is less than 1 percent. (WDFW 2013a) Approximately 5 percent of the hatchery returning adults spawn naturally in the watershed, primarily in Issaquah Creek both upstream and downstream of the hatchery. WDFW has been investigating options for providing improved fish passage upstream of the hatchery and water intake.

Chinook in the basin are fall run and adults enter the Lake Washington basin from June through September. Spawning generally occurs from September through October and depending on water temperature during incubation, fry typically emerge from January through March. For most ocean-type Chinook (the majority of Lake Washington basin Chinook exhibit ocean-type behavior), juveniles may rear in tributary streams, larger rivers, lakes, or estuaries for one to six months before migrating into saltwater. Peak smolt outmigration typically occurs at the locks from June through August, but smaller numbers out-migrate from February through September. There may be a small number of stream-type Chinook present in the watershed, which rear for approximately one year in freshwater and out-migrate the year following emergence. (USACE and King County 2002)

WDFW lists the Sammamish River as potential spawning habitat for Chinook salmon (WDFW 2013b). The project area would not be likely to provide suitable spawning habitat due to angular rock and fine sediments and Chinook spawning has not been documented in the project area. The project area is a migratory corridor for both adult and juvenile Chinook salmon. Chinook adults pass through the project area on their way to tributaries of Lake Sammamish. These fish are predominantly hatchery-derived fish, although natural spawning occurs and wild fish could be sustained in the system. Due to the lack of cool water and pools, adult fish transit through the project area quickly, often taking only minutes, or at night when temperatures are lower (Fresh, et al. 1999). A number of dead adult Chinook were observed in the Sammamish River in 1998 and 1999, up to several dozen on each date counted (R. Tabor, USFWS, unpublished data from 1998 and 1999), and while a specific study on mortality has not been conducted, it is speculated that high water temperatures contributed to their death (R. Tabor, USFWS, Pers. comm.

[7] WDFW conducts live index counts in Bear Creek (RM 1.3 to 8.8), Cottage Lake Creek (RM 0 to 2.3), Issaquah Creek (RM 0 to 3.0), and the East Fork Issaquah Creek (RM 0 to 3.1). In addition, other areas are surveyed annually.

2013). Juvenile Chinook similarly pass through and may rear in the project area for short periods of time. It is unlikely that juveniles would spend a substantial amount of time in the project area due to the lack of cover and limited habitat diversity.

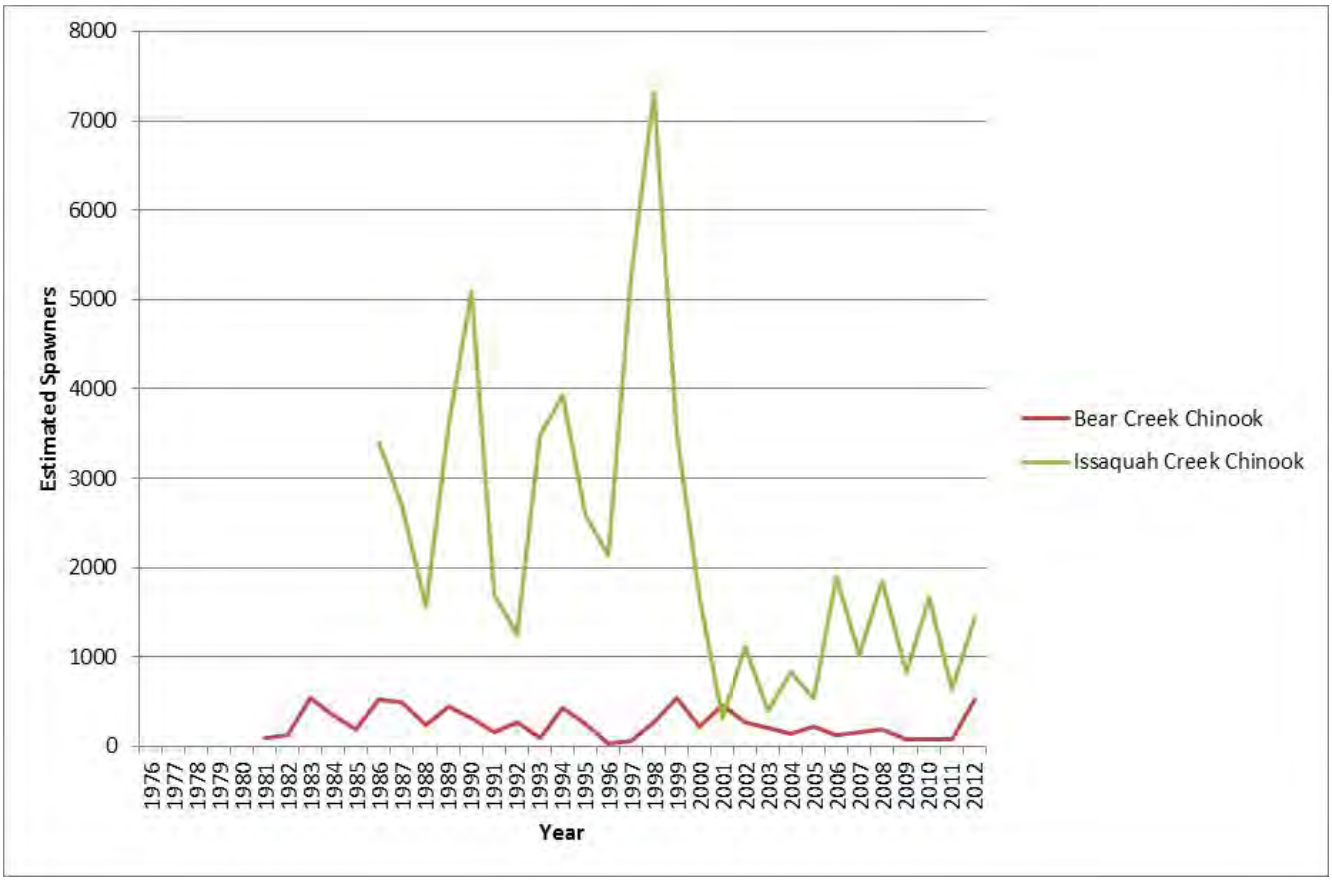

Figure 7. Chinook adult escapement since 1980 in Bear and Issaquah Creek systems.

Coho Salmon. Coho salmon occur throughout the greater Lake Washington watershed and WDFW identifies two stocks: Cedar River and Lake Washington/Sammamish Tributaries. The Puget Sound coho salmon ESU is a candidate species for listing under the Federal Endangered Species Act. No genetic analysis has been conducted on the Lake Washington/Sammamish Tributaries stock, but the stock is considered to be of mixed hatchery and wild origin. Naturally spawning adult returns have ranged from 34 to 20,002 since 1980. Figure 8 shows the coho adult spawner return estimates since 1980 (along with sockeye spawner estimates). There is a distinct declining trend. The lowest count on record (of 34) occurred in 2011. The recovery goal for the Lake Washington/ Sammamish Tributaries stock is 13,526 adults; however, there is no active management to achieve this goal. The Issaquah Hatchery produces 450,000 juvenile coho per year and approximately 29,000 adults are produced. An average of 26 percent of the broodstock is from natural origin returns. Over 14,000 adults are excess to broodstock requirements and it is not known what percentage naturally spawn in the watershed.

WDFW lists the upper Sammamish River as rearing habitat for coho juveniles (WDFW 2013b). Coho adults attempting to spawn were observed during the 1999 habitat survey of the Sammamish River (E.

Jeanes, R2 Resource Consultants, pers. comm. 2001). Lake Washington basin coho are fall run and enter the locks from August to December. Spawning typically occurs in tributaries in November and December, although spawning may occur as early as October. Fry emerge from March through June and juveniles typically rear in freshwater for one year. Juveniles rear in natal tributaries, larger rivers, and lakes in the watershed (USACE and King County 2002). In general, freshwater habitat that is structurally complex with dense wood, pools, and other cover is preferred by coho juveniles (Sandercock 1991). Smolts typically migrate out through the locks in May as yearlings. In the project area, both coho adults and juveniles migrate though, although limited rearing may also occur.

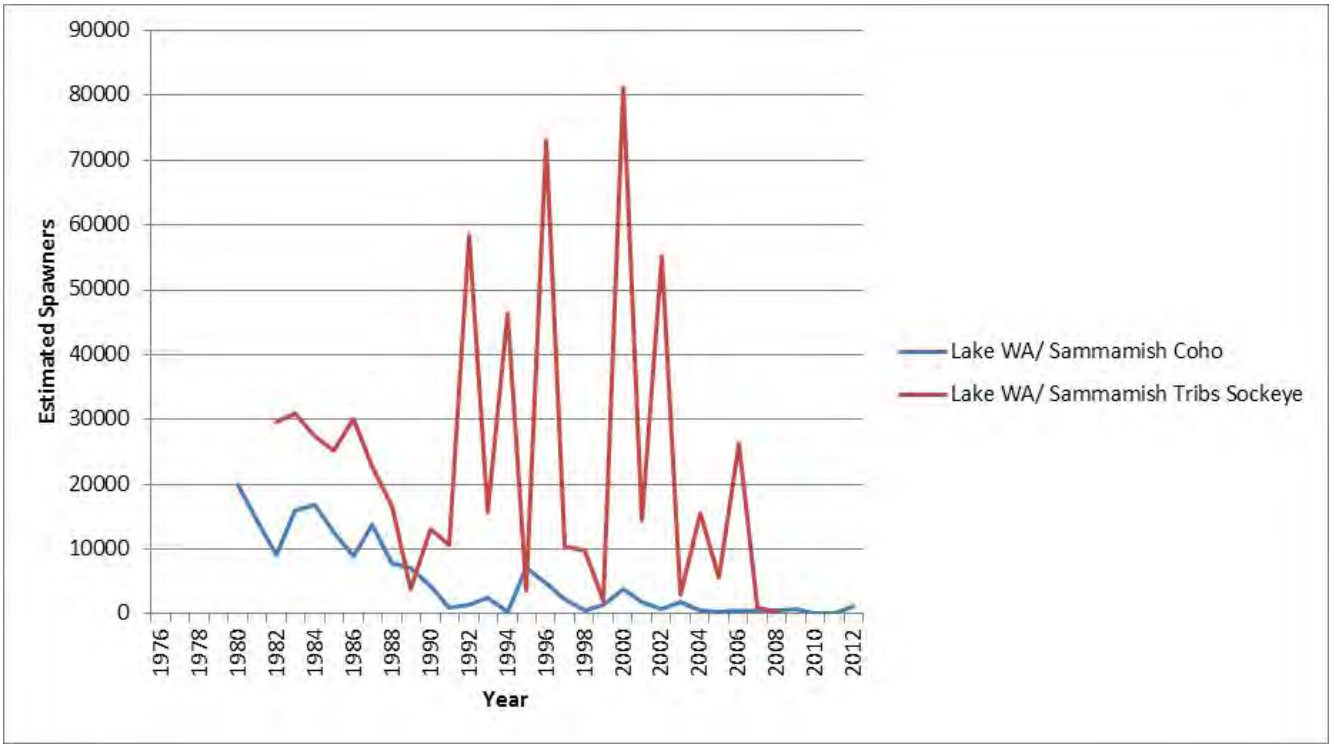

Figure 8. Lake Washington/Sammamish tributaries adult coho and sockeye spawner returns since 1980.

Sockeye Salmon. Sockeye salmon occur throughout the greater Lake Washington watershed and WDFW identifies two stocks: Cedar River and Lake Washington/Sammamish Tributaries. The Lake Washington/Sammamish stock primarily spawns in the Cedar River, Bear Creek and Issaquah Creek systems; some spawning also occurs in Little Bear Creek. Recent genetic analysis (Spies, et al. 2007) indicates that the Bear Creek sockeye population appears to be genetically distinct from sockeye in the remainder of the watershed and is likely native. The sockeye from other parts of the watershed (Cedar River, Lake Washington beach spawning, and Issaquah Creek) are more similar to Baker Lake sockeye, the source of most historic introductions in the watershed. Escapement (natural spawners) has ranged from 246 to 81,090 based on counts of live spawners in Bear Creek. The lowest return on record was 246 in 2008. The numbers are highly variable from year to year, so no obvious trend is observed (Figure 8).

WDFW lists the upper Sammamish River as a migratory corridor for sockeye salmon (WDFW 2013b). Sockeye are fall run and typically enter the Lake Washington basin from June through August. Spawning occurs from September through January, although the peak spawning period is in October, and fry typically emerge from January through May and migrate quickly (or over one to two months) to Lakes Sammamish and Washington to rear for up to one year. Smolts out-migrate through the locks typically in May and June (USACE and King County 2002). In the project area, both adult and juvenile sockeye migrate through.

Kokanee. Kokanee are the same species as, but a resident form of, sockeye salmon; spending their entire life history in fresh water. The U.S. Fish and Wildlife Service received a petition in 2007 to list all naturally spawning kokanee in the Lake Washington watershed (USFWS 2008). A substantial finding was published in 2008 and a 12-month status review was undertaken; it was determined that kokanee were not warranted for listing (USFWS 2011). Three runs had been recognized in the Lake Washington/Sammamish population including summer-run, fall-run, and winter-run. The summer and fall runs appear to have been extirpated (USFWS 2011). Remnant fall runs in the Sammamish River and tributaries were collected and genetic analysis suggests that they are of Baker Lake origin (H. Berge, King County, Pers. comm. 2014). The winter run that still exists in Lake Sammamish and its tributaries is of native origin, with spawners numbering from 64 to 4,702 since 1996. Late run spawning occurs from late October through March in tributaries to Lake Sammamish (H. Berge, King County, Pers. comm. 2014). The Kokanee Work Group comprised of local, state, federal agencies and several citizen groups, has been undertaking emergency supplementation efforts since 2008, and has also identified several restoration projects to benefit kokanee. Kokanee juveniles and adults likely pass through the project area; kokanee spawning has been observed downstream in restored reaches of the Sammamish River (H. Berge, King County, Pers. comm. 2013).

Pink Salmon. There is not a designated pink salmon population in the Lake Washington watershed (WDFW 2013a); however, occasional pink salmon have been observed and are likely to be strays from nearby watersheds (H. Berge, King County, Pers. comm. 2013). Pink salmon typically have only a two-year life span, thus, even and odd-year spawning populations can become differentiated and Puget Sound populations are predominantly odd-year runs (Heard 1991). Adults enter freshwater in August and September and spawning occurs in September and October.

Steelhead. Steelhead in the Lake Washington watershed are identified by WDFW as two stocks: Cedar River and North Lake Washington/Sammamish. The stocks were identified as separate based on the differing habitats used (snowmelt dominated Cedar River vs. rainfall dominated tributaries). Puget Sound steelhead were listed as a threatened species in 2007 (NOAA 2007). The steelhead population has been so low in recent years that it is not known if steelhead still occur in North Lake Washington and Sammamish tributaries or if they transit through the project area.

WDFW lists the upper Sammamish River as a migratory corridor for steelhead (WDFW 2013b). Steelhead in the basin are winter run. Steelhead return to the locks from December through March and spawn in tributaries from March to June. Juveniles rear in natal streams and larger rivers from one to three years and then migrate as smolts from May through July. (USACE and King County 2002)

Cutthroat Trout. Cutthroat trout have a diversity of life history strategies including anadromous, adfluvial (lake resident, tributary spawning) to stream resident. Very little information on cutthroat trout populations exists for the Lake Washington basin and they are not identified as a stock by WDFW. A sizable adfluvial population is known to exist in Lakes Washington and Sammamish with resident fish also observed in most tributaries, including the Sammamish River. Adfluvial and resident adults spawn in tributaries from April to May, and anadromous fish may spawn from December to January. Juveniles may spend several years in freshwater before migrating to saltwater. Escapement values are unknown. (USACE and King County 2002) Cutthroat trout are likely to migrate through the project area as juveniles or adults and may rear in the project area.

Bull Trout. Bull trout can also have a diversity of life history strategies. The presence and status of bull trout is not well understood in the Lake Washington basin. A resident population occurs above Chester Morse dam in the upper Cedar River, but only isolated observations have occurred elsewhere in the basin. Individual observations have occurred in Lake Sammamish and Issaquah Creek (King County 2000a). King County conducted surveys to identify if bull trout are present in Issaquah Creek (King County 2000b), but no conclusive information was collected. Bull trout prefer cold streams with temperatures less than 55° F (13° C). Spawning occurs from August through November. Fry emerge from April to May and rear in areas with extensive cover from wood or boulders. (USACE and King County 2002) It is not likely that bull trout are currently present in the project area.

3.1 Fish Data Gaps

Fish use of the project area (Upper Sammamish River) is not well documented as the Sammamish River is a unique habitat area and is not included in spawning surveys and other regular programs; although the Fresh et al. (1999) study tracked Chinook adults through the project area. Particularly, it is not known to what extent juvenile salmonids and other native fish species use the project area and their seasonal timing. It is recommended that a juvenile fish survey be conducted during the February through August time period to identify species, size, and timing to inform what types of habitats would be most beneficial for rearing.

4. Hydrology

As previously discussed, construction of the Lake Washington Ship Canal and Locks lowered the surface elevation of Lake Washington by up to 9 feet and changed the Squak Slough into a more riverine environment – now the Sammamish River (Ajwani 1956; Chrzastowski 1983). Base flows have been decreased as a result of increased impervious surfaces in the watershed and reduced floodplain and groundwater connections. The flood control project in the 1960s further disconnected and drained the floodplain, likely causing additional loss of groundwater flow as a result of reduced floodplain storage. Base inflows (summer/fall) into Lake Sammamish have decreased substantially as a result of development and impervious surfaces in tributary watersheds, thus also affecting outflows into the Sammamish River (NHC 2013); Figure 9 shows mean monthly discharge for Issaquah Creek (from NHC 2013, Table 5, USGS gage 12121600 WY 2002-2008), which is the largest inflow to Lake Sammamish and

for the Sammamish River at the weir (King County gage 51M, data from 2001-2013). Impervious surface area has increased in the Sammamish floodplain as well, reducing the opportunity for groundwater recharge. Water withdrawals for domestic and agricultural uses may have reduced water volume in the river resulting in greater heating of the smaller volume of water (Jain, et al. 2000). Peak flows in the Sammamish River appear to have increased as a result of increased capacity from the flood control project (NHC 2013). However, this does not mean increased frequency of connection to the floodplain.

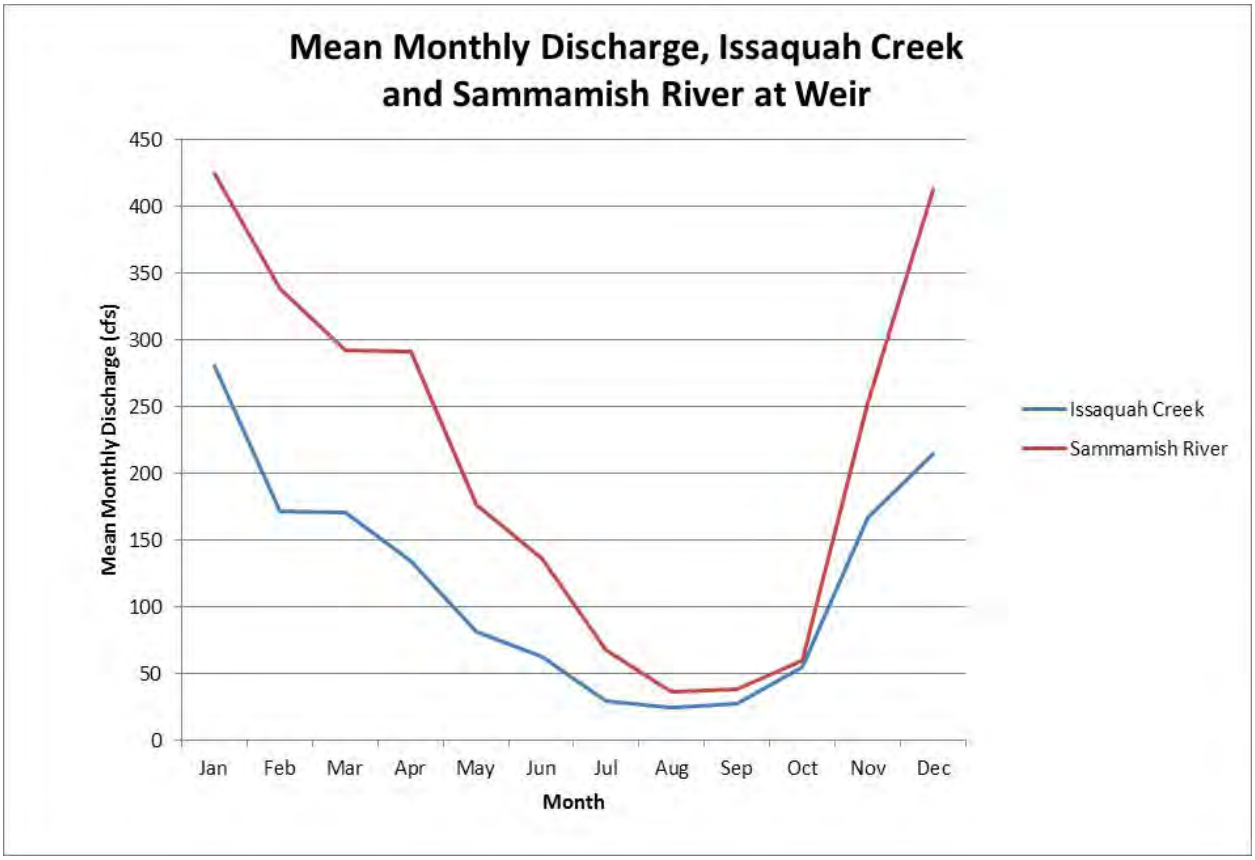

Figure 9. Issaquah Creek and Sammamish River (at the weir) mean monthly discharge.

Lake Sammamish peak water elevations appear to have increased over time, causing concerns to lakeside residents. A hydrologic analysis by Northwest Hydraulic Consultants (2013) indicates that 90% of the highest lake levels have occurred since 1989[8], and post-1998 lake levels are significantly different (statistically) than pre-1998 lake levels. Causes for peak lake levels include high or prolonged inflows to Lake Sammamish, cumulative high lake levels prior to a specific storm event, vegetation condition in the Transition Zone, and high Bear Creek flows. Vegetation condition and capacity in the Transition Zone are both conditions to explore in the project area for potential to reduce high elevations on Lake Sammamish.

[8] Based on data from 1965 to 2010 (NHC 2013).

5. Water Quality

Water quality in the project area is poor. The Washington Department of Ecology's 303(d) list of impaired waterbodies in the State of Washington has listed the Sammamish River downstream of the project area and multiple tributaries upstream and also in Lake Sammamish (WDOE 2013). Table 2 provides the Category 5 (polluted water bodies requiring a Total Maximum Daily Load, TMDL) listings in the project area. Issaquah and Tibbetts Creeks have an approved TMDL for bacteria.

Table 2. 303(d) listed waterbodies in project area and upstream.

Waterbody	Parameters Listed (Category 5)
Sammamish River (below Transition Zone)	Temperature, bacteria, dissolved oxygen
Tosh Creek	Bacteria
Country Creek	Bacteria
Villa Marina Creek	Temperature, bacteria, dissolved oxygen
Idylwood Creek	Temperature, bacteria, dissolved oxygen
Unnamed west-side tributary	Bacteria
Pine Lake Creek	Bacteria, dissolved oxygen
Laughing Jacobs Creek	Bacteria, dissolved oxygen
Lewis Creek	Temperature, bacteria, dissolved oxygen
Eden Creek	Bacteria
Tibbetts Creek	Temperature, dissolved oxygen
Issaquah Creek	Dissolved oxygen
Lake Sammamish	Bacteria, dissolved oxygen

High water temperature and low dissolved oxygen concentrations are the most serious concerns for fish and the aquatic ecosystem in the project area. Water temperatures as high as 80° F (27° C) have been measured in late July (Martz, et al. 1999; R. Tabor, unpublished data). As the discharge from the Lake that enters the Sammamish River is from the surface, the river temperatures are naturally seasonally high. Figure 10 shows the monthly mean, mean maximum, and mean minimum Sammamish River water temperatures (at the weir, Gage 51M, and near the railroad bridge downstream of Bear Creek, Gage 51L). Even with cooler Bear Creek water flows, temperatures downstream of Bear Creek are still high.

Temperature modeling of the Sammamish River has been conducted by King County and others (King County 2009, 2001; Buchak, et al. 2001; Jain, et al. 2000) to evaluate existing conditions and potential scenarios for reducing temperatures. As summarized in King County (2001), under existing conditions there is a thermal stress on average of 1.35 degrees above 17° C every day during the August to October timeframe analyzed for the project area (i.e. the water temperature exceeds 17° C by an average of 1.35 degrees over each 24 hour day). Since this is an average exceedance, the maximum water temperatures during this time period are often several degrees higher – the maximum thermal stress is 7.02 degrees (i.e. maximum water temperatures each day average about 7.02 degrees above 17° C). A number of scenarios for reducing temperatures were evaluated and compared to existing conditions (base case) and the only scenarios that can significantly reduce water temperatures in the upper river were the hypolimnetic withdrawal scenarios of 10 or 20 cfs from deep in Lake Sammamish. Other scenarios such as riparian restoration can provide cumulative benefits to the river and reduce water temperatures in

the lower river (by preventing heating throughout the upper river), but do not substantially reduce temperatures in the upper river. The large scale changes to the whole river system have so substantially altered what historically existed that water temperatures in the upper river are now very far from meeting water quality standards and standard restoration measures are not likely to achieve the level of temperature reduction that would make a substantial difference in the upper river.

The Washington Department of Ecology (WDOE) water temperature standard is 63.5° F (17.5° C) for salmonid spawning, rearing and migration (September 16 to June 14) and 60.8° f (16° C) for core salmonid summer habitat (June 15 to September 15; WDOE 2012). This is similar to Environmental Protection Agency (EPA) guidance provided to the states for setting water quality standards that recommends daily maximum temperatures not exceed 64° F (18° C; UWPA 2003) in waters where adult migration and non-core juvenile rearing occurs. A review of temperature requirements and effects on salmonids by Carter (2005) indicates that 50 percent mortality of Chinook occurs around 77° (25° C), but coho are more tolerant and 50 percent mortality occurs at 82° F (28° C). NOAA (1996) considers optimal temperatures for salmonids to be 50-57° F (10-14° C). Beyond acute mortality, high water temperatures cause a variety of physiological effects (sub lethal) that are harmful to salmon survival and reproduction as well as increasing the potential for disease. Disease risk becomes high at temperatures from 64-68° F (18-20° C; USEPA 2003). Figure 11 shows the Sammamish River water temperatures along with the general timing of salmon presence in the river, and the WDOE temperature standards.

Water temperatures exceed WDOE water temperature standards during the months of July and August, even the minimum (nighttime) temperatures. The mean monthly maximum temperatures exceed WDOE standards from April through October. Dissolved oxygen is not measured at these river gage sites.

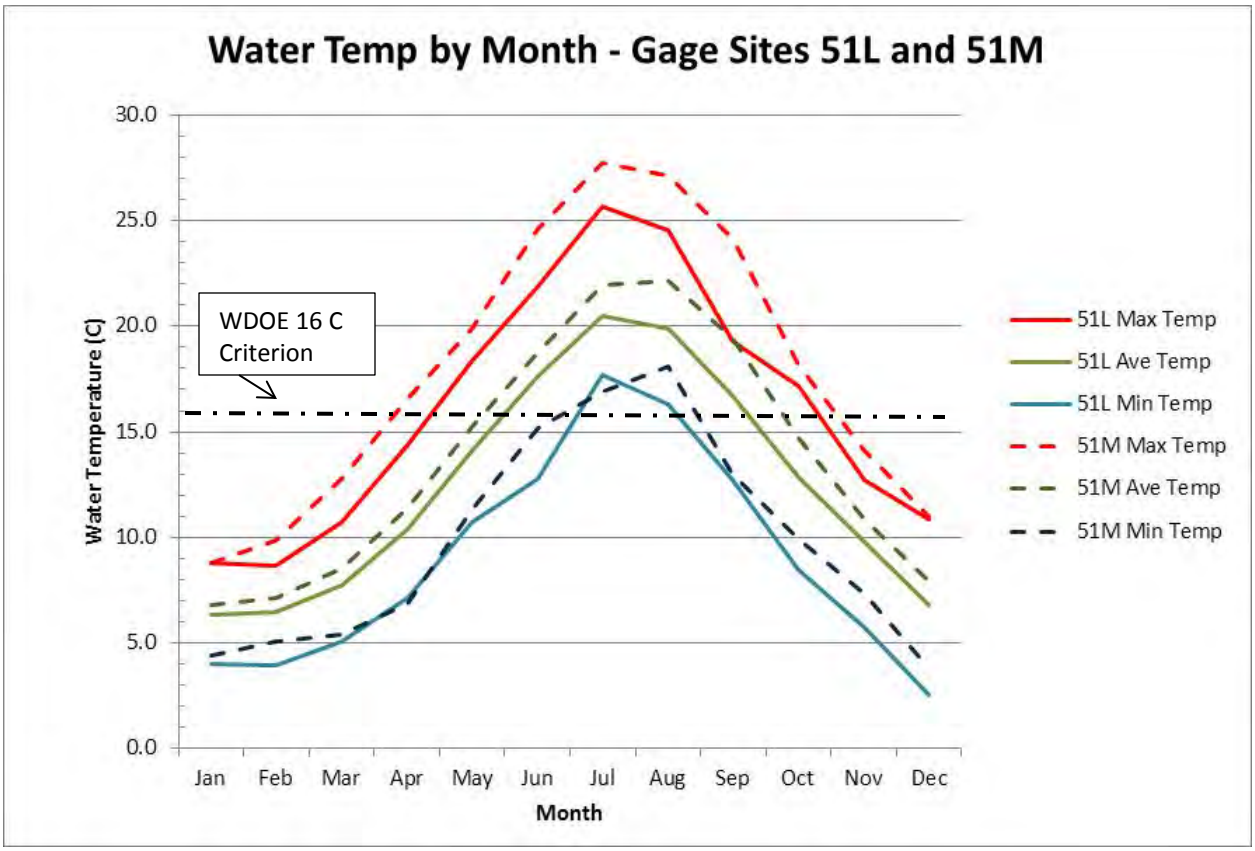

Figure 10. Monthly water temperatures in Sammamish River at Weir (Gage 51M) and railroad bridge (Gage 51L)

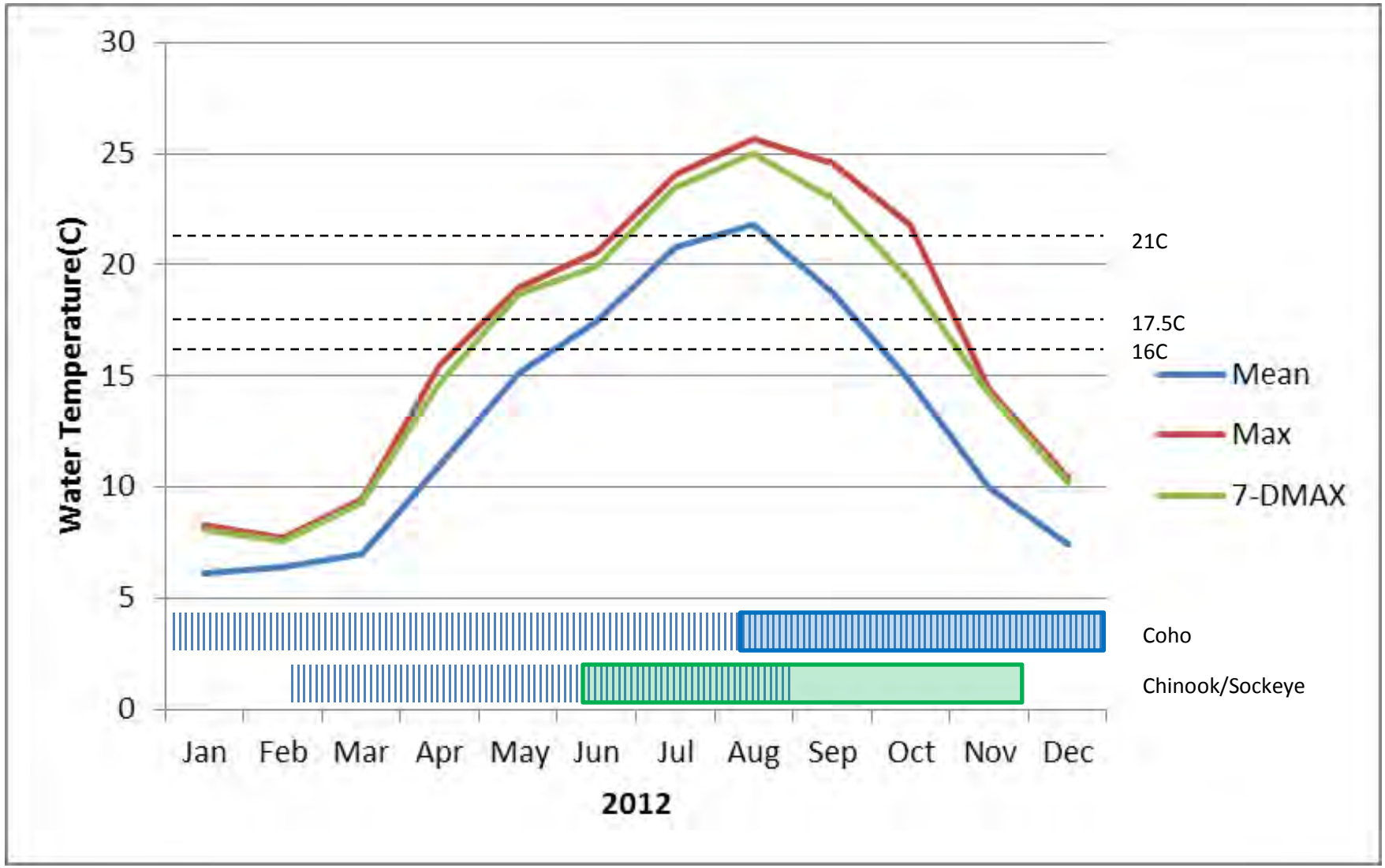

Figure 11. Average and maximum monthly water temperature in the Upper Sammamish River and comparison to water quality thresholds and fish presence. Hatched bars indicate timing of juvenile salmon; solid bars indicate timing of adult salmon in Lake Washington basin.

In Lake Sammamish, Gage 612 (near the middle of the lake) has data loggers at multiple depths including surface (1 meter or 3.3 feet), mid-depth (10 meters or 33 feet and 15 meters or 49 feet) and deep water (20 meters or 66 feet). Figure 12 shows mean and maximum water temperatures by month at these three depths for Gage 612. Figure 13 shows mean dissolved oxygen concentrations by month at these three depths for Gage 612. The WDOE criterion for dissolved oxygen is 9.5 milligrams/liter (mg/l) for core summer salmonid habitat and 8 mg/l for salmonid spawning, rearing, and migration (WDOE 2012).

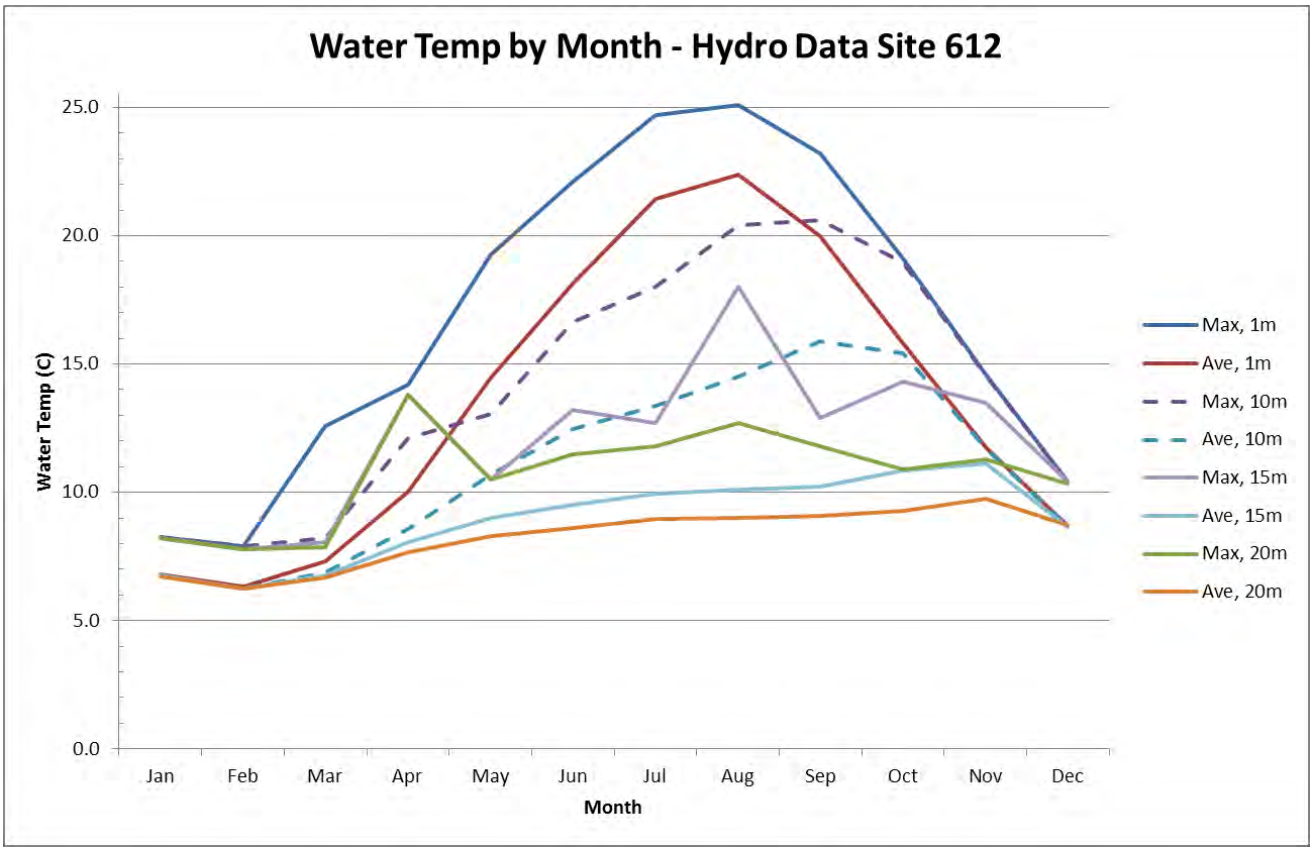

Figure 12. Monthly mean and maximum water temperatures at Lake Sammamish Gage 612 at 1, 10, 15, and 20 meter depths

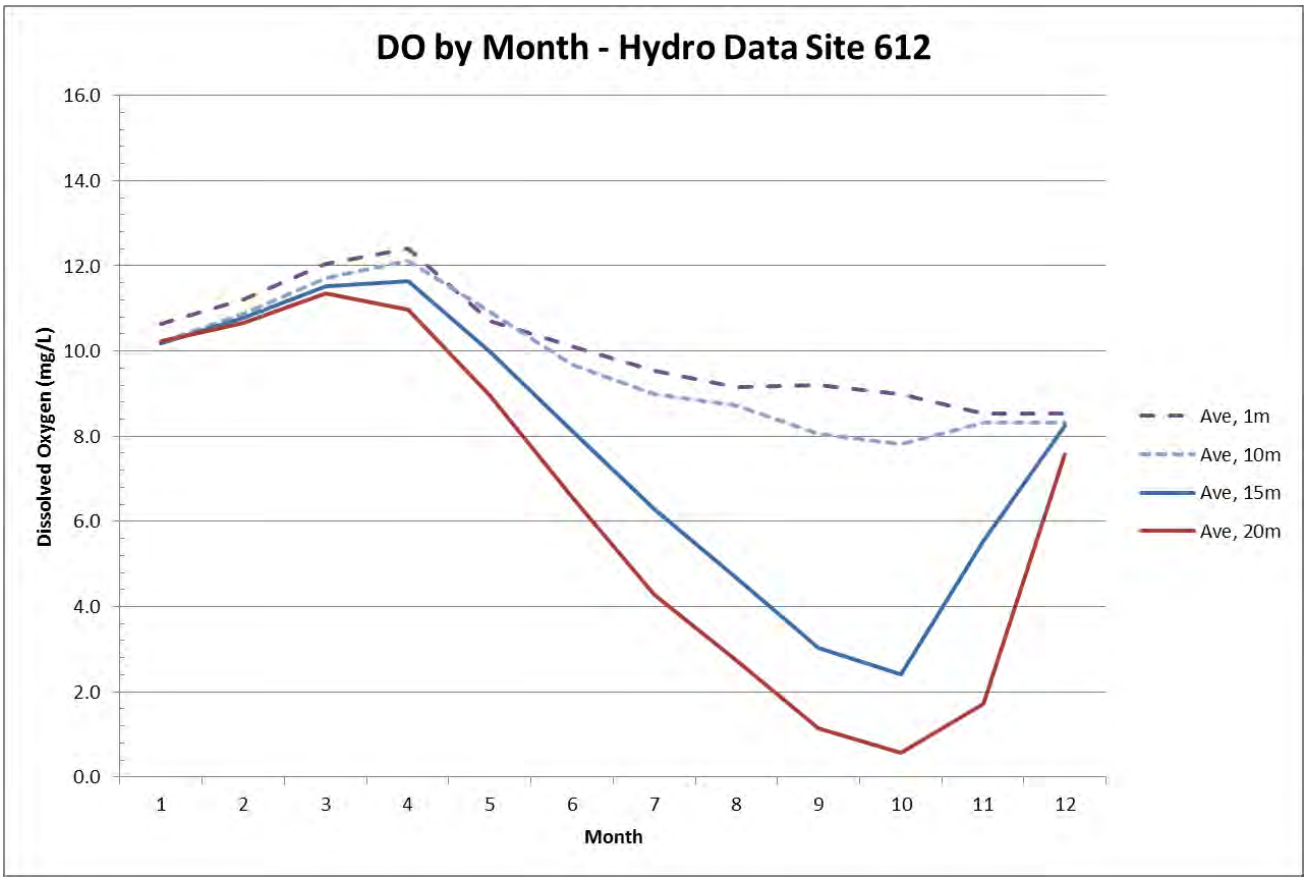

Figure 13. Monthly mean dissolved oxygen concentrations at Lake Sammamish Gage 612 at 1, 10, 15, and 20 meter depths

Dissolved oxygen (dissolved oxygen) is inversely related to temperature. King County deployed continuous sensors to measure temperature and DO from July 3 through September 27, 2012 (King County unpublished data). In the project area (located just downstream of the Transition Zone), the minimum DO concentration was 5.2 mg/l, maximum was 10.8 mg/l, and mean was 8.9 mg/l over the 2012 data collection period.

6. Wetlands

Previous studies of existing conditions for the project area included wetland delineations completed in 2003 (Bowles *et al.* 2003) and 2005 (Bowles 2005). Updating the wetland delineation and functional assessment is being undertaken because conditions may have changed since the previous reports and wetland delineation protocol details for the region have been revised (USACE 2010). This report is intended to provide updated mapping, functional assessment, and narrative description of the wetlands within the study area; building on previous reports by Bowles *et al.* and supplementing with recent field investigations.

In conjunction with these field investigations, data were collected regarding the vegetation communities present throughout the entire study area, including both wetland and upland communities.

6.1 Historic Land Use and Site Alterations

The project area was formerly agricultural and single-family residential. Thus, the soils have been plowed and disturbed over the past 100 plus years. The site has generally been fallow as open space for nearly 20 years and owned by King County. A portion of the site was used as a wastewater treatment facility including settling ponds. Much of the area that was formerly occupied by the wastewater treatment facility is now operated as a rowing facility (Sammamish Rowing Association) and includes an access road, storage buildings, a launch site, and a mitigation area. A former willow nursery is also present at the south end of the project area, but it has also been fallow for many years.

Construction of the 1964 channel improvements included dredging of the river sediments; most of which were side-cast onto the riverbanks to raise the bank elevation. Thus, locations along the riverbank have river sediments (primarily sands) as opposed to natural soils present.

6.2 Precipitation Data and Analysis

Field work for the delineation was conducted during October 2013 at the end of the dry summer season when fall rains typically begin. The months preceding had both normal and well above normal precipitation (Table 3) (NRCS 2013; NOAA-NWFSO 2013). August 2013 had near normal precipitation while September 2013 had substantially more precipitation than normal. During the two weeks prior to the delineation there was virtually no precipitation (NOAA-NWFSO 2013) and no precipitation on the days of the field investigation (October 28 and 29, 2013). Precipitation data from the Seattle-Tacoma Airport was used for this analysis because it was the closest source for both the NOAA-National Weather Service Data and WETS Station Data.

Six shallow piezometers were installed in late October 2013 to help confirm the wetland delineation and water levels were recorded through May 2014. The water level data indicated that these areas were wet (water present at, above, or within 1 foot of the ground surface during several months), and a supplemental site visit to add additional areas as wetlands was conducted in June 2014.

TABLE 3. Precipitation comparison at closest WETS and NOAA weather station site (Sea-Tac). WETS data includes the average monthly precipitation and 30% chance range (in parenthesis).

PRECIPITATION MONTH OF DELINEATION		PRECIPITATION PRECEDING MONTHS			
October (inches)		August (inches)		September (inches)	
2013	Normal	2013	Normal	2013	Normal
1.54[/1]	3.19 (1.96 – 3.86)[/2]	1.35[/1]	1.02 (0.38 – 1.24)[/2]	6.17[/1]	1.63 (0.62 – 2.03)[/2]

[/1] NOAA-NWFSO 2013
[/2] NRCS 2013

6.3 Methods

Wetlands are defined by the U.S. Army Corps of Engineers (USACE) and the U.S. Environmental Protection Agency (EPA) as:

> *"Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas."*

Wetlands are generally characterized by three parameters: vegetation, soil, and hydrology. At least one indicator for each parameter is required to delineate an area as a wetland, except in certain circumstances defined in the wetland delineation manual (USACE 1987) and subsequent guidance and regional manuals (USACE 2010).

The field wetland delineation was completed within the study area on October 28 and 29, 2013 following the 1987 Wetland Delineation Manual (USACE 1987) protocol, along with supplemental detail provided in the Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region (Version 2.0, USACE 2010). The functional assessment was conducted following the protocol in the Washington State Wetland Rating System for Western Washington (Hruby 2004, annotated August 2006).

Prior to field work a base map was prepared showing the wetlands delineated in the 2003 and 2005 reports, as well as wetlands reported by the National Wetland Inventory (NWI) and the City of Redmond. Soil surveys were reviewed to determine the presence of hydric soils (NRCS 2013).

A routine level field sampling method was employed throughout the project site, where accessible, to evaluate wetland conditions. Sample plots were located to represent wetland and upland sites and were typically "paired" or located in close proximity to demonstrate the differences and potential boundary location. In areas not previously determined to be wetland, sample plots were located generally along a transect extending across the project area from West Lake Sammamish Parkway to the river. Individual sample plots consisted of holes dug to 14 inches deep in representative wetland and upland plots. Vegetation, soils, and hydrology were sampled at each plot and data were recorded on wetland rating forms for western Washington (Appendix B).

Field indicators were assessed using the Regional Supplement (USACE 2010) and the latest version of the National Wetland Plant List (USACE 2013). Wetland plot vegetation data were collected using sample plot circular diameters of 30 feet for tree canopy, 12 feet for shrubs, and six feet for herbaceous cover and determining percent cover for each species present. Sample plots were located using a Trimble GeoXT GPS (sub meter accuracy) and wetland boundaries were compared to previous boundaries; location data were then translated into a wetland delineation map using ArcGIS.

Additional sample plots to document vegetation communities were also identified with field plots measuring approximately 30 feet in diameter, within which all vegetation present and percent cover were recorded. These communities were then located using the Trimble GeoXT GPS and translated into ArcGIS map polygons in the office.

6.4 Results

6.4.1 Soils

Soils mapped within the study area included Alderwood gravelly sandy loam (6-15 percent slopes), Earlmont silt loam, Kitsap silt loam (2-8 percent slopes), Pilchuck loamy fine sand, Seattle muck, Sultan silt loam, and Tukwila muck (NRCS 2013). Soils are categorized as hydric (100 percent hydric), predominantly hydric (66-99 percent hydric), predominantly non-hydric (1-32 percent hydric), and non-hydric (NRCS 2013). Tukwila and Seattle mucks are hydric soils and Earlmont is predominantly hydric. Alderwood, Pilchuck, Kitsap, and Sultan soils are predominantly non-hydric, but may have hydric inclusions.

In general, the mapped soils were not confirmed in the field, although diatomaceous material was found in many sample plots and is identified as a layer in the Earlmont soil. Overall, most soil plots were closest in resemblance to the Earlmont soils. Many of the soils had mottling that is indicative of reduction and oxidation occurring from seasonal inundation or saturation, and this is consistent with the description of the Earlmont soils. However, even when soils have been effectively drained, hydric soil indicators such as mottles can remain in the soil, making it difficult to determine if a site is still wetland, or not.

6.4.2 Hydrology

Plots with strong positive hydrology indicators were either saturated within the upper 12 inches of the soil, had a water table within the upper 12 inches of the soil, or had standing surface water. Secondary hydrology indicators were typically not present.

In general, hydrology was a strong indicator of wetlands in many areas of the site. However, in some parts of the site, there were no hydrology indicators present. As the delineation occurred at the end of the dry summer season and some of the wetlands on the site are seasonal, the lack of hydrology does not necessarily mean the site was not wetland. In order to assist wetland determinations on portions of the site that were lacking hydrology, six piezometers were installed along with data loggers that recorded water levels through May 2014. Piezometer data was used to determine wetlands in some locations.

6.4.3 Vegetation

Dominant trees on the site include black cottonwood (*Populus balsamifera*), red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*), Oregon ash (*Fraxinus latifolia*), Douglas fir (*Pseudotsuga menziesii*), Pacific willow (*Salix lucida s. lasiandra*), and Sitka willow (*Salix sitchensis*). Isolated ornamental trees are also present including domestic apple (*Pyrus malus*); indicative of the former agricultural and residential land use.

Scrub-shrub layers are overwhelmingly dominated by non-native blackberries (*Rubus armeniacus*) throughout the site, but also have substantial cover of Sitka and Pacific willows, Douglas spirea (*Spiraea douglasii*), red osier dogwood (*Cornus sericea s. occidentalis*), and peafruit rose (*Rosa pisocarpa*). Non-native shrubs including Scotch broom (*Cytisus scoparius*), English hawthorn (*Crataegus monogyna*), butterfly bush (*Buddleia davidii*) and Japanese knotweed (*Reynoutria japonica*) are present in patches. Less common native shrubs include snowberry (*Symphoricarpos albus*), thimbleberry (*Rubus parviflorus*), and salmonberry (*Rubus spectabilis*).

The herbaceous layer is overwhelmingly dominated by reed canary grass (*Phalaris arundinaceae*) throughout the site, which often occurrs as a monoculture in large areas. In some areas, reed canary grass is interspersed with patches dominated by sedges (*Carex obnupta*), rushes (*Juncus effusus*), other grasses (*Agrostis gigantea*), and Canada thistle (*Cirsium arvense*). Other common herbaceous plants included creeping bent grass (*Agrostis stolonifera*), yellow flag iris (*Iris pseudacorus*), creeping buttercup (*Ranunculus repens*), tall fescue (*Schedonorus arundinaceus*), and bittersweet nightshade (*Solanum dulcamara*). Two Regulated Class B noxious weeds are present along the river in Wetlands B and C, purple loosestrife (*Lythrum salicaria*) and yellow or garden loosestrife (*Lysimachia punctata or L. vulgaris*).

Vegetation is overall highly disturbed and dominated by non-native species throughout the study area. In general, the vegetation was not a reliable indicator of wetlands as there were many facultative (FAC) species and many non-native species that occur equally well in upland and wetland locations.

6.4.4 Wetland Determinations

A total of five wetland areas were found and mapped within the study area (Figures 14 and 15). In general, these wetlands confirmed the wetlands as previously delineated (Bowles *et al.* 2003, Bowles 2005), with some increases in extent. A description of representative sample plots is provided below for each wetland. Data sheets are attached as Appendix B.

Creeks that were mapped in the project area included Tosh Creek and County Creek. County Creek was located from West Lake Sammamish Parkway through approximately half of its alignment, but an extensive area of standing water in Wetland E did not allow for its entire alignment to be mapped to the Sammamish River. It was confirmed that this creek does not flow through the Willow Nursery area (at the southeast end of the study area within a large reed canary grass monoculture) as previously shown on King County mapping. There were no swales, channels, or depressions of note within the former Willow Nursery area.

Wetland A

Wetland A covers 9.2 acres and is located in the northwest corner of the study area. It extends parallel to West Lake Sammamish Parkway roughly from NE 58th Court at the north end to NE 50th Way at its south end. It is a long narrow depressional wetland that is likely influenced by groundwater and surface runoff from West Lake Sammamish Parkway and the developed hill slope to the south.

Wetland Plot 2

Wetland Plot 2 was located in a flat terrace below West Lake Sammamish Parkway at the north end of the site. The vegetation was dominated by black cottonwood (FAC), big-leaf maple (FACU), creeping bentgrass (FAC), small-fruited bulrush (*Scirpus microcarpus*; OBL), and bittersweet nightshade (FAC). Standing water was present at a depth of two inches. The soil was highly saturated throughout the pit and was organic (histosol). A soil color was not taken as the soil was so wet and loose that an appropriate sample could not be pulled out. Positive indicators for all three parameters were found and this plot was determined to be wetland.

Wetland Plot 3

Wetland Plot 3 was paired with Wetland Plot 2 to contrast the upland characteristics. The vegetation was dominated by black cottonwood (FAC), big-leaf maple (FACU), and reed canary grass (FACW). The soil was fine gravelly sand with a matrix color of 10YR 3/2 and no mottles. The soil color was dark enough to meet hydric soil indicator F3 (depleted matrix). No hydrology indicators were present. As both the vegetation and soil indicators were fairly weak and significantly different from the vegetation and soil at Wetland Plot 2 (located approximately 8 feet away), and no hydrology indicators were present, this plot was determined to be upland.

Wetland Plot 9

Wetland Plot 9 was located further to the south and east, still immediately below West Lake Sammamish Parkway. The vegetation was dominated by black cottonwood (FAC), Sitka willow (FACW), Douglas spirea (FACW), creeping bent grass (FAC), slough sedge (OBL), and tall fescue (*Schedonorus arundinaceae*; FAC). The soil was medium sand with a matrix color of 10YR 4/1 and distinct mottles with a color of 7.5YR 5/8. This met the hydric soil indicator S5 (sandy redox). The soil was saturated at twelve inches. Positive indicators for all three parameters were found and this plot was determined to be wetland.

Wetland Plot 8

Wetland Plot 8 was paired with Wetland Plot 9 to contrast the upland characteristics. The vegetation was dominated by black cottonwood (FAC), Lombardy poplar (N.L), Sitka willow (FACW), Himalayan blackberry (FACU), timothy (*Phleum pratense*; FAC), and creeping bent grass (FAC). The soil was medium sand with a matrix color of 10YR 5/1 and a few indistinct mottles of 10YR 5/8. The mottles were not distinct enough to meet hydric soil indicator S5 (sandy redox). There were no hydrology indicators

present in October 2013. However, based on piezometer data, standing water was present in close proximity. Thus, this site was determined to be wetland.

Boundary Determination

The boundary determination was generally made where a distinct vegetation community change was observed, or where hydrology disappeared.

Wetland B

Wetland B covers 2.3 acres and is a riverine wetland located along the Sammamish River TZ on the south or west bank (left bank). This area is separated from Wetland A by an access roadway for maintenance vehicles that runs along the top of the river bank. The wetland extends the length of the TZ starting near the north boundary of the study area and extending just upstream of the weir and roughly corresponds to the designed high flow channel. The toe of the berm slope is roughly where the wetland boundary lies and is also indicated by the presence of the Ordinary High Water Mark (OHWM) observable where the tree line persists. Angular rock and sandy high chroma soils were present on the slope, indicating well drained conditions. Two sample plots were within this wetland.

Wetland Plot 4

Wetland Plot 4 was located on the slope of the bank just below the transition zone (but below the access road). Vegetation was dominated by Sitka willow (FACW), Himalayan blackberry (FACU), reed canary grass (FACW), and yellow-flag iris (OBL). The soil was gleyed silty sand with a matrix color of Gley1 3/N and distinct mottles of 7.5YR 5/8. This met the hydric soil indicator S4 (sandy gleyed matrix). Groundwater was present at 8 inches and the soil was saturated to the surface. Positive indicators for all three parameters were present and this plot was determined to be wetland.

Wetland Plot 5

Wetland Plot 5 was located in the high flow area of the TZ. The vegetation had been recently mowed, but was dominated by reed canary grass (FACW) and small-fruited bullrush (OBL). The soil was gleyed silty sand with a matrix color of Gley1 4/5GY and distinct mottles of 7.5YR 5/8. This met the hydric soil indicator S4 (sandy gleyed matrix). Groundwater was present at 8 inches and the soil was saturated to the surface. Positive indicators for all three parameters were present and this plot was determined to be wetland.

Boundary Determination

The boundary determination was made at either the ordinary high water mark (OHWM) as evidenced in the field by living woody vegetated stems and by topography and presence of angular rock located on the bank slope up to the access roadway.

Wetland C

Wetland C also covers 2.3 acres and is a riverine wetland located along the Sammamish River TZ on the north or east bank (right bank), just across from Wetland B. Wetland C roughly mirrors Wetland B in length and width.

Wetland Plot 35

Wetland Plot 35 was located in the high flow area of the TZ. The vegetation had been recently mowed, but was dominated by reed canary grass (FACW). The soil was gleyed silty sand with a matrix color of Gley1 3/10Y and no mottles. This met the hydric soil indicator S4 (sandy gleyed material). The soil was saturated to the surface. Positive indicators for all three parameters were present and this plot was determined to be wetland.

Wetland Plot 37

Wetland Plot 37 was located in the high flow channel area of the TZ where sediment had recently been removed. Vegetation was sparse and dominated by blue grass (*Poa pratensis*; FAC). The soil was silt with quarry spalls with a matrix color of 10YR 4/1 with no mottles. This does not meet hydric soil indicator F3 (depleted matrix) without mottles. Water was present at 10 inches below the surface and the soil was saturated. Positive indicators for vegetation and hydrology were present and particularly due to the presence of water, this plot was determined to be wetland. The soil was comprised largely of quarry spalls that would not show redoximorphic features.

Boundary Determination

The boundary determination was made at either the ordinary high water mark (OHWM) as evidenced in the field by living rooted woody vegetated stems or by topography and presence of angular rock located on the bank slope up to the trail.

Wetland D

Wetlands D1 and D2 are two very small depressional wetlands that each comprise approximately 0.2 acres and are not large enough to create visible polygons on the mapping. Both wetlands were immediately visible in the field due to an abrupt change from reed canary grass to nearly 100% cover of slough sedge (*Carex obnupta),* an obligate wetland species. Soils are silty clay with a matrix of Gley1 4/5GY and distinct mottles of 10YR 5/6. The soil was saturated at 10 to 12 inches depth.

These two patches are fairly near to what had been identified as Wetland B in the Bowles, et al. (2003) report, which could not be found during this wetland investigation. It is not likely that a Douglas spirea wetland (previously identified) would have transitioned to a sedge-dominated wetland without evidence of dead shrubs. It is more likely that the formerly Douglas spirea wetland has been overgrown with Himalayan blackberry and was not observed during this wetland delineation.

Wetland E

Wetland E is a lake-fringing wetland that extends into the floodplain and covers 41.4 acres and is located in the southeast portion of the study area. Its eastern border follows the open water boundary of Lake Sammamish and Sammamish River, extending from the lake to just downstream of Tosh Creek. The wetland covers the bulk of the southern portion of the study area, including areas surrounding the Sammamish Rowing Association buildings and the abandoned wastewater treatment ponds. Three piezometers were installed in the western portion of this wetland to confirm the wetland in this area.

Wetland Plot 15

Wetland Plot 15 is located at the eastern end of Wetland E. Vegetation is dominated by Douglas spirea (FACW) and reed canary grass (FACW). The soil is silty clay with a matrix color of 10YR 4/2. There were clods of diatomaceous earth at 10 to 12 inches (could have been historically plowed). The soil was not dark enough to meet hydric soil indicator F3 (depleted matrix) without mottles. The soil was saturated, however, at 10 inches. The presence of strong vegetation and hydrology indicators indicates that the plot is likely a wetland even with a lack of a hydric soil indicator. Particularly the presence of saturated soils in late fall is a strong indicator that the site is a wetland.

Wetland Plot 16

Wetland Plot 16 was paired with Wetland Plot 15 to distinguish upland characteristics. Vegetation is dominated by Himalayan blackberry (FACU), pea-fruit rose (FAC) and reed canary grass (FACW). The soil was the same silty clay with a matrix color of 10YR 4/2 without mottles. There were no hydrology indicators. Due to the lack of either hydric soil or hydrology indicators coincident with the transition to blackberry dominated vegetation, this plot was determined to be upland.

Wetland Plot WA

Wetland Plot WA was taken in June 2014 in proximity to piezometer #3. Vegetation is dominated by scouring rush (*Juncus effusus*; FACW). The soil is silt loam with a diatomaceous layer below 10 inches with a matrix color of 10YR 6/1 with numerous mottles of 10YR 6/8. Piezometer data indicated this area had water within one foot of the surface for several months. This plot was determined to be wetland.

Wetland Plot 26

Wetland Plot 26 was located south and east of the Sammamish Rowing Association road and buildings. The vegetation was dominated by reed canary grass (FACW) with much lesser abundance, but still dominant Himalayan blackberry (FACU); the prevalence index was 2.2. The soil was silty clay with a matrix color of 10YR 3/2 and distinct mottles of 10YR 5/6. The met the hydric soil indicator F3 (depleted matrix). Oxidized root channels (rhizospheres) were present along living roots, meeting that hydrology indicator although no water was present. Positive indicators of all three parameters indicate this plot is wetland.

Wetland Plot 27

Wetland Plot 27 was paired with Wetland Plot 26 to distinguish upland characteristics. Vegetation is dominated by reed canary grass (FACW). The soil was silty clay with a matrix color of 10YR 4/2 with indistinct mottles of 10YR 5/3. The mottles were determined to be barely distinguishable and thus did not meet the hydric soil indicator F3 (depleted matrix). There were no hydrology indicators. Due to the lack of either hydric soil or hydrology indicators this plot was determined to be upland.

Wetland Plot 33

Wetland Plot 33 was located in the eastern portion of Wetland E closer to Lake Sammamish. Vegetation is dominated by Oregon ash (*Fraxinus latifolia*; FACW) and reed canary grass (FACW). The soil was clayey silt with a matrix color of 10YR 2/1 without mottles. This is sufficiently dark to meet hydric soil indicator F3 (depleted matrix). Water was present at 12 inches below the surface and the soil was saturated to the surface. Positive indicators of all three parameters indicate this plot is wetland.

Lake Fringing Wetland

Vegetation was documented in this area of standing water (Vegetation Plot 29). Vegetation is dominated by Pacific willow (*Salix lucida* var. lasiandra; FACW), reed canary grass (FACW), red osier dogwood (*Cornus stolonifera*; FACW), thimbleberry (FACU), and Oregon ash (FACW).

Boundary Determination

The boundary determinations were made where the vegetation dominance changed (such as to Himalayan blackberry) or where the soil and hydrology indicators were lost.

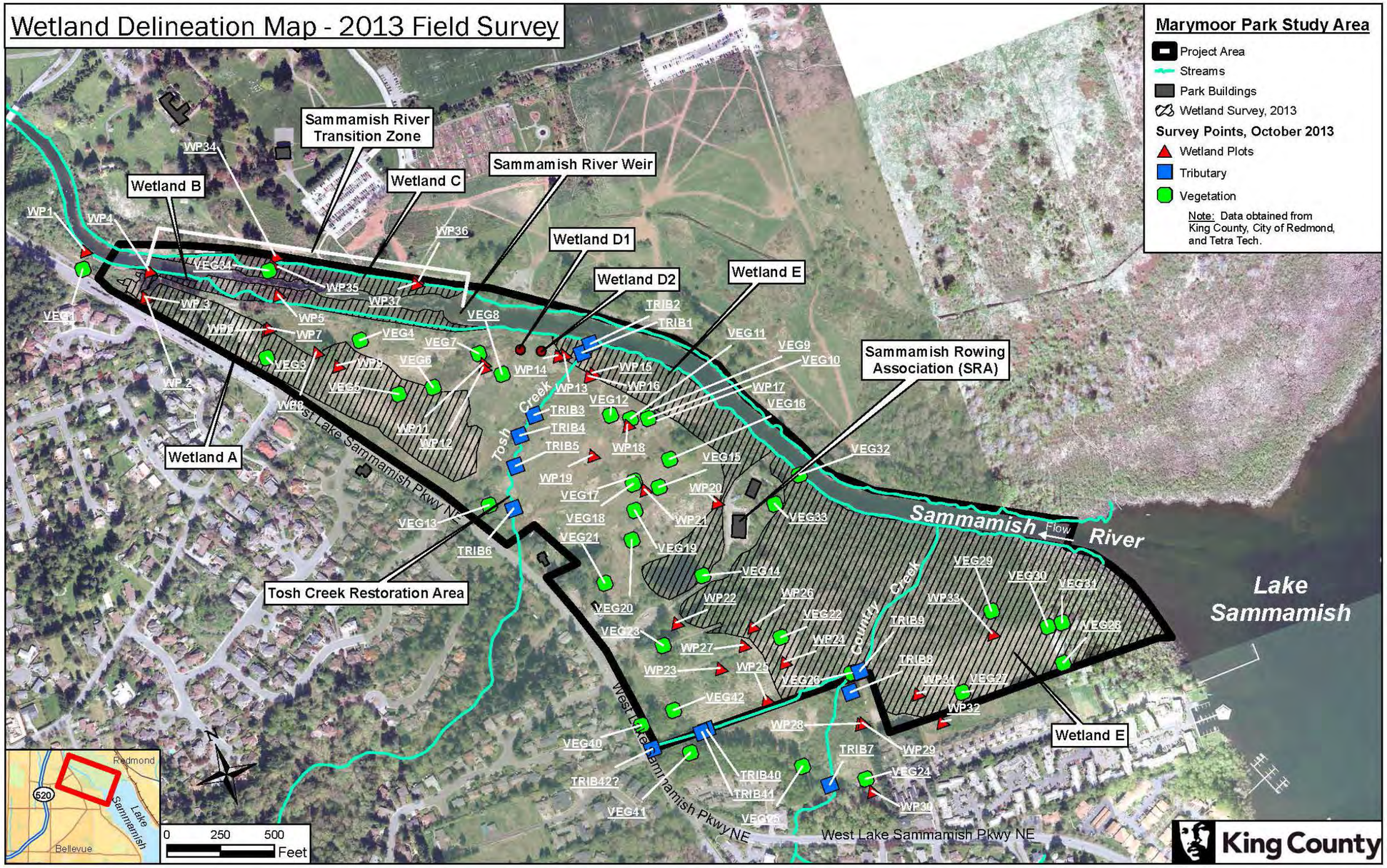

Figure 14. Wetland Sample Plot and Boundary Map.

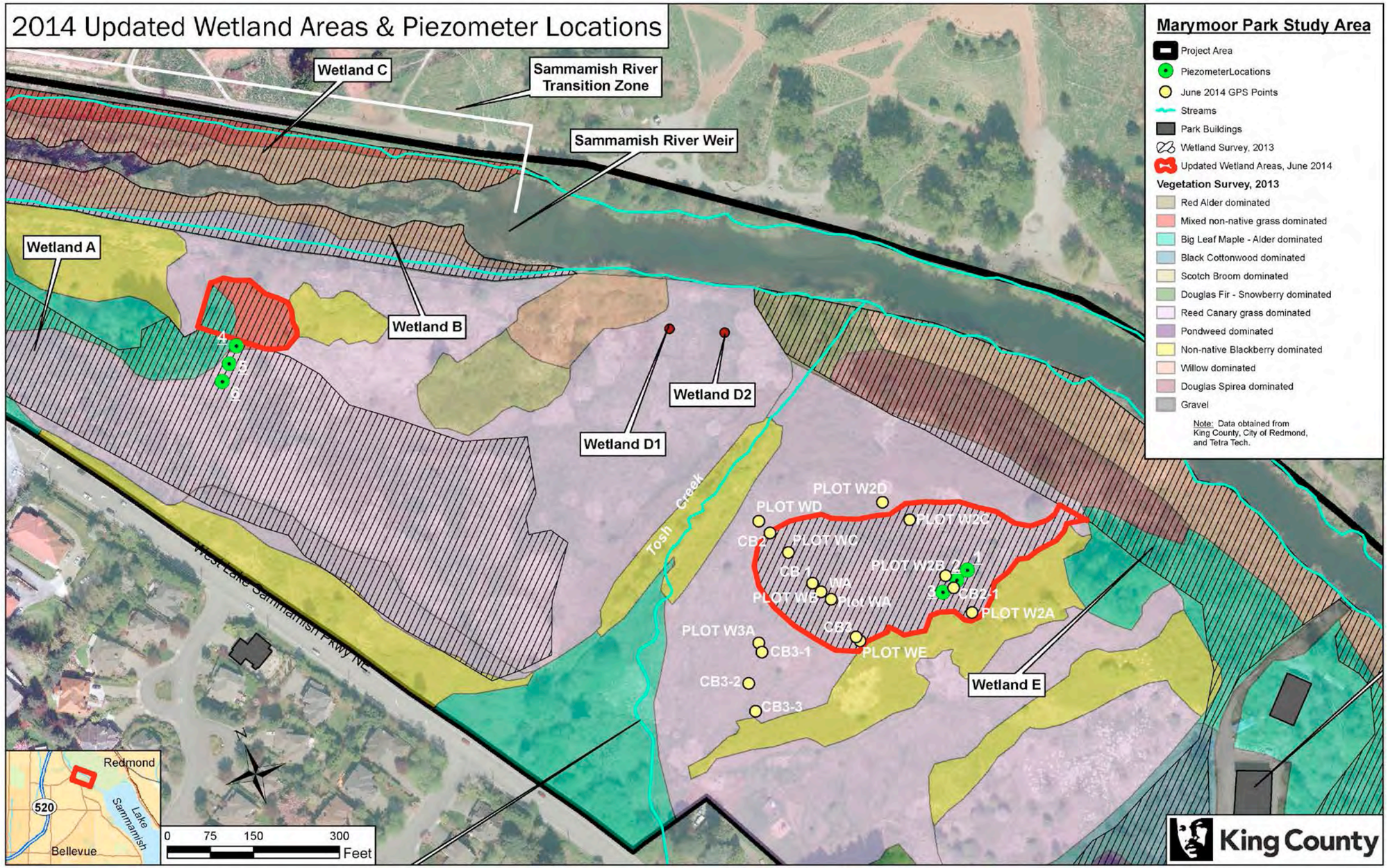

Figure 15. Updated Wetland Boundaries and Piezometer Locations, 2014.

6.5 Wetland Functional Assessment and Rating

Information used to prepare the functional assessment came from data collected in the field on October 28 and 29, 2013, data available from previous investigations (Bowles *et al*. 2003 and Bowles 2005) and online sources, and information from County staff and park users familiar with the study area. Wetlands delineated in the study area were rated and categorized according to the Washington State Wetlands Rating System (2004). Functional assessment data sheets are provided in Appendix C.

The rating system requires the assessment of several parameters that describe existing wetland conditions, which are translated into a point system to indicate the level of function occurring or that has the potential to occur within the wetland. The parameters are divided into water quality functions, hydrologic functions, and habitat functions. The final outcome of the rating system is placement of the wetland into a Category of I, II, III, or IV. Category I wetlands are those that provide excellent function, are ecologically valuable or sensitive, or are unique or rare. These wetlands must be protected from degradation. Category II wetlands are functionally valuable, and though they are not as essential to protect as Category I wetlands, still require a relatively high level of protection. Category III wetlands provide a moderate level of wetland functions, but can be less diverse or more isolated from other natural resources in the landscape. Category IV wetlands have the lowest functional value, typically due to heavy disturbance. These wetlands often have the potential to improve. In some cases, these wetlands provide at least one important function and should be protected. Understanding the current level of function of the wetland on the project site will help in the identification of restoration or enhancement measures that could improve function.

Water quality functions include ratings for surface flow conditions, soil condition, and characteristics of persistent vegetation. If the wetland has the potential to provide improvements to water quality, the score is doubled. The potential to provide improvements is based on the potential for pollutants to be within the study area, or to be washed into the study area. Because the area is adjacent to residential development and roadways, and because untreated stormwater runs into the wetland via culverts or streams throughout the site, each wetland score in Table 3 has been doubled for water quality functions.

Hydrology is assessed using characteristics of surface flow, depth of water storage during wet periods, and contribution of wetland to storage in larger watershed. Again, if the wetland has the opportunity to provide improvement to hydrologic functions, based on the presence of hydrologic problems within the area, the score is doubled. The potential for improving hydrologic function varies between wetlands and not all scores were doubled.

Habitat conditions are rated by assessing the potential for the wetland for supporting habitat for a variety of species, the wetlands hydroperiod variability, richness of plant species, interspersion of plant communities and habitats, presence of special habitat features, buffer condition, corridors and connectivity to other habitats, presence of priority habitats as defined by WDFW, and the larger wetland landscape. There is no doubling factor possible for this function rating.

If a wetland contains one or more items from a special set of characteristics (i.e. documented to contain a listed species), it can be categorized as a Category I wetland based solely on that condition. There were no wetlands in the study area that could be categorized based on these special characteristics (although Wetlands A, B, and E fringe waterbodies known to contain listed salmon species) and none of the project wetlands were Natural Heritage Wetlands (DNR 2013).

Based on data gathered over the past several years by Friends of Marymoor Park, there are several Washington Department of Fish and Wildlife priority species that are known to be present in the study area. According to the wetland rating system, wetlands with priority species present may require additional protections Additional details on wildlife and wildlife habitat are provided in Appendix D.

Prior to performing the rating assessment, it must be determined which classification best describes the wetland. Within the study area, wetlands were identified as depressional (Wetlands A and D), riverine (Wetlands B and C), and lake-fringe (Wetland E). Though Wetland E had multiple wetland types, the largest area of the wetland was classified as lake fringe. Wetland classifications, ratings, and category are provided in Table 4.

Table 4. Wetland Functional Assessment and Rating Categories.

Wetland	A	B	C	D	E
Classification	Depressional	Riverine	Riverine	Depressional	Lake-fringe
Water Quality	24	20	20	8	24
Hydrology	10	18	18	4	12
Habitat	16	22	22	9	26
Total Score	50	60	60	21	62
Category	**III**	**II**	**II**	**IV**	**II**
Priority Species Present?	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*

Wetland A

Wetland A is a depressional wetland that received a Category III rating, primarily due to its lack of hydrologic functioning. Though the site retains water and should have the potential to reduce flooding and erosion, the depth of water storage and the size of the wetland are not sufficient. Water quality and habitat functions received higher overall ratings. The wetland has the potential to improve water quality since the unit is a depression with no water leaving, has persistent ungrazed vegetation throughout the majority of the site, and the wetland is seasonally ponded throughout more than half its area. The hydrologic score is doubled since the wetland ponds surface water runoff that might otherwise flow into

a river that has flooding problems. Habitat function is fair with good scores for buffers, corridors, and lake-fringe landscape, and low scores for special habitat features, vegetation structure and hydroperiod. Opportunities for enhancement include control of non-native species and planting a more diverse native plant community, placement of wood, and excavation of microtopographic features to store water longer and provide diversity of habitat.

Wetland B

This riverine wetland has an overall score of 60, giving it a Category II rating. In this case, scores for water quality, hydrologic, and habitat functioning are all similar and are valuable ecologically. The wetland unit has the potential to improve water quality and hydrologic functions, as well as the opportunity to do both. This is due to the ability of the wetland to reduce flood flows and trap sediments and also has the opportunity to do so due to the presence of human structures and natural resources downstream that may be damaged by flooding. However, the area is relatively small with little overbank storage capacity. Habitat function strengths include a variety of hydroperiods within the wetland, high interspersion of existing habitats, buffers, corridors and the overall wetland landscape or proximity to other wetlands. Habitat function weaknesses include low species richness, lack of WDFW priority habitats, and lack of special habitat features. Opportunities for enhancement include control of non-native species, placement of wood, reducing mowing/maintenance by increasing capacity, and planting a more diverse native plant species community.

Wetland C

This riverine wetland has received the same functional assessment as Wetland B, Category II with 60 total points. Wetland C conditions mirror those described for Wetland B, since they are separated only by the narrow river low-flow channel. Opportunities for enhancement include control of non-native species, placement of wood, reducing mowing/maintenance by increasing capacity, and planting a more diverse native plant species community.

Wetlands D1 and D2

These two small depressional wetlands have received scores of 21 and fall into Category IV. Though these wetlands have the potential for improving water quality (and scores have been doubled to reflect that potential) and hydrologic function, their size is so small that the opportunity results in no appreciable benefit. There is no opportunity to improve hydrologic function and those scores have not been doubled. Further, because the unit area is so small, very little habitat diversity is present and habitat function is very low. Opportunities for enhancement include the potential to connect these small wetland patches to the larger Wetland E, control of non-native species, placement of wood, and planting a more diverse native plant species community.

Wetland E

Wetland E received the highest score within the study area and is a Category II lake-fringe wetland. Water quality and habitat functions received higher scores, while hydrologic functions were fair. Water quality functions were strong due to a high average width of vegetation along the lakeshore, extent of

herbaceous cover within the wetland, and having the potential to improve water quality. Hydrologic function is based on vegetation classes along the lakeshore and an extensive boundary of shrubs or forest in this wetland, along with its potential to improve hydrologic function due to presence of human structures and activities. Habitat functions at this wetland were also high. Vegetation structure, hydroperiod, interspersion of habitats, buffers, corridors, and landscape context received highest scores, while special habitat features, WDFW priority habitats, and species richness were low. Opportunities for enhancement include control of non-native species, placement of wood, excavation of microtopographic features in the more disturbed areas of the wetland, and planting a more diverse native plant species community.

7. Vegetation Community Mapping

A number of distinct vegetation types were observed during field wetland delineations. A total of 75 vegetation sample plots were inventoried throughout the study area. In some cases, access was not possible to portions of the study area due to deep standing water or impassable blackberry thickets. Where vegetation could not be physically reached for evaluation, aerial photograph interpretation was used to determine map polygons. A total of 13 vegetation communities were identified, and if possible, classified and described as a habitat type based on Kunze (1994) for wetland areas. However, Kunze (1994) does not include non-native dominated wetland vegetation communities. Upland vegetation communities have been described using data and nomenclature from the Washington Natural Heritage Program (Chappell 2006). All vegetation communities present have been described below and all communities with areas greater than 0.1 acres have been mapped on Figure 16.

Red alder dominated. This community occurs at the mouth of Tosh Creek and in other patches. Tree canopy cover is at least 50%. This community is a variant of the natural *Alnus rubra-Rubus spectabilis* community described by Kunze (1994), but on the project site is highly disturbed with understory species including reed canary grass and Himalayan blackberry. A small component of *Rubus spectabilis* is present.

Mixed non-native grass dominated. This community represents the areas throughout the site that were dominated by non-native grasses other than reed canary grass. Creeping bent grass (*Agrostis stolonifera*) occurred throughout the site as part of the larger herbaceous layer mosaic where it grew in patches, or as individual plants under scrub-shrub or tree canopy. Poa was present in distinct large patches where maintenance activities take place, such as along the berms to the east and west of the river, along the terraces alongside the river, and in staging areas on the west side of the river. Non-native grasses colonize rapidly after disturbance to native habitats and generally require continued disturbance to remain.

Bigleaf maple – red alder dominated (Chappell 2006). This community type occurs mostly around shorelines and most remaining examples are small, fragmented, and degraded to varying degrees by non-native species. The community is dominated by bigleaf maple and/or red alder and may be associated with several other species. Within the study area, other associated species included Douglas

fir, thimbleberry, snowberry, vine maple, rose, sword fern, and horsetail. Chappell notes that non-native blackberry is a prolific invader of this association, and this was found to be true at the study site. Reed canary grass, English hawthorn, and holly (*Ilex aquifolium*) were also present. Other trees of lesser dominance in this community included native black cottonwood and Oregon ash. These communities primarily occurred at the margins of the study area along West Lake Sammamish Parkway and the access road leading to the Rowing Association buildings.

Sedge dominated (Kunze 1994) Slough sedge is a robust perennial herb that grows 20 to 60 inches in height. Pockets of slough sedge wetlands were present, but were too small to create polygons on the mapping. These areas are a monoculture of slough sedge and are less than 10 square meters in size. Kunze notes that this community type is often monospecific and field observations confirmed this. This community type occurred as patches in a mosaic that also included *Phalaris* dominated, *Agrostis* dominated, and *Rubus* dominated communities.

Black cottonwood dominated. Cottonwood is present in patches or as a minor component in many other vegetation communities. Cottonwood is a natural riparian species that often dominates in patches along lakes and streams. At the project site, it is only dominant in small areas.

Scotch broom dominated (non-native) Scotch broom is a perennial shrub of the Pea family that may reach heights of 10 feet. Scotch broom, once established, spreads rapidly and may become an impenetrable thicket to wildlife species. It displaces native and beneficial plants and prevents reforestation by shading out saplings. Its seeds are toxic to humans, horses, and other livestock and the plant is considered a fire hazard. Though control of this species is not required in the study area according to King County's noxious weeds categorization, it is recommended. Within the study area, Scotch broom grows in several distinct locations and typically indicates the presence of upland soils.

Douglas fir /snowberry-serviceberry dominated (Chappell 2006) Within the study area there were some distinct Douglas fir dominated forest canopy, such as along West Lake Sammamish Parkway near the parking lot for the Sammamish Rowing Association access road. These areas were associated with some of the species listed by Chappell, including snowberry, ocean spray, bigleaf maple, sword fern, bracken fern, and Scotch broom. They were also often found with holly, blackberry, reed canary grass and ornamental trees, such as Lombardy poplar.

Reed canary grass dominated (non-native). Reed canary grass is a perennial sod-forming grass that may grow to 8 feet (NRCS 2002). Benefits of this grass include its ability to control erosion and provide filtering of wastewater; it is also used by some wildlife for nesting, escape cover, and seed foraging. However, this plant rapidly becomes invasive where native species are unable to compete with its robust adaptations to inundation and frost. Initially seeded as hay or pasture on sites too wet for good performance of other forage plants, it has spread throughout the U.S. and become invasive in many sites. The study area has extensive cover of reed canary grass and it occurs in nearly every plant community on the site. It grows as a dense monoculture in many areas, as a mosaic with other patches, and as an herbaceous layer under forest canopy and scrub-shrub. Only thick blackberry seem to outcompete this grass.

Pondweed dominated (Kunze 1994) Pondweed (*Potomogeton* sp.) is an aquatic perennial herb that grows in permanently flooded areas including shallow lake margins or throughout shallow ponds. It was found in all four abandoned wastewater treatment ponds along the gravel road leading to the Sammamish Rowing Association buildings.

Non-native blackberry dominated. The Himalayan blackberry is a non-native and invasive species that can rapidly claim native habitats once established. It is technically a perennial subshrub of the rose family. Himalayan and evergreen blackberries (*Rubus laciniatus*) are both classified as Class C noxious weeds on the Washington State Noxious Weed List and are non-regulated noxious weeds in King County. Though the non-native blackberry species may occur occasionally in wetlands as FACU species, they are most often present in uplands. Throughout the study area, blackberries tended to be an indicator of upland and were often good wetland boundary indicators. These subshrubs quickly out-compete other native understory vegetation and prevent the establishment of trees that require sun for germination. Dense thickets prevent large mammals from moving freely through habitat and may restrict access to water or forage. Brambles also reduce habitat diversity and availability and may mask erosion issues along streambanks. Root structure is not adequate for bank stabilization.

Willow dominated (Kunze 1994). This community can be found in seasonally or permanently flooded wetlands. Vegetation can include any of the *Salix* species that occur in the region, and is often associated with Douglas spirea. These species tend to consist of several shrubby species forming a dense stand where one or more species of *Salix* is dominant. Within Marymoor Park, willow species include Pacific, Sitka, Piper's and Scouler's willow. Dominant species in the project area were usually Sitka willow and Pacific willow. In many *Salix* dominated communities, black cottonwood was also present. Not all willow community types in the study area were associated with wetlands.

Douglas spirea dominated (Kunze 1994) Spirea is a perennial deciduous shrub in the rose family that grows 2 to 7 feet tall. It grows in dense thickets and can withstand competition from wetland grasses better than other woody species (Darris and Gonzalves 2009). This community provides good cover for birds and small mammals and contributes to stabilization of stream banks. This community occurred in one discrete location north of the Rowing Association buildings and near the river, where it grew as a thick cover. Reed canary grass was also present in this area. Small patches of spirea were also present in areas mapped as *Phalaris* dominated.

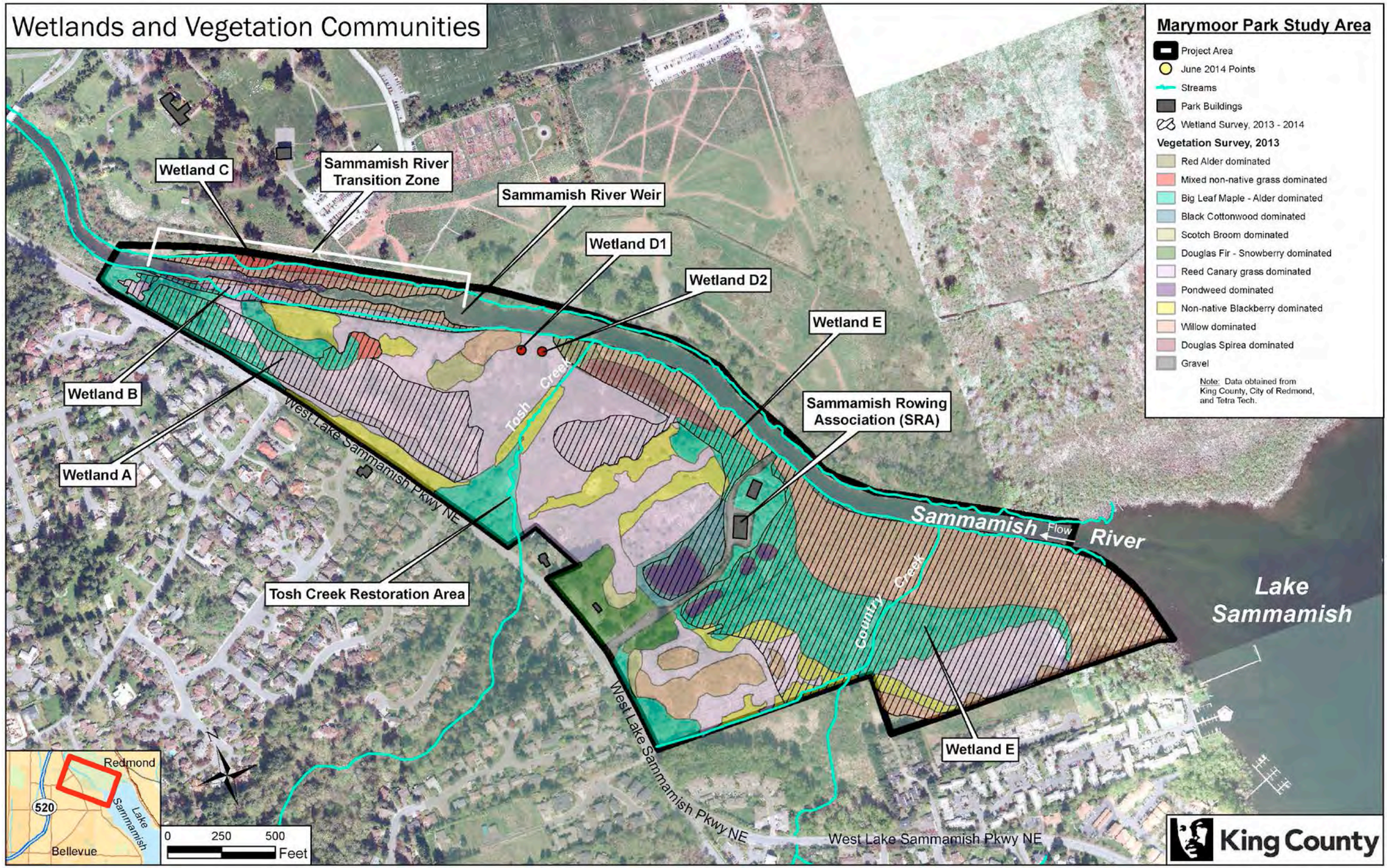

Figure 16. Vegetation Communities Present In the Project Area.

8. Wildlife

Marymoor Park, between the Sammamish River and Lake Sammamish Parkway, is an open space park with a variety of wetland and upland vegetation communities and habitats (Figure 16). A diverse assemblage of native and non-native wildlife species uses the project area and greater Marymoor Park throughout the year, including resident and migratory birds, large and small mammals, amphibians, and reptiles. The purpose of this report is to describe the current wildlife habitat and condition within the project area, describe the native and non-native wildlife assemblages that occur, and provide recommendations for enhancing or restoring those habitats to improve wildlife use.

Each wildlife guild of interest for this study, including birds, mammals, and amphibians/reptiles, has been presented below along with representative native species or any known species of special concern that occur in the area. Each species description presents life history and habitat preference data. Wildlife presence in the study area comes from reported sightings by the Friends of Marymoor Park and incidental sightings recorded during field investigations in October 2013.

8.1 Mammals

Since 1998, the Friends of Marymoor Park have collected observation data for mammals in the study area and seen over 1,187 individuals of various species. The most common sightings are of introduced species such as Eastern gray squirrel and Eastern cottontail, which are seen repeatedly during each month of the year. Other more common species are coyote, river otter, raccoon, weasel, mule deer, and muskrat. Animals that have been rarely sighted include opossum, mink, bobcat, mountain beaver, northern flying squirrel, and Townsend's chipmunk. Though none of these species is included on Federal or State lists of threatened, endangered, or sensitive species, the northern flying squirrel and Townsend's chipmunk are both protected from hunting under Washington state law. There have been no mammals categorized as WDFW priority species observed at the study site. Detailed accounts of mammal presence in the park and habitats used were provided by M. Hobbs (Pers. comm. 2013).

Beaver (Castor canadensis) (WDFW 2013, Burke 2013)

Beavers are medium sized mammals weighing between 28-77 pounds at full size. Beavers are adapted to living year-round in water having a thick waterproof coat, paddle shaped tail, webbed feet and valvular ears and nostrils which can be sealed when submerged. Once beavers reach 1.5 to 3 years of age, mating begins, typically in the month of February. Gestation is 4 months and commonly produces between 2 and 5 furry kits. Both parents care for young and life expectancy is 10-15 years.

Habitat preferences are based on where beavers can create lodges or dens and find sufficient food sources. The best locations include forested wetlands where beavers can collect tree branches and logs to create dams and lodges. Dams are constructed to pond water, creating a safe place for chewing trees down, foraging, storing food underwater, and creating underwater access to lodges. Lodges are then built with collected tree branches and downed logs, and other materials available, and can be as large as 30 feet in diameter. The leaves, buds, and bark of their home territory trees also comprise their diet.

Preferred habitats include trees of aspen, poplar, birch, maple, willow and alder. Beavers will also consume lilies and other aquatic vegetation in the early spring.

Beaver have been observed several times within the project area, generally during the months of February and June, including within the former wastewater treatment ponds adjacent to the Sammamish Rowing Association buildings. At least one beaver den is present in the project area, built into the river bank about 100 yards downstream of the weir in the TZ, and beavers have been denning at the site for many years. Prior to construction activities at the Sammamish Rowing Association buildings, beaver were denning at the ponds. Additional evidence of beaver activity includes a partial dam built in the TZ earlier this year, as well as numerous beaver spikes and girdled or cut down trees. Beavers use all wetted habitats and probably cross upland patches between the river and ponds to reach additional foraging ground.

River Otter (Lutra canadensis) (WDFW 2013)

River otters are a medium to small furbearer of the family Mustelidae, subfamily Lutrinae. Including their tail, otters reach an average of 4 feet in length and can weigh 20-28 pounds. Streamlined bodies, short legs, webbed toes, and long tapered tails are aquatic life adaptations. River otters reach reproductive age at 2 years and generally give birth to 2-4 pups per year born March through May. Young otters learn to swim at about 7 weeks and explore beyond the den at 10 weeks. In late fall, young of the year will leave to establish their own territories.

River otters select aquatic habitats throughout Washington including ponds, lakes, river, sloughs, estuaries, bays and open waters and can survive in fresh, brackish, or salt water. River otters will avoid polluted waterways, though they are not averse to urban areas. Otters are not the builders that beavers and muskrats are, choosing instead to occupy hollow logs, log jams, piles of driftwood or boulders, and lodges abandoned by other aquatic mammals. Dens are typically well hidden and birthing dens are lined with small sticks, shredded vegetation and other available insulating materials. River otters are opportunistic feeders, consuming anything from fish to insects to crustaceans to other smaller mammals or birds.

A total of 45 confirmed sightings of river otter have been recorded in the project area, including sightings within every month of the year, at least once since 1998. Otters are most commonly seen where the lake and the river meet, commonly called the slough due to slow water velocities. Otter have also been seen swimming and fishing in the TZ near the weir. Young otter have been observed onsite and slides, or smooth otter-sized swales used to slide from dens into water, have been seen on the west bank of the river. This is evidence that river otters are reproducing in the study area.

Coyote (Canis latrans) (WDFW 2013)

Coyotes are part of the Canidae family, which also includes dogs, foxes, and wolves. Litters are born in April to late May with an average of 4 pups. Pups emerge from the den after two to three weeks and will disperse to establish their own territory when they reach six to eight months of age. Availability of food determines how distant the juvenile coyotes will travel to establish territories. Mated coyote pairs have

been known to live, hunt, and raise pups for many years or for life. Male coyotes can reach about 2 feet tall at the shoulder and weight 20-35 pounds.

Coyotes have adapted to occupy almost every habitat type in Washington, from open ranch to forest to city streets. Despite encroachment on coyote habitat, these animals continue to maintain their population numbers or even increase in some areas. Coyotes may maintain a network of dens, which can be opportunistically used, such as abandoned burrows or hollow logs, or may be dug out under an uprooted tree, log, or thicket. Coyotes both hunt and scavenge and will eat any small mammal captured or carrion discovered, including rodents, rabbits, squirrels, snakes, lizards, birds, and fish. They will also consume grass, fruits, and berries during summer and fall as those foods become more available. Coyotes that have consumed human food, such as outdoor pet food or garbage, can become aggressive toward humans when foraging in neighborhoods.

Coyote have been observed at the study area 29 times, including a sighting in every month except November, since 1998. Coyotes were more consistently observed throughout the year in the past, but recently have declined. It is unknown why, though possibly related to increasing development and disturbance. Coyotes have been observed passing through most habitat types in the project area and have even been seen catching rabbits. No young coyotes have been observed onsite and dens are probably not present. The site is primarily valuable as a hunting ground for coyotes in the area.

Long-tailed weasel (Mustela frenata) (Newell 2002)

The long-tailed weasel, like the river otter, is a member of the Mustelidae family. It is a furbearer that reaches a little over one foot in body length, with a tail that is half as long, and weighs less than one pound. They have short legs and shiny brown fur that is shed twice a year. Mating occurs in the summer, but delayed implantation of the egg can result in a gestation time of about 280 days, and young are born generally from April to May. Average litter size is 6 pups. At 36 days, young weasels are weaned and eat solid food. After about two months, weasels are able to hunt on their own. Females reach reproductive age in their first summer, while males typically reach reproductive age in their second year.

Like coyotes, weasels are opportunistic in selecting habitat and taking over abandoned burrows. They do well in a wide range of habitats from crop fields to small woodlots to suburban neighborhoods or urban areas. However, they do not generally occur in deserts or thick forests. Weasels are good climbers and swimmers and use habitats that provide food, cover, water, and refuge. Home ranges of adult male weasels do not overlap and territory is aggressively defended. Primary prey items include small rodents, but weasels will also eat a variety of other small animals, fruits, and berries.

Long-tailed weasels have been observed within the project area a total of 57 times, including sightings in all months except October since 1998. Given the territoriality of these species, it is possible that all 57 sightings are of a very few individuals. They are most often seen along the slough and are using the project area for both hunting and denning. Young of the year have been observed, as have weasels hunting and carrying voles and other rodents through the site.

Mule Deer (Odocoileus hemionus) (WDFW 2013, Misuraca 1999)

Mule deer are a part of the Cervidae family and the largest deer in Washington state. Males can reach 330 pounds and heights of 3.5 feet at the shoulder. Males also develop antlers that are shed each year and regrown in time for the breeding season. Though older bucks tend to have more antler points than young ones, the number of antler points is not an accurate measure of age. Dropped antlers are chewed by a variety of small mammals in order to sharpen their teeth, but in the process also receive calcium, phosphorous and other minerals. Mule deer and black-tailed deer have a close resemblance, but mule deer can be distinguished by their tail having only a black tip, not a black patch across the entire tail length.

Breeding begins in late season, in November and December, and young of the year are born the following summer in June or July. Two young are the average litter size. Weaning begins at about 5 weeks and after 4 months is usually complete. Females reach reproductive age usually in their second year, though first year reproduction does occur.

Mule deer occur in a wide variety of habitats, but are sometimes referred to as an "edge" species, selecting habitats that include open areas adjacent to forest or other cover types. Many wooded suburban environments fulfill this requirement and Marymoor Park is a good example. Deer are herbivorous ruminants that prefer to eat the growing tips of trees and shrubs, known as browse. Secondary diet items include grass, clover, fruit, nuts, and farm and garden crops if available. Some of the preferred browse of mule deer that occur at the study area include rose, thimbleberry, willow, snowberry, dogwood, Douglas fir, and bluegrass.

Mule deer have been positively identified at the study area a total of 45 times according to the Friends of Marymoor Park, with observations occurring in the months from March to November, since 1998. During the 2013 wetland field investigation for this project, a single mule deer was observed moving from north to south through the project area, along the edge of the Douglas spirea habitat near Tosh Creek. Mule deer have a territory from one-half to 3 square miles range, so it is possible that sightings are of one or only a few individuals. Evidence of mule deer bedding in the project area was observed during the wetland investigation, and notably occurred in large areas of reed canary grass. Very young deer have also been observed by the Friends of Marymoor Park and breeding may be taking place in the park.

Bobcat (Lynx rufus) (Ciszek 2002)

The bobcat is a member of the cat or Felidae family. It is a medium sized mammal, ranging in length from two to 3.5 feet and weighing up to 33 pounds. The bobcat is distinguished by its tufted ears and short tail, which is typically less than 7 inches long. Bobcat usually mate in spring and after a gestation of 60-70 days an average litter of 3 pups is born. Young open their eyes at 10 days old, nurse through their second month, and disperse during the winter at about 8 months of age. Lifespan is an average of 15 years in the wild.

These solitary cats are territorial; male home ranges may overlap, but female home ranges do not. Selected habitats include forests, mountains, and brushland. They sleep in dens that are often located in hollow trees, thickets, or rocky crevices. Bobcats are carnivorous and hunt rodents, rabbits, large ground birds, and small ungulates. Occasionally they will hunt reptiles, small domesticated animals and poultry.

Bobcat activity in the study area has been increasing in the past year. Before then, bobcat were only sighted once in 2010. However, in the past year, and just in fall 2013, a bobcat has been observed 4 separate times by the Friends of Marymoor Park. Photos confirm the sighting. The continuous sightings and territoriality of bobcat indicate that this individual may be establishing residency in the project area.

8.2 Birds

Over 200 bird species have been recorded within Marymoor Park by the Friends of Marymoor Park. This substantial number precludes a life history and habitat preference evaluation of each species. Instead, representative species of each bird group has been described below. Bird guilds have been grouped into herons, waterfowl, raptors, upland game birds, shorebirds, owls, swifts, and songbirds. For each group, species that are WDFW priority species have also been described below. A total of 7 birds with a sensitive status have been sighted in the project area. No sightings have been made of birds on the Federal list of threatened or endangered species. Observation details for all bird species have been provided by M. Hobbs (Pers. comm. 2013).

Herons (Naumann 2002, Ehrlich et al. 1988, SAS 2013, Butzbaugh 2001)

Herons, and similar birds most commonly observed in the study area include great blue heron (*Ardea herodias*) and green heron (*Butorides virescens*). Less often seen, but still commonly present is American bittern (*Botaurus lentiginosus*), while the great egret (*Ardea alba*) is only rarely observed. A sandhill crane (*Grus canadensis*) was observed on two occasions in 2010 but has not been seen in the area since. The sandhill crane is a state listed endangered species.

Most wading birds begin nesting in February and birds are hatched by May, though some species may breed as late as July. Clutches can include 2 to 5 eggs on the average, which hatch after about 30 days of incubation. Chicks live in nests for about 2 months until they are ready to fledge or leave the nest. Herons can live up to 15 years in the wild, though shorter lifespans are known for some species. Green herons have only been known to live approximately 8 years.

Herons, bitterns, and egrets are wading birds associated with aquatic habitats, including freshwater or estuarine wetlands, ponds, and streams with thick emergent vegetation and riparian cover. These species prefer habitats that are free of human disturbance and have plenty of vegetative cover. The diet of wading birds is primarily fish and insects, though they will also consume amphibians, reptiles, small mammals and other birds. Great blue herons and egrets in Washington will also hunt on land and a large portion of their diet consists of rodents and grasshoppers. Green heron are known to use tools to attract bait, placing flies on the surface of the water and waiting for prey.

Great blue heron are resident within the project area and are commonly found feeding along the edges of the river or wading through puddles and channels in the TZ. In addition, great blue herons are

conspicuously nesting at Marymoor Park; a heronry has been established in a cottonwood stand located within the off-leash dog area. The heronry was established two years ago and the number of nests has risen to 18 since then. Selecting this busy location may be the result of human disturbance that restricts other competitive species from entering the area (raccoons and eagles). Green herons had previously been known to nest at the former wastewater treatment ponds, but did not establish nests this year. American bittern were once more common in the park, but have declined and have not been seen since 2009. It is possible that mowing vegetation along the river has reduced their use of the area, but the cause is not certain. Herons are tree nesters and are not typically observed in other areas of Marymoor Park away from the river or lake.

Waterfowl (SAS 2013, Ehrlich et al. 1988)

Over 40 waterfowl species have been observed in the project area including geese, swans, wigeon, teal, pintail, scaup, merganser, wood duck, and gadwall. The most commonly sighted ducks are gadwalls, wood ducks, mallard, bufflehead, and both hooded and common merganser. Canada geese, grebes, coots, and cormorants are also very common. The common loon, which has been observed several times in the project area, is a state listed sensitive species (WDFW 2012). Western and Clark's grebes, also known to be present within the project area, are candidates for state listing. A general description of waterfowl diet, reproduction, and habitat has been provided to represent this group.

The uniting factor of each of the species included in this group is their requirement for nesting near aquatic habitats and their food preferences. Some species, such as common goldeneye, prefer to nest in trees adjacent to open water sources, while others, such as green-winged teal and mallard, usually nest in grasses or brush within two hundred feet of a waterbody. Waterfowl diet preferences vary by species, though in general ducks prefer insects, but will also eat seeds, roots, aquatic plants, and aquatic invertebrates. Most species graze opportunistically, both on land or under water, as food is available. Breeding begins in late December and eggs are laid in spring. Clutches vary widely and depend on conditions and availability of food. The average clutch for a common goldeneye is about 7 eggs, mallards average 9 eggs, and many species lay even more.

In winter, Canada geese, mallard, gadwall, American coot, and green-winged teal are present in the study area and seem to prefer areas that are mowed. Common goldeneye, common merganser, and pied-billed grebes tend to feed in the main river channel. Many of the ducks, coots, and grebes remain in the area until mid-spring. There are no confirmed duck nest sitings; however, presence of very young fledgling mallards indicates that nesting for some species is occurring onsite.

Raptors

A total of eleven raptors have been positively identified within the project area. The most commonly observed raptors include osprey, bald eagle, Northern harrier, sharp-shinned hawk, Cooper's hawk, merlin, red-tailed hawk, peregrine falcon and American kestrel. Lesser seen raptors include turkey vulture, Swainson's hawk and rough-legged hawk. Life history data for the bald eagle and red-tailed hawk have been included below and are representative of the raptor group.

Bald Eagle (Haliaeetus leucocephalus) (Siciliano 2013, SAS 2013)

The bald eagle is a state listed sensitive species and a federally listed species of concern. It is the national symbol and adults are easily distinguished by its white head feathers and large wing span. Females tend to be larger than males, weighing as much as seven pounds with a wingspan of 7.5 feet. Nesting dates vary regionally, and in Washington bald eagles are early nesters, laying eggs in late February and incubating through May. Average clutch size is two and eggs hatch from April to May. Females reach sexual maturity at five years and typical lifespan is 15-20 years in the wild.

The bald eagle typically prefers areas near large water bodies with large trees. They most often select areas that have available prey, tall trees, and a low level of human disturbance. Bald eagles build the largest nests of any other bird species in North America, which have been measured at nine feet in diameter. Nest trees are usually large coniferous trees surrounded by smaller trees. Nests may also occur on cliffs, cell towers or electrical poles. Their diet includes many aquatic species, including fish and waterfowl. Recently spawned fish are a favorite, as eagles do not dive to obtain prey, but retrieve fish from the water surface with powerful talons. Adult water birds, their nestlings and eggs are also common food items. In Washington, American coots are an important part of a bald eagles' winter diet. Eagles will also hunt small mammals, steal food from other raptors, and consume carrion.

Bald eagles were observed repeatedly in every month of 2012 by the Friends of Marymoor Park. Eagles are generally observed perched on trees along the slough in the southeast corner of the project area. Although nests are not located within the project area, they are known to have been established in and near the park for most years since data have been collected. Over 30 bald eagles were seen in the north quarter mile of the lake in a single day.

Red-tailed Hawk (Buteo jamaicensis) (Arnold 2002)

Red-tailed hawks are smaller than bald eagles, with an average wingspan of four feet and maximum weight of less than three pounds. Female hawks lay eggs around the first week of April and incubate for 28-35 days. Average clutch size is three and fledging age is between 42 and 46 days. Chicks become completely independent at about ten weeks after fledging. Average lifespan of red-tailed hawks is about 29 years. Reproductive age is reached after an average of two years.

Red-tailed hawks are found in almost every type of habitat, but select locations that have open areas interspersed with a mosaic of trees or other elevated perches. Unlike bald eagles, red-tailed hawk do not prefer habitat near open water for foraging or nesting. Hawks prefer to build nests where forest edge meets open meadow in the tallest tree available. Diet consists of small mammals, birds, reptiles and sometimes fish or large insects, if available. Raptors will also eat fresh carrion.

Red-tailed hawks were observed in every week of 2012 within the project area and one individual was observed during the 2013 wetland investigation. Two nests are located on the west side of West Lake Sammamish Parkway and the project area is likely the main foraging area for the two pairs.

Other nesting raptors include Cooper's hawks, which are one of most common, active, and visibly present raptors in the area, and osprey. Osprey have established an ongoing nest in a man-made tower along Highway 520 near the velodrome. These birds are often seeing foraging along the slough.

Upland Game Birds

California quail and ring-necked pheasant are the most commonly observed game birds in the project area, while ruffed grouse are present but rarely seen. Upland game birds have very similar habitat preferences and diet. According to Hobbs (Pers. comm. 2013), natural populations of upland game birds are extremely rare these days. Though the California quail has been seen at the project area in the past, it has been very rare in the past several years. These birds used to nest on the slopes west of West Lake Sammamish Parkway and come into the park to forage. The disappearance of quail from the site generally coincides with the development of residences on the west slope. Ring-necked pheasants are released for hunting in the area, but are rarely seen.

California quail (Callipepla californica) (SAS 2013, Price 2000)

This small upland game bird ranges in weight from only five to seven ounces and may reach nearly ten inches in length. It is the state symbol and easily recognized by the distinct coloration and teardrop-shaped plume. Quail nest between May and June, laying an average of 13-17 eggs, and females incubate eggs for 22-23 days. Breeding typically occurs once yearly, though a second attempt may result from unsuccessful initial breeding. Average lifespan in the wild is almost seven years. Outside of breeding months, quails form coveys or groups that may include 25-40 birds. Preferred habitats of quail include open woodlands, brushy foothills, valleys with streams, agricultural lands and suburbs. They often use edge habitat with fruit producing plants and shrubs for cover. They are typically ground dwellers. Primary diet of the California quail includes seeds, gains, and nuts. In Washington, quail rely heavily on seeds from broad-leafed legumes, but will also eat fruits, berries, nuts, and insects, if available.

Shorebirds

At least 30 shorebirds have been observed in the project area including sandpipers, killdeer, snipes, gulls, rails, sora, and terns. The most common of these are killdeer, Wilson's snipe, and five species of gull. These species are seen in habitats associated with water. Shorebirds generally use shorelines for foraging that are flat or have little vegetation. Rails and sora will often perch on low hanging vegetation within wetlands. The most commonly used habitats in the project area are the sparse grassy areas along the river, or where willows provide perches. According to Hobbs (Pers. comm. 2013), there are only two shorebirds that occur regularly in the project area; spotted sandpiper and Wilson's snipe. However, other parts of the park do host a variety and abundance of shorebirds when ephemeral puddles form in parking lots. These attract migrating shorebirds and provide excellent foraging habitat.

Wilson's Snipe (Gallinago delicata) (SAS 2013)

This snipe is a part of the family Scolopacidae, which includes sandpipers, yellowlegs, curlews, godwits, dowitchers and phalaropes. This long billed brownish shorebird is about 10-11 inches in length. Breeding

activity peaks April through August, and most females produce four eggs that hatch after 18-20 days. Fledging occurs after 20 days. They are generally found in lowland, freshwater marshes, wet meadows, sedge meadows, ditches, and occasionally mudflats. Diet items include insects, earthworms, and other invertebrates that burrow in wet soils in marshes. Nests are built in grasses or on sedge hummocks and lined with moss, leaves, and grass. Annual surveys suggest that this species in decline in Washington State, potentially as a result of loss of wetlands and hunting. The project area is a significant wintering site for Wilson's snipe. They are present from October to the end of April and use habitats along the TZ, in ponds, and take cover in the reed canary grass to the west of the TZ.

Owls

Owls observed in the project area include barn, Western screech, great horned and short-eared owls. Less commonly observed are Northern saw-whet, snowy, barred, and long-eared owls. The most common owls in the area are barn owls, which have been nesting in the park annually in several locations. They have nests established in cottonwood trees and in a man-made nest box. The great horned owl is widely distributed in a variety of habitat types, but has become less common in the project area. Its life history, habitat preferences, and diet are described below.

Great Horned Owl (Bubo virginianus) (SAS 2013, Dietrich 2013)

Great horned owls are a solitary member of the Strigidae family, which includes all owls. The great horned owl can reach lengths of over two feet and have wingspans that extend to four feet. Owls reproduce once a year, with breeding months between November and April. Average number of eggs laid is three, incubation takes between 30-37 days, and fledging occurs six to nine weeks after hatching. Great horned owls become sexually mature after one to three years and live an average of 13 years in the wild. Home ranges may be occupied by an individual or pair and generally cover two square miles.

These large birds are suited for many habitats, but are most commonly found in interspersed areas of woodland and open fields, much like red-tailed hawks. They prefer habitats with forest edge adjacent to grasslands, swamps, and marshes, including areas in both rural and urban areas. Open meadow areas provide their preferred food items; small mammals. They consume rodents, rabbits, skunks, grouse, coots, and other birds. Other foods that may be consumed include reptiles, amphibians, fish and large insects.

A total of five sightings of great horned owl were recorded in the project area in 2012. In prior years, more sightings were recorded including reports of this owl nesting in the project area. Though great horned owls have not nested in the project area in the past few years, they are nesting in adjacent areas and using the project area for hunting.

Passerines and other Smaller Birds (Ehrlich et al. 1988, Hobbs pers. comm. 2013)

Over 100 passerines, or perching birds, have been observed in the project area. These are species that include sparrows, meadow larks, orioles, warblers, swallows, flycatchers, and similar. Because of the vast number of birds in this category, habitat preferences are described in general.

Songbirds occupy a wide variety of habitats and are likely present in most areas of the project site. Particularly good habitat is available where willow dominated shrub cover is adjacent to the river or ponds. Willows provide excellent perches, especially when over water or surrounded by other vegetative cover. Feeding opportunities draw both resident and migratory birds to the area. Resident songbirds include chickadee, bushtit, Bewick's wren, golden-crowned kinglet, ruby-crowned kinglet, American robin, song sparrow, dark-eyed junco, and red-winged blackbird. Marsh wrens are resident and also breed in the cattails along the river margins. Migrating birds that pass through the site include towhees and a variety of sparrows and warblers. Common yellowthroat are migrants that return to the area in spring where they nest in the willows along the river. Summer breeding songbirds at the site include cedar waxwing, yellow warbler, song sparrow, red-winged blackbird, American goldfinch and willow flycatchers.

Many birds in the area are becoming adapted to the presence of non-native plant species, particularly blackberry and reed canary grass. In particular, a significant number of smaller birds have been observed using blackberry during winter as cover. Fox sparrows, towhees, golden-crowned sparrows are all seen perched in blackberry thickets. Robins, thrushes, grosbeaks, house finches, and other bird species consume the berries during summer and into the fall. Marsh wrens and common yellowthroat are known to nest in reed canary grass, though will select more suitable shrub species when present.

8.3 Amphibians and Reptiles

Very few amphibians are known to be present in the study area, and fewer still that are native. The single native amphibian regularly observed is the Pacific tree frog. During 2013 field investigations, these frogs were heard throughout the project area. While no sampling was done on-site in 2013, other native species that occur in the vicinity include long-toed salamanders and Northwestern salamanders (Richter & Ostergaard 1999). Other native species known to be present in the watershed include rough-skinned newt, Pacific giant salamander, Western toad, and Northern red-legged frog (Richter & Ostergaard 1999). Non-native amphibians and reptiles present include the bullfrog, painted turtle, and red-eared slider. Despite their non-native status, these species are likely contributing substantially to the diet of other native birds and mammals in the area.

There is little information on reptiles present in the study area, although the Washington Herp Atlas (WDNR 2014) indicates that the common, Northwestern and Western terrestrial garter snakes and rubber boas are present in King County.

Pacific Treefrog (Pseudacris regilla) (Hallock and McAllister 2005)

Pacific treefrogs are small members of the family Hylidae that usually grow to less than two inches. These frogs have a variety of body colors, ranging from bright green to brownish and a conspicuous dark mask typically extends from the tip of the nose through the eye to the shoulder. Eggs are laid in loose groups of nine to 70 eggs each mass approximately one inch in diameter. Egg laying begins in mid-February and eggs hatch after two to five weeks. Tadpoles develop over 1.5-2.5 months.

Treefrogs are the most common frog species in Washington and occur in a wide variety of habitats, even adapting well to urban areas. Breeding habitats must have still or slow-moving water, which can include

ponds, slow-moving stretches of streams, or even roadside ditches. Treefrogs use breeding sites for only a few weeks or months of the year and then move into upland areas the rest of the year where they can be found in almost any slightly moist habitat including under rocks and logs or inside animal burrows in riparian corridors, forests, or grasslands. Adult treefrog diet consists of beetles, flies, spiders, ants and other invertebrates.

Bullfrog (Rana catesbiana) (Hallock and McAllister 2009)

Bullfrogs are not native to the Western U.S., but are described here due to their ubiquity in Marymoor Park and potential effects on native wildlife species. Bullfrogs are large heavy-bodied frogs of the family Ranidae (true frogs) and can attain sizes up to 6 inches in length. Their dorsal body color can range from tan to brown to olive-brown with black mottles or speckles and typically are greenish in the upper jaw and eye area. The underside is typically white to cream colored and may have dark mottling. Eggs are laid in a thin film at the water's surface that may extend for greater than one foot in diameter. There are usually many thousands of eggs in this mass and they often sink to the bottom before hatching. Eggs are typically laid in June or July, or even as late as August and hatching occurs rapidly within a few days to a week (depending on water temperature). Tadpoles grow rapidly but do not metamorphose until their second or third summer. Frogs are typically dormant in the Pacific Northwest the colder months from November to April.

Bullfrogs require permanent year-round waterbodies for their life history, although they are occasionally found in terrestrial sites at night and will disperse over uplands and temporary puddles/ponds on warm rainy nights. They overwinter in permanent waterbodies with well-oxygenated water. They are able to exist and proliferate in waterbodies with exotic warm-water fish and may benefit from the presence of these fish. While bullfrogs have been considered detrimental to native amphibians and populations of native frogs have declined in many waterbodies with bullfrogs present, it is unclear at this time if non-native fish are more of a cause of native amphibian decline than bullfrogs.

Turtles

Turtles in the study area are all introduced species. Yet, their presence has become somewhat naturalized over time. Washington State affords protection to the painted turtle; it is unlawful to collect or hunt this species. Throughout the study area, sliders and painted turtles are extremely common, particularly during summer time, but also during spring and fall on sunny afternoons. Turtles can be found in all the waterways of the site, including the river and former wastewater treatment ponds.

8.4 Local and Regional Habitat Value

The diversity and abundance of mammals and birds present in the study area, coupled with its proximity to urban centers, makes Marymoor Park an extremely valuable regional resource for birding and other wildlife observation. However, additional opportunity exists to improve the natural habitat condition and provide greater access of the site to potential visitors.

The desire for outdoor opportunities to observe and photograph nature has grown as cities have expanded and natural areas have declined. According to the 2006 Outdoor Recreation Survey

(Willmorth 2007), the second-most common recreational activity in Washington State for the same year was observing or photographing wildlife or nature, which was reported by survey participants to occur 3.1 million times. Only more popular was recreational walking (without a pet, which occurred 3.5 million times). Of those surveyed for the report, nearly 26% reported wanting to engage in more observation or photography of wildlife or nature in the subsequent year than they had pursued in the current year. This indicates increasing demand for access to natural areas to experience nature and wildlife.

Marymoor Park is exceptionally located where an existing natural area and Lake Sammamish, comes in contact with the expanding suburban and urban growth of surrounding cities. The park is central to the communities of Bellevue, Redmond, Kirkland, Sammamish, and Issaquah and serves more than 3 million visitors annually. Most activities in Marymoor Park are centered on physical activity, events, or sporting. However, there is a large community of nature enthusiasts in this region, headed by the dedicated members of the Friends of Marymoor Park. Ongoing wildlife observation by members of the group have provided evidence of the need for protection and enhancement of the undeveloped areas of Marymoor Park, both through collecting data about the wildlife in the park and by demonstrating their enthusiasm for natural observation.

The project area is largely undeveloped. The Sammamish Rowing Association uses a small portion of this area and there are periodic maintenance efforts to remove vegetation along the Sammamish River Transition Zone. Despite these human activities, and a long history of land use, this section of the park remains in a relatively natural state. Because of this, a large number of small and large mammals, resident and migratory birds, and amphibians and reptiles are present. However, there are opportunities to provide passive public access for wildlife viewing.

The main constraint facing human use of the area for recreational nature observation currently is the lack of easy access. Trails are only present on the perimeter and standing water, blackberries, and thick vegetation make it extremely difficult to access the site further. There is one way to reach the interior of the site and view the river; this can be achieved using the maintenance access trail that enters from areas downstream of the Transition Zone. This trail is not developed, but is easy to walk. It reaches roughly to the weir and terminates, offering views of only a small portion of the overall site. Improving access to the site by building trails or boardwalks into wetlands would offer nature enthusiasts the safest and easiest access to the site. However, it is always necessary to consider the impacts of inviting additional human activity into areas that are currently relatively undisturbed. Strategic view points and/or limited trails could enhance access while minimizing disturbance.

9. Opportunities for Habitat and Water Quality Improvements

9.1 Restoration Opportunities and Constraints for Fish

The primary limiting factor for salmon and other native fish species in this reach is elevated water temperature, to the point of being lethal. Other than water temperature, aquatic habitat is of low to moderate quality in this reach.

Many indicators of quality salmonid habitat are clearly degraded in the project area. Key restoration opportunities identified for the project reach include (from USACE and King County 2002; WRIA 8 Steering Committee 2005): 1) temperature reduction through modification of the Lake Sammamish outflow; 2) riparian revegetation; 3) restore remnant meander adjacent to the transition zone; 4) creation of cool water refuge via possible groundwater sources in the reach; 5) restore hyporheic flows; 6) restore/enhance wetland habitats; 7) create and enhance river pool habitat; 8) provide wood and other cover; and 8) enhance mouths of tributaries to create cool water pools and cover.

Suggested ways to improve lamprey passage through the weir are to provide smooth ramps and rounded corners or more natural substrate as well as reducing velocities (USACE 2009).

An evaluation of the potential to reduce water temperatures in the Sammamish River was explored in Jain, et al. (2000) and King County (2001) and further evaluated in this study (King County 2014). Fourteen possible scenarios to reduce temperatures have been modeled including using cold water from deep in Lake Sammamish, riparian shading at various widths and distances, eliminate existing surface water withdrawals, augmenting flows with groundwater inputs, increased Bear Creek flows and various combinations of scenarios. The scenarios with the greatest potential to reduce water temperatures in the upper reach of the river include replacing 5, 10, or 20 cfs of lake outflow with cooled water such as from deep in Lake Sammamish or cooled via hyporheic flow or heat exchange system – these types of measures could reduce thermal stress in the upper river substantially. It is still unlikely that the river will meet the water quality standard of 16° C for summer core rearing habitat, but cooling the river to something well below lethal temperatures may be achievable.

9.2 Restoration Opportunities and Constraints for Mammals

There are a number of opportunities to improve habitat conditions for mammals in the area. These include a variety of options for modifying the existing ponds and vegetation.

Wetland Expansion and Connections

Moderately shallow wetland habitats are preferred by beaver and river otter. Increasing the area of seasonal water flow and creating connections between them will improve habitat for these species. Specific modifications could include:

- Creating connections between existing ponds,
- Connecting the ponds to the river, or
- Creation of backwater wetlands that extend from the river.

Constraints to these actions include the potential for poor water quality within the ponds, turbidity or erosion issues related to backwaters, or difficulty of access for large equipment.

Non-Native Vegetation Removal and Native Plantings

Vegetation on the site has been substantially disturbed from past agricultural activities and surrounding development. Plant communities are overwhelmingly comprised of non-native and invasive species. Reed canary grass, blackberries and Scotch broom are dense and difficult for many mammals to pass through or use and are not generally conducive to ecological function for the mammals described above. Opportunities to improve vegetation conditions include:

- Removal of blackberry where dense thickets prevent larger wildlife from accessing wetland resources,
- Removal of Scotch broom to prevent potential growth of dense thickets,
- Removal of purple and yellow loosestrife, which must be controlled in King County and are currently only growing in very limited areas within the project site,
- Control of reed canary grass through excavation to create deeper wetland ponding, and
- Plantings of native tree and shrub species, especially those preferred by beavers and mule deer.

Constraints to improving vegetation typically include difficulty/ineffectiveness of invasive species control methods. It is extremely difficult to fully eradicate invasive plants and any attempt to control these species requires ongoing maintenance, which in turn requires a labor force, adequate funds, and a plan to maintain the newly planted native species. Plantings of rapid growing native trees such as cottonwood, alder, and willow species will tend to quickly establish shading that can reduce the density and vigor of reed canary grass and blackberries. The density of species preferred by beaver and mule deer should likely be increased to compensate for expected browsing. Maintenance actions focused on the first 3-5 years following a project including mowing, spot herbicide application and removal of individual weedy species that are not widespread can help lead to rapid establishment of native tree/shrub species.

9.3 Restoration Opportunities and Constraints for Birds

Non-Native Vegetation Removal and Native Plantings

In contrast to mammal species, there appears to be some value in the blackberries that occur on-site for bird species. However, uncontrolled growth of blackberry would likely result in the loss of the diversity of the site that maintains its attractiveness as a feeding and nesting ground for many species. Because blackberry is difficult to control and nearly impossible to eradicate, it may be worthwhile to employ a more targeted control approach in specific locations. In addition to providing cover and forage, blackberries have the benefit of also reducing human disturbance.

Additional opportunities to improve vegetation include:

- Removal of Scotch broom to prevent potential growth of dense thickets,

- Removal of purple and yellow loosestrife, which must be controlled in King County and are currently only growing in very limited areas within the site,
- Excavation of reed canary grass with dense replanting of native meadow plants (such as using sod mats); dense mats of reed canary grass create cover that is too thick for effective hunting by raptors and owls,
- Plantings with rapid-growing native tree and shrub species, especially those preferred by nesting raptors, owls and passerines.

As noted previously for mammals, controlling invasive species is difficult and ongoing maintenance is required to keep invasives from growing back, and to ensure survival of newly planted species.

Increased Habitat Interspersion

Currently, habitat diversity and interspersion is moderate and there are opportunities to increase the variety and mosaic pattern of habitats. Many bird species prefer edge habitats, where emergent plants meet water, where forest meets meadow, or where forests have complex and diverse understory. Opportunities to improve habitat interspersion include:

- Excavate depressions in reed canary grass fields to allow seasonal ponding and densely revegetate areas around ponds with emergent vegetation or willows and spirea; this will reduce reed canary grass, and create additional edge habitat for passerines, wading birds, and shorebirds, while creating additional open water habitat for waterfowl,
- Create backwater habitats connected to the river to provide additional wetland edge and open water habitat,
- Replace ornamental trees and Scotch broom with native conifers that provide nesting and perching habitat for raptors, owls, woodpeckers, and other perching birds,
- Replace blackberry understory with native thimbleberry, snowberry, ocean spray, and Indian plum to provide cover, structure, and food for passerines.

Increased Availability of Nesting Habitat

Some passerine species appear to select nest sites in reed canary grass. However, this is most likely the result of a lack of other grass habitats. The removal of reed canary grass and replacement with dense plantings or mats of native grass or meadow species could potentially improve the availability of nesting sites for ground-nesting species. Replacement of other invasive species, such as Scotch broom and blackberry, with native shrubs such as spirea, thimbleberry, snowberry, and willow, will improve nesting availability.

Increased Shorebird Habitat

Currently, a large number of shorebirds are passing through the project area, but the vast majority do not stop or stop only very briefly. Little foraging habitat is available to shorebirds that prefer mudflat shorelines along shallow water bodies. Where it does exist, a surprisingly large number of shorebirds will stop to take advantage of foraging. Solitary sandpiper, yellowlegs, dowitchers and other shorebirds pass through in April/May and again in later summer and if there is standing water over gravel or dirt,

they stop to feed. It is especially beneficial if the puddle is ephemeral; as the puddle shrinks, a band of wet mud is formed, releasing additional food items. The creation of ephemeral pools would attract a substantial number of shorebirds throughout the migration seasons. As many of the non-native species such as reed canary grass and yellow-flag iris readily invade bare ground, ephemeral/seasonal ponds may be most effective connected to the river where there will be long periods of inundation.

9.4 Restoration Opportunities and Constraints for Herptiles

There are few native species expected to use the project area, since the region is naturally low in diversity of turtles and frogs. However, the species that are present would benefit from a variety of actions that would increase habitat function. These include:

- Create habitat variability along streams and in wetlands through meandering streams, creating backwaters, and placing woody debris along shorelines,
- Create a variety of new wetlands of varying depths to ensure that shallow water habitats, which are preferred by amphibians, are present during the native species' breeding season,
- Create microhabitat along shorelines and wetlands by adding log jams, brush piles or rocks piles,
- Establish seasonal marshes where thin stemmed emergent vegetation provides amphibian egg laying structures.
- Maintaining or creating suitable dispersal corridors (without roads or parking areas) along the river and from uplands to the wetlands.

Constraints include the difficulty of controlling invasive plant species and the need to maintain channel capacity.

Following from these recommendations, specific targets are suggested for physical habitat features to be included for habitat restoration measures. Table 5 outlines suggested targets and identifies the problems that each restoration measure addresses.

Table 5. Recommended habitat restoration measures, suggested targets, and problems that each measure could address

Potential Restoration Measure	Possible Habitat Target	Problems Addressed
Cool water input near weir	1. Meet 17.5° C (7-day maximum) standard for migration 2. Not exceed 21° C maximum daily temperature (incipient lethal temperature)	Eliminate fish mortality and reduce stress Prevent seasonal fish barrier due to temperature
Reconnect transition zone to excavated floodplain	1. Connect at typical winter high flows (November to May, 70% exceedance)	Increase capacity of upper river channel Restore off-channel habitat that currently is rare Lack of connections between wetlands and river
Protect and enhance riparian zone and wetlands from Lake to Bear Creek	1. Minimum 150 width per City of Redmond code 2. Focus on rapid plant growth and shading to outcompete non-native species	Increase shading Increase habitat complexity and suitability for wildlife Increase aquatic food resources Recruit large wood over time

Potential Restoration Measure	Possible Habitat Target	Problems Addressed
		Reduce non-native species Increase cover and nesting habitat
Create and enhance pools	1. Increase number of pools/mile 2. Pools >1 meter residual depth with complex cover	Increase adult holding habitat and juvenile rearing habitat Increase cool water refugia Provide amphibian habitat Provide shorebird habitat (mudflats)
Enhance mouths of Tosh and Country Creeks	1. Provide cover and complexity via wood placement 2. Consider routing Tosh Creek into a side channel around weir	Increase cool water refugia Increase channel complexity and cover
Reconfigure weir as riffle	1. Provide unhindered fish passage upstream and downstream at all flows (all life stages) 2. 2 fps max velocity at annual peak flow or complex hydraulics	Create more natural structure that is more conducive to lamprey and juvenile fish migration
Create side-channel using one or more alternate water sources	1. Provide cool water passage during summer/fall 2. Provide natural substrate channel for unhindered fish passage upstream/downstream with complex hydraulics	Reduce seasonal barrier Reduce fish mortality and stress Improve fish passage for multiple species Provide habitat interspersion and connections
Place large wood and brush in floodplain	1. Provide cover and complexity for wildlife species	Increase overwinter and dispersal habitat

In conclusion, there are multiple opportunities for habitat enhancement in the project area directed at water temperature, aquatic and riparian habitat complexity and quality. If the critical high water temperatures were reduced and more complex aquatic habitats and cover were created, juvenile salmon could potentially more effectively use the area for rearing and the thermal barrier and effects to adult salmon could be reduced. To facilitate the recovery of salmon species, NOAA has developed Viable Salmonid Population (VSP) goals for the Lake Washington watershed. The improvement of the Sammamish River to support smolt rearing and allow unhindered migration of adults is important objectives for improving the diversity of the population and the distribution of spawning populations (Salmon Recovery Council 2009).

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Appendix A: Photos

Photo 1. Wetland Plot 2 (wetland). Mixed forest community.

Photo 2. Wetland Plot 3 (upland). Edge of mixed forest (Rubus understory dominated).

Photo 3. Wetland Plot 9 (wetland). *Phalaris* dominated community with sparse trees.

Photo 4. Wetland Plot 8 (upland). *Rubus* dominated.

Photo 5. Wetland Plot 4 (wetland). *Phalaris* dominated.

Photo 6. Wetland Plot 5 (wetland). Transition Zone, *Phalaris* dominated.

Photo 7. Wetland Plot 35 (wetland). Transition Zone.

Photo 8. Wetland D Patch. *Carex obnupta* dominated.

Photo 9. Wetland D patch*. Carex obnupta* dominated.

Photo 10. Wetland plot 15 (wetland). *Spiraea* dominated.

Photo 11. Wetland plot 16 (upland). *Phalaris* dominated.

Photo 12. Wetland Plot 26 (wetland). *Phalaris* dominated.

Photo 13. Wetland plot 27 (upland). *Phalaris* dominated.

Photo 14. *Salix* dominated area of Wetland E.

Appendix B: Wetland Data Sheets

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/28/13
Applicant/Owner: King County State: WA Sampling Point: WP2
Investigator(s): Townsend, Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.659559081 Long: -122.123103902 Datum: NAVD88
Soil Map Unit Name: Alderwood gravelly sandy loam, 6 to 15% NWI classification: None
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes	x	No	___
Hydric Soil Present?	Yes	X	No	___
Wetland Hydrology Present?	Yes	x	No	___

Is the Sampled Area within a Wetland? Yes x No ___

Remarks: Plot located in relatively high flat ground near West Lake Sammamish Parkway

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Populus balsamifera	50	Y	FAC
2. Alnus rubra	10		FAC
3. Acer macrophyllum	20	Y	FACU
4.			
	80	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1.			
2.			
3.			
4.			
5.			
	0	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Agrostis stolonifera	30	Y	FAC
2. Scirpus microcarpus	50	Y	OBL
3. Solanum dulcamara	30	Y	FAC
4. Reynoutria japonica	10		FACU
5. Phalaris arundinaceae	20		FACW
6. Equisetum telmateia	10		FACW
7.			
8.			
9.			
10.			
11.			
	150	= Total Cover	

Woody Vine Stratum (Plot size: 4m)			
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum ___

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 4 (A)
Total Number of Dominant Species Across All Strata: 5 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 80% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A = ___

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes x No ___

Remarks:

SOIL

Sampling Point: WP2

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Redox Features Type[1]	Redox Features Loc[2]	Texture	Remarks
0-14							Muck, too wet to get color sample	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- x Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):

Type: ___

Depth (inches): ___

Hydric Soil Present? **Yes** x **No** ___

Remarks: Soil was so wet and loose fell off the shovel as liquid, did not sample color.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- x Surface Water (A1)
- x High Water Table (A2)
- x Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- x Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Stunted or Stressed Plants (D1) (**LRR A**)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)
- ___ Raised Ant Mounds (D6) (**LRR A**)
- ___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes	x	No	___	Depth (inches): 2
Water Table Present?	Yes	x	No	___	Depth (inches): ___
Saturation Present? (includes capillary fringe)	Yes	x	No	___	Depth (inches): ___

Wetland Hydrology Present? **Yes** x **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: Standing water even in fall

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/28/13
Applicant/Owner: King County State: WA Sampling Point: WP3
Investigator(s): Townsend, Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.659580958 Long: -122.123123399 Datum: NAVD88
Soil Map Unit Name: Alderwood gravelly sandy loam, 6 to 15% NWI classification: None
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ___	No X	**Is the Sampled Area within a Wetland?**	**Yes** ___ **No** x
Hydric Soil Present?	Yes x	No ___		
Wetland Hydrology Present?	Yes ___	No X		

Remarks: Plot located in relatively high flat ground near West Lake Sammamish Parkway

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Populus balsamifera	75	Y	FAC
2. Acer macrophyllum	20	Y	FACU
3.			
4.			
	95	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1. Rubus procerus	70	Y	FACU
2.			
3.			
4.			
5.			
	70	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Phalaris arundinaceae	20	Y	FACW
2. Equisetum telmateia	5		FACW
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	25	= Total Cover	

Woody Vine Stratum (Plot size: 4m)			
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum 10

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)
Total Number of Dominant Species Across All Strata: 4 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 50% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species	25	x 2 =	50
FAC species	75	x 3 =	225
FACU species	90	x 4 =	360
UPL species		x 5 =	
Column Totals:	190 (A)		635 (B)

Prevalence Index = B/A = 3.3

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- ___ 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** ___ **No** x

Remarks:

SOIL

Sampling Point: WP3

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Redox Features Type[1]	Redox Features Loc[2]	Texture	Remarks
0-10	10YR3/2						Fine gravelly sand; rock at depth	No mottles

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
x Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):
Type: ___
Depth (inches): ___

Hydric Soil Present? **Yes** x **No** ___

Remarks: Weak indicator for F3

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes	___	No	X	Depth (inches): ___
Water Table Present?	Yes	___	No	X	Depth (inches): ___
Saturation Present? (includes capillary fringe)	Yes	___	No	X	Depth (inches): ___

Wetland Hydrology Present? **Yes** ___ **No** x

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: Upland paired plot to WP2

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/28/13
Applicant/Owner: King County State: WA Sampling Point: WP4
Investigator(s): Townsend, Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.659876960 Long: -122.122886758 Datum: NAVD88
Soil Map Unit Name: Alderwood gravelly sandy loam, 6 to 15% NWI classification: None
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes	X	No	___
Hydric Soil Present?	Yes	X	No	___
Wetland Hydrology Present?	Yes	X	No	___

Is the Sampled Area within a Wetland? Yes X No ___

Remarks: Plot located in relatively high flat ground near West Lake Sammamish Parkway. Quarry spalls present as area used for staging/access

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Salix sitchensis	10	Y	FACW
2.			
3.			
4.			
	10	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1. Rubus procerus	20	Y	FACU
2.			
3.			
4.			
5.			
	20	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Phalaris arundinaceae	100	Y	FACW
2. Iris pseudacorus	30	Y	OBL
3. Typha latifolia	20		OBL
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	150	= Total Cover	

Woody Vine Stratum (Plot size: 4m)		
1.		
2.		
	0	= Total Cover

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)
Total Number of Dominant Species Across All Strata: 4 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 75% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes x No ___

Remarks:

SOIL

Sampling Point: WP4

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-6							Peat	
6-14	Gley1 3/N	80%	7.5YR 5/8	20%	C	M	Silty sand	Quarry rock

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- x Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** x **No** ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- x Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Stunted or Stressed Plants (D1) (**LRR A**)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)
- ___ Raised Ant Mounds (D6) (**LRR A**)
- ___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes	___	No	X	Depth (inches):	___
Water Table Present?	Yes	X	No	___	Depth (inches):	8”
Saturation Present? (includes capillary fringe)	Yes	X	No	___	Depth (inches):	Surface

Wetland Hydrology Present? **Yes** x **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/28/13
Applicant/Owner: King County State: WA Sampling Point: WP5
Investigator(s): Townsend, Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.659876960 Long: -122.120738600 Datum: NAVD88
Soil Map Unit Name: Alderwood gravelly sandy loam, 6 to 15% NWI classification: Palustrine scrub/shrub
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ___	**Is the Sampled Area within a Wetland?**	**Yes X No ___**
Hydric Soil Present?	Yes X	No ___		
Wetland Hydrology Present?	Yes X	No ___		

Remarks: Plot located in transition zone that was recently mowed

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1.			
2.			
3.			
4.			
5.			
	0	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Phalaris arundinaceae (mowed)	100	Y	FACW
2. Scirpus microcarpus (mowed)	20	Y	OBL
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	120	= Total Cover	

Woody Vine Stratum (Plot size: 4m)			
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)
Total Number of Dominant Species Across All Strata: 2 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes x No ___

Remarks:

SOIL

Sampling Point: WP5

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-4							Peat	
4-8							Coarse sand	
8-10	Gley1 4/5GY	75%	7.5YR 5/8	25%			Silty sand	Excavated?
10+							Rock	Quarry rock

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- x Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** x **No** ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- x High Water Table (A2)
- x Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Stunted or Stressed Plants (D1) (**LRR A**)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)
- ___ Raised Ant Mounds (D6) (**LRR A**)
- ___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes	___	No	X	Depth (inches): ___
Water Table Present?	Yes	X	No	___	Depth (inches): 8”
Saturation Present? (includes capillary fringe)	Yes	X	No	___	Depth (inches): Surface

Wetland Hydrology Present? **Yes** x **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/28/13
Applicant/Owner: King County State: WA Sampling Point: WP6
Investigator(s): Townsend, Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.658679569 Long: -122.121163701 Datum: NAVD88
Soil Map Unit Name: Alderwood gravelly sandy loam, 6 to 15% NWI classification: None
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ___	**Is the Sampled Area within a Wetland?**	**Yes x No ___**
Hydric Soil Present?	Yes X	No ___		
Wetland Hydrology Present?	Yes ___	No x		

Remarks: Strong vegetation and soil indicators and no hydrology. As sampling occurred at end of long dry season, presume hydrology present in late winter/spring to strongly affect veg and soil.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Salix lucida	50	Y	FACW
2. Fraxinus latifolia	30	Y	FACW
3.			
4.			
	80	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1. Rubus procerus	20	Y	FACU
2.			
3.			
4.			
5.			
	20	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Phalaris arundinaceae	100	Y	FACW
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	100	= Total Cover	

Woody Vine Stratum (Plot size: 4m)			
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)
Total Number of Dominant Species Across All Strata: 4 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 75% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes x No ___

Remarks:

SOIL

Sampling Point: WP6

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-4							Root mat	
4-14	10YR 6/2	50%	2.5YR 4/8	50%	C	M	Silty loam	
~12							Diatomaceous layer	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
x Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):
Type: _____
Depth (inches): _____

Hydric Soil Present? **Yes** x **No** ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes	___	No	X	Depth (inches): _____
Water Table Present?	Yes	___	No	X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes	___	No	X	Depth (inches): _____

Wetland Hydrology Present? **Yes** ___ **No** x

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/28/13
Applicant/Owner: King County State: WA Sampling Point: WP7
Investigator(s): Townsend, Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.658691305 Long: -122.121110987 Datum: NAVD88
Soil Map Unit Name: Alderwood gravelly sandy loam, 6 to 15% NWI classification: None
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ___	**Is the Sampled Area within a Wetland?** **Yes** ___ **No** x
Hydric Soil Present?	Yes X	No ___	
Wetland Hydrology Present?	Yes ___	No X	

Remarks: Weak vegetation indicator, in blackberry patch. Appears to be upland plot and is paired with WP6 (wetland)

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Salix lucida	25	Y	FACW
2. Fraxinus latifolia	50	Y	FACW
3.			
4.			
	75	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1. Rubus procerus	90	Y	FACU
2.			
3.			
4.			
5.			
	90	= Total Cover	

Herb Stratum (Plot size: 2m)			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	0	= Total Cover	

Woody Vine Stratum (Plot size: 4m)			
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)
Total Number of Dominant Species Across All Strata: 3 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 67% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** x **No** ___

Remarks:

SOIL

Sampling Point: WP7

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-6							Organic enriched loam	
6-14	10YR 4/2	60%	10YR 5/8	40	C	M	Fine sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
x Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):
Type: _____
Depth (inches): _____

Hydric Soil Present? **Yes** x **No** ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): _____
Water Table Present? Yes ___ No X Depth (inches): _____
Saturation Present? (includes capillary fringe) Yes ___ No X Depth (inches): _____

Wetland Hydrology Present? **Yes** ___ **No** x

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/28/13
Applicant/Owner: King County State: WA Sampling Point: WP8
Investigator(s): Townsend, Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.658198838 Long: -122.120403697 Datum: NAVD88
Soil Map Unit Name: Alderwood gravelly sandy loam, 6 to 15% NWI classification: None
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present? Yes X No ___
Hydric Soil Present? Yes X No ___
Wetland Hydrology Present? Yes X No ___

Is the Sampled Area within a Wetland? Yes x No ___

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Populus balsamifera	50	Y	FAC
2. Populus nigra	20	Y	N.L.
3. Salix sitchensis	15	Y	FACW
4.			
	85	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1. Rubus procerus	20	Y	FACU
2. Frangula purshiana	10		
3. Crataegus monogyna	10		
4. Cytisus scoparius	10		
5.			
	50	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Phleum pratense	20	Y	FAC
2. Agrostis stolonifera	60	Y	FAC
3. Schedonorus arundinaceae	10		FAC
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	90	= Total Cover	

Woody Vine Stratum (Plot size: 4m)		
1.		
2.		
	0	= Total Cover

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 4 (A)
Total Number of Dominant Species Across All Strata: 6 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 67% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes x No ___

Remarks:

SOIL

Sampling Point: WP8

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-4							Organic enriched sand	
4-14	10YR 5/1	98%	10YR 5/8	2%	C	M	Medium sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
x Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):
Type: ___
Depth (inches): ___

Hydric Soil Present? **Yes** ___ **No** x

Remarks: Redox mottles are a little weak, but noticeable enough to classify as hydric.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
x Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): ___
Water Table Present? Yes ___ No X Depth (inches): ___
Saturation Present? (includes capillary fringe) Yes ___ No X Depth (inches): ___

Wetland Hydrology Present? **Yes** x **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available: Plot is close enough in proximity to piezometer #4 that had ponded water for a couple of months in 2014 to be considered wetland.

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/28/13
Applicant/Owner: King County State: WA Sampling Point: WP9
Investigator(s): Townsend, Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.657951085 Long: -122.120114300 Datum: NAVD88
Soil Map Unit Name: Alderwood gravelly sandy loam, 6 to 15% NWI classification: None
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes	X	No	
Hydric Soil Present?	Yes	X	No	
Wetland Hydrology Present?	Yes	X	No	

Is the Sampled Area within a Wetland? **Yes** X **No** ___

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Populus balsamifera	20	Y	FAC
2. Salix sitchensis	20	Y	FACW
3.			
4.			
	40	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1. Spirea douglasii	15	Y	FACW
2.			
3.			
4.			
5.			
	15	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Agrostis stolonifera	60	Y	FAC
2. Phalaris arundinaceae	20		FACW
3. Carex obnupta	30	Y	OBL
4. Schedonorus arundinaceae	25	Y	FAC
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	135	= Total Cover	

Woody Vine Stratum (Plot size: 4m)		
1.		
2.		
	0	= Total Cover

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 6 (A)
Total Number of Dominant Species Across All Strata: 6 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** x **No** ___

Remarks:

SOIL

Sampling Point: WP9

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-2							Organics/duff	
2-14	10YR 4/1	90%	7.5YR 5/8	10%	C	M	Medium sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- X Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** x **No** x

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- x Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Stunted or Stressed Plants (D1) (**LRR A**)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)
- ___ Raised Ant Mounds (D6) (**LRR A**)
- ___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes		No	X	Depth (inches):	
Water Table Present?	Yes		No	X	Depth (inches):	
Saturation Present? (includes capillary fringe)	Yes	X	No		Depth (inches):	12

Wetland Hydrology Present? **Yes** x **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/28/13
Applicant/Owner: King County State: WA Sampling Point: WP10
Investigator(s): Townsend, Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: Long: Datum: NAVD88
Soil Map Unit Name: Alderwood gravelly sandy loam, 6 to 15% NWI classification: Palustrine emergent
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ___	No X	**Is the Sampled Area within a Wetland?** **Yes** ___ **No** x
Hydric Soil Present?	Yes ___	No x	
Wetland Hydrology Present?	Yes ___	No X	

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1. Cytisus scoparius	80	Y	N.L.
2.			
3.			
4.			
5.			
	80	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Agrostis stolonifera	20	Y	FAC
2. Atriplex sp.	20	Y	N.L.
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	40	= Total Cover	

Woody Vine Stratum (Plot size: 4m)		
1.		
2.		
	0	= Total Cover

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)
Total Number of Dominant Species Across All Strata: 3 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 33% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- ___ 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** ___ **No** x

Remarks:

SOIL

Sampling Point: WP10

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-1							Organics/duff	
1-14	10YR 4/2	100					Medium sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- X Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** ___ **No** x

Remarks: Redox mottles are not distinct or prominent to meet S5 indicator

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Stunted or Stressed Plants (D1) (**LRR A**)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)
- ___ Raised Ant Mounds (D6) (**LRR A**)
- ___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes	___	No	X	Depth (inches): _____
Water Table Present?	Yes	___	No	X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes	___	No	x	Depth (inches): _____

Wetland Hydrology Present? **Yes** ___ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/28/13
Applicant/Owner: King County State: WA Sampling Point: WP11
Investigator(s): Townsend, Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.657369537 Long: -122.117496098 Datum: NAVD88
Soil Map Unit Name: Earlmont silt loam NWI classification: Palustrine emergent
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ___	**Is the Sampled Area within a Wetland?**	**Yes** ___ **No** x
Hydric Soil Present?	Yes X	No ___		
Wetland Hydrology Present?	Yes ___	No X		

Remarks: Weak hydrophytic vegetation indicator and no hydrology (previous data indicated not wetland).

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Betula pendula	50	Y	FACU
2.			
3.			
4.			
	50	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Cytisus scoparius	25	Y	N.L.
2. Rubus procerus	10		FACU
3.			
4.			
5.			
	35	= Total Cover	

Herb Stratum (Plot size: 2m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Carex obnupta	75	Y	OBL
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	75	= Total Cover	

Woody Vine Stratum (Plot size: 4m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum 10

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)
Total Number of Dominant Species Across All Strata: 3 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 33% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	75	x 1 =	75
FACW species		x 2 =	
FAC species		x 3 =	
FACU species	60	x 4 =	240
UPL species		x 5 =	
Column Totals:	135 (A)		315 (B)

Prevalence Index = B/A = 2.3

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- ___ 2 - Dominance Test is >50%
- x 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** x **No** ___

Remarks:

SOIL

Sampling Point: WP11

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-2							Organics/duff	
2-14	10YR 5/2	70	10YR 5/8	30	C	M	Silty loam	
~12							Diatomaceous	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
- ___ Loamy Gleyed Matrix (F2)
- X Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** x **No** ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Stunted or Stressed Plants (D1) (**LRR A**)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)
- ___ Raised Ant Mounds (D6) (**LRR A**)
- ___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes	___	No	X	Depth (inches): _____
Water Table Present?	Yes	___	No	X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes	___	No	x	Depth (inches): _____

Wetland Hydrology Present? **Yes** ___ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: Previous install of piezometers (King County 2003) indicated not wet.

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/28/13
Applicant/Owner: King County State: WA Sampling Point: WP12
Investigator(s): Townsend, Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.657321306 Long: -122.117519407 Datum: NAVD88
Soil Map Unit Name: Earlmont silt loam NWI classification: Palustrine emergent
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ___	No X	**Is the Sampled Area within a Wetland?**	**Yes** ___ **No** x
Hydric Soil Present?	Yes X	No ___		
Wetland Hydrology Present?	Yes ___	No X		

Remarks: Only hydric soil indicator present; previous piezometer monitoring indicated not wetland.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Betula pendula	50	Y	FACU
2. Unidentified ornamental	30	Y	N.L.
3.			
4.			
	80	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1. Cytisus scoparius	20	Y	N.L.
2. Ilex aquifolium	5		
3.			
4.			
5.			
	25	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Agrostis stolonifera	90	Y	FAC
2. Phalaris arundinaceae	10		FACW
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	100	= Total Cover	

Woody Vine Stratum (Plot size: 4m)		
1.		
2.		
	0	= Total Cover

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)
Total Number of Dominant Species Across All Strata: 4 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 25 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species	10	x 2 =	20
FAC species	90	x 3 =	270
FACU species	50	x 4 =	200
UPL species	35	x 5 =	175
Column Totals:	185 (A)		665 (B)

Prevalence Index = B/A = 3.6

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- ___ 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** ___ **No** x

Remarks:

SOIL

Sampling Point: WP12

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-2							Organics/duff	
2-14	10YR 6/1	90	10YR 8/6	30	C	M	Silty loam	Diatomaceous mixed in

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
X Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):
Type: ___
Depth (inches): ___

Hydric Soil Present? **Yes** x **No** ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes	___	No	X	Depth (inches): ___
Water Table Present?	Yes	___	No	X	Depth (inches): ___
Saturation Present? (includes capillary fringe)	Yes	___	No	x	Depth (inches): ___

Wetland Hydrology Present? **Yes** ___ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: Previous piezometer monitoring indicated not wetland

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/28/13
Applicant/Owner: King County State: WA Sampling Point: WP13
Investigator(s): Townsend, Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.657139733 Long: -122.116003493 Datum: NAVD88
Soil Map Unit Name: Earlmont silt loam NWI classification: Palustrine emergent
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ___	**Is the Sampled Area within a Wetland?** **Yes X No ___**
Hydric Soil Present?	Yes X	No ___	
Wetland Hydrology Present?	Yes X	No ___	

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Salix lucida	35	Y	FACW
2.			
3.			
4.			
	35	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1. Spirea douglasii	10	Y	FACW
2.			
3.			
4.			
5.			
	10	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Carex obnupta	90	Y	OBL
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	90	= Total Cover	

Woody Vine Stratum (Plot size: 4m)		
1.		
2.		
	0	= Total Cover

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)
Total Number of Dominant Species Across All Strata: 3 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes x No ___**

Remarks:

SOIL

Sampling Point: WP13

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-2							Organics	
2-14	Gley1 4/5GY	40	10YR 5/6	60	C	M	Silty clay	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
- x Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** x **No** ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- x Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Stunted or Stressed Plants (D1) (**LRR A**)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)
- ___ Raised Ant Mounds (D6) (**LRR A**)
- ___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes	___	No	X	Depth (inches): ___
Water Table Present?	Yes	___	No	X	Depth (inches): ___
Saturation Present? (includes capillary fringe)	Yes	x	No	___	Depth (inches): 10”

Wetland Hydrology Present? **Yes** x **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/28/13
Applicant/Owner: King County State: WA Sampling Point: WP14
Investigator(s): Townsend, Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.657155493 Long: -122.116122349 Datum: NAVD88
Soil Map Unit Name: Earlmont silt loam NWI classification: Palustrine emergent
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ___	**Is the Sampled Area within a Wetland?** **Yes** ___ **No** x
Hydric Soil Present?	Yes X	No ___	
Wetland Hydrology Present?	Yes ___	No x	

Remarks: Weak hydrophytic vegetation indicator – weedy species. Previous piezometer monitoring indicated not wetland.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Rubus procerus	10	Y	FACU
2.			
3.			
4.			
5.			
	10	= Total Cover	

Herb Stratum (Plot size: 2m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Phalaris arundinaceae	30	Y	FACW
2. Agrostis stolonifera	50	Y	FAC
3. Schedonorus arundinaceae	20	Y	FAC
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	100	= Total Cover	

Woody Vine Stratum (Plot size: 4m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)
Total Number of Dominant Species Across All Strata: 4 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 75% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** x **No** ___

Remarks:

SOIL

Sampling Point: WP14

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-2							Organics	
2-14	10YR 5/2	90	10YR 6/6	10	C	M	Silt w/ diatomaceous	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
x Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):
Type: ___
Depth (inches): ___

Hydric Soil Present? **Yes** x **No** ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): ___
Water Table Present? Yes ___ No X Depth (inches): ___
Saturation Present? (includes capillary fringe) Yes ___ No X Depth (inches): ___

Wetland Hydrology Present? **Yes** ___ **No** x

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/28/13
Applicant/Owner: King County State: WA Sampling Point: WP15
Investigator(s): Townsend, Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.656801082 Long: -122.115609596 Datum: NAVD88
Soil Map Unit Name: Earlmont silt loam NWI classification: Palustrine emergent
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes	X	No	
Hydric Soil Present?	Yes		No	x
Wetland Hydrology Present?	Yes	x	No	

Is the Sampled Area within a Wetland? **Yes** x **No** ___

Remarks: Strong vegetation and hydrology indicators, if hydrology is present, preponderance of evidence is that it is a wetland

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1. Spirea douglasii	75	Y	FACW
2.			
3.			
4.			
5.			
	75	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Phalaris arundinaceae	50	Y	FACW
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	50	= Total Cover	

Woody Vine Stratum (Plot size: 4m)			
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)
Total Number of Dominant Species Across All Strata: 2 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** x **No** ___

Remarks:

SOIL

Sampling Point: WP15

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Redox Features Type[1]	Redox Features Loc[2]	Texture	Remarks
0-2							Organics	
2-14	10YR 4/2						Silty clay w/ diatomaceous	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):
Type: _____
Depth (inches): _____

Hydric Soil Present? **Yes** ___ **No** x

Remarks: No mottles to meet hydric soil indicators

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
x Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): _____
Water Table Present? Yes ___ No X Depth (inches): _____
Saturation Present? (includes capillary fringe) Yes x No ___ Depth (inches): 10”

Wetland Hydrology Present? **Yes** x **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/28/13
Applicant/Owner: King County State: WA Sampling Point: WP16
Investigator(s): Townsend, Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.656779926 Long: -122.115697686 Datum: NAVD88
Soil Map Unit Name: Earlmont silt loam NWI classification: Palustrine emergent
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ___	**Is the Sampled Area within a Wetland?** **Yes** ___ **No** x
Hydric Soil Present?	Yes ___	No X	
Wetland Hydrology Present?	Yes ___	No X	

Remarks: Neither hydric soil nor hydrology present.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Rubus armeniacus	40	Y	FACU
2. Rosa pisocarpa	30	Y	FAC
3.			
4.			
5.			
	70	= Total Cover	

Herb Stratum (Plot size: 2m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Phalaris arundinaceae	60	Y	FACW
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	60	= Total Cover	

Woody Vine Stratum (Plot size: 4m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)
Total Number of Dominant Species Across All Strata: 3 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** x **No** ___

Remarks:

SOIL

Sampling Point: WP16

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-2							Organics	
2-14	10YR 4/2						Silty clay	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):

Type: ___

Depth (inches): ___

Hydric Soil Present? **Yes** ___ **No** x

Remarks: No mottles to meet hydric soil indicator F3

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- x Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Stunted or Stressed Plants (D1) (**LRR A**)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)
- ___ Raised Ant Mounds (D6) (**LRR A**)
- ___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes	___	No	X	Depth (inches): ___
Water Table Present?	Yes	___	No	X	Depth (inches): ___
Saturation Present? (includes capillary fringe)	Yes	___	No	x	Depth (inches): ___

Wetland Hydrology Present? **Yes** ___ **No** x

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/28/13
Applicant/Owner: King County State: WA Sampling Point: WP17
Investigator(s): Townsend, Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.656023455 Long: -122.114853263 Datum: NAVD88
Soil Map Unit Name: Earlmont silt loam NWI classification: Palustrine emergent
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ___	**Is the Sampled Area within a Wetland?** **Yes** ___ **No** x
Hydric Soil Present?	Yes ___	No X	
Wetland Hydrology Present?	Yes ___	No X	

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Alnus rubra	20	Y	FAC
2.			
3.			
4.			
	20	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1. Rubus procerus	20	Y	FACU
2.			
3.			
4.			
5.			
	20	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Agrostis stolonifera	80	Y	FAC
2. Cirsium arvense	10		FAC
3. Equisetum telmateia	2		FACW
4. Schedonorus arundinaceae	30	Y	FAC
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	122	= Total Cover	

Woody Vine Stratum (Plot size: 4m)		
1.		
2.		
	0	= Total Cover

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)
Total Number of Dominant Species Across All Strata: 4 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 75% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** x **No** ___

Remarks:

SOIL

Sampling Point: WP17

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Redox Features Type[1]	Redox Features Loc[2]	Texture	Remarks
0-2							Organics	
2-14	10YR 4/2						Silty clay	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):
Type: _____
Depth (inches): _____

Hydric Soil Present? **Yes** ___ **No** x

Remarks: No mottles to meet hydric soil indicator F3

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): _____
Water Table Present? Yes ___ No X Depth (inches): _____
Saturation Present? (includes capillary fringe) Yes ___ No x Depth (inches): _____

Wetland Hydrology Present? **Yes** ___ **No** x

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/28/13
Applicant/Owner: King County State: WA Sampling Point: WP18
Investigator(s): Townsend, Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.656029017 Long: -122.115307042 Datum: NAVD88
Soil Map Unit Name: Earlmont silt loam NWI classification: Palustrine emergent
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ___	**Is the Sampled Area within a Wetland?** **Yes** ___ **No** x
Hydric Soil Present?	Yes X	No ___	
Wetland Hydrology Present?	Yes ___	No X	

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0 = Total Cover		

Sapling/Shrub Stratum (Plot size: 4m)			
1.			
2.			
3.			
4.			
5.			
	0 = Total Cover		

Herb Stratum (Plot size: 2m)			
1. Agrostis stolonifera	90	Y	FAC
2. Juncus effusus	10		FACW
3. Schedonorus arundinaceae	10		FAC
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	110 = Total Cover		

Woody Vine Stratum (Plot size: 4m)			
1.			
2.			
	0 = Total Cover		

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)
Total Number of Dominant Species Across All Strata: 1 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** x **No** ___

Remarks:

SOIL

Sampling Point: WP18

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-2							Organics	
2-12	10YR 2/2	100					Loam	
12-14	10YR 8/2	95	10YR 5/8	5	C	M	Loam w/ diatomaceous	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
x Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):
Type: ___
Depth (inches): ___

Hydric Soil Present? **Yes** x **No** ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes	___	No	X	Depth (inches): ___
Water Table Present?	Yes	___	No	X	Depth (inches): ___
Saturation Present? (includes capillary fringe)	Yes	___	No	x	Depth (inches): ___

Wetland Hydrology Present? **Yes** ___ **No** x

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/28/13
Applicant/Owner: King County State: WA Sampling Point: WP19
Investigator(s): Townsend, Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.655811177 Long: -122.116117062 Datum: NAVD88
Soil Map Unit Name: Earlmont silt loam NWI classification: Palustrine emergent
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ___	**Is the Sampled Area within a Wetland?** **Yes** ___ **No** x
Hydric Soil Present?	Yes X	No ___	
Wetland Hydrology Present?	Yes ___	No X	

Remarks: Very strong vegetation and soils indicators, may be a small patch of wetland, did not find hydrology. Currently did not call wetland, but piezometers to be installed to monitor hydrology.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1.			
2.			
3.			
4.			
5.			
	0	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Iris pseudacorus	40	Y	OBL
2. Juncus effusus	50	Y	FACW
3. Agrostis gigantea	20		FAC
4. Phalaris arundinaceae	10		FACW
5. Carex obnupta	30	Y	OBL
6.			
7.			
8.			
9.			
10.			
11.			
	150	= Total Cover	

Woody Vine Stratum (Plot size: 4m)			
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)
Total Number of Dominant Species Across All Strata: 3 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** x **No** ___

Remarks:

SOIL

Sampling Point: WP19

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-2							Organics	
2-14	10YR 4/2	90	10YR 6/8	10	C	M	Loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
- ___ Loamy Gleyed Matrix (F2)
- X Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** x **No** ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- x Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Stunted or Stressed Plants (D1) (**LRR A**)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)
- ___ Raised Ant Mounds (D6) (**LRR A**)
- ___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes	___	No	X	Depth (inches): _____
Water Table Present?	Yes	___	No	X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes	___	No	x	Depth (inches): _____

Wetland Hydrology Present? **Yes** ___ **No** x

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/28/13
Applicant/Owner: King County State: WA Sampling Point: WP20
Investigator(s): Townsend, Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.654732522 Long: -122.114196309 Datum: NAVD88
Soil Map Unit Name: Earlmont silt loam NWI classification: None
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ___	**Is the Sampled Area within a Wetland?**	**Yes X No ___**
Hydric Soil Present?	Yes X	No ___		
Wetland Hydrology Present?	Yes x	No ___		

Remarks: Within planted mitigation area for SRA, seasonal wetland

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Alnus rubra	10	Y	FAC
2. Salix sitchensis	20	Y	FACW
3. Spirea douglasii	10	Y	FACW
4. Picea sitchensis	10	Y	FAC
5. Populus balsamifera	10	Y	FAC
	60	= Total Cover	

Herb Stratum (Plot size: 2m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Phalaris arundinaceae	60	Y	FACW
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	60	= Total Cover	

Woody Vine Stratum (Plot size: 4m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 6 (A)
Total Number of Dominant Species Across All Strata: 6 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes x No ___

Remarks:

SOIL

Sampling Point: WP20

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-2							Organics	
2-14	10YR 3/2	75	10YR 5/6	25	C	M	Silty clay	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
- ___ Loamy Gleyed Matrix (F2)
- X Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** x **No** ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Stunted or Stressed Plants (D1) (**LRR A**)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Saturation Visible on Aerial Imagery (C9)
- x Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- x FAC-Neutral Test (D5)
- ___ Raised Ant Mounds (D6) (**LRR A**)
- ___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes	___	No	X	Depth (inches): ___
Water Table Present?	Yes	___	No	X	Depth (inches): ___
Saturation Present? (includes capillary fringe)	Yes	___	No	x	Depth (inches): ___

Wetland Hydrology Present? **Yes** x **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/28/13
Applicant/Owner: King County State: WA Sampling Point: WP21
Investigator(s): Townsend, Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.655180825 Long: -122.115396706 Datum: NAVD88
Soil Map Unit Name: Earlmont silt loam NWI classification: None
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ___	**Is the Sampled Area within a Wetland?** **Yes** ___ **No** x
Hydric Soil Present?	Yes X	No ___	
Wetland Hydrology Present?	Yes ___	No X	

Remarks: Neither vegetation or soils indicators all that strong; weedy vegetation and no mottles, determined to not be wetland.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Crataegus monogyna	5		FAC
2. Rubus procerus	5		FACU
3.			
4.			
5.			
	10	= Total Cover	

Herb Stratum (Plot size: 2m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Cirsium arvense	30	Y	FAC
2. Agrostis gigantea	70	Y	FAC
3. Equisetum telmateia	10		FACW
4. Schedonorus arundinaceae	20	Y	FAC
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	130	= Total Cover	

Woody Vine Stratum (Plot size: 4m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)
Total Number of Dominant Species Across All Strata: 3 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** x **No** ___

Remarks:

SOIL

Sampling Point: WP21

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-2							Organics	
2-14	10YR 3/2	100					Loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
- ___ Loamy Gleyed Matrix (F2)
- X Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** x **No** ___

Remarks: Meets F3 indicator without mottles (sufficiently dark).

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Stunted or Stressed Plants (D1) (**LRR A**)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)
- ___ Raised Ant Mounds (D6) (**LRR A**)
- ___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes	___	No	X	Depth (inches): _____
Water Table Present?	Yes	___	No	X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes	___	No	x	Depth (inches): _____

Wetland Hydrology Present? **Yes** ___ **No** x

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/28/13
Applicant/Owner: King County State: WA Sampling Point: WP22
Investigator(s): Townsend, Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.653440810 Long: -122.115654008 Datum: NAVD88
Soil Map Unit Name: Earlmont silt loam NWI classification: Palustrine emergent
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ___	**Is the Sampled Area within a Wetland?** **Yes** ___ **No** x
Hydric Soil Present?	Yes X	No ___	
Wetland Hydrology Present?	Yes ___	No X	

Remarks: Vegetation indicator not all that strong, weedy species, and no hydrology, determined to not be wetland.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
Populus balsamifera	10	Y	FAC
2.			
3.			
4.			
	10	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1. Rubus procerus	15	Y	FACU
2.			
3.			
4.			
5.			
	15	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Phalaris arundinaceae	50	Y	FACW
2. Cirsium arvense	5		FAC
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	55	= Total Cover	

Woody Vine Stratum (Plot size: 4m)		
1.		
2.		
	0	= Total Cover

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)
Total Number of Dominant Species Across All Strata: 3 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 67% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** x **No** ___

Remarks:

SOIL

Sampling Point: WP22

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-2							Organics	
2-12	10YR 3/2	85	10YR 5/8	15	C	M	Loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
X Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):
Type: ___
Depth (inches): ___

Hydric Soil Present? **Yes** x **No** ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): ___
Water Table Present? Yes ___ No X Depth (inches): ___
Saturation Present? (includes capillary fringe) Yes ___ No x Depth (inches): ___

Wetland Hydrology Present? **Yes** ___ **No** x

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/28/13
Applicant/Owner: King County State: WA Sampling Point: WP23
Investigator(s): Townsend, Martz Section, Township, Range:
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.652712659 Long: -122.115154402 Datum: NAVD88
Soil Map Unit Name: Earlmont silt loam NWI classification: Palustrine emergent
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ___	**Is the Sampled Area within a Wetland?** **Yes x** **No ___**
Hydric Soil Present?	Yes X	No ___	
Wetland Hydrology Present?	Yes ___	No X	

Remarks: Strong vegetation and hydric soil indicators, very sparse understory, appears to be inundated, but no hydrology present at time of survey.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
Salix lucida	100	Y	FACW
2.			
3.			
4.			
	100	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1.			
2.			
3.			
4.			
5.			
	0	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Ranunculus repens	10	Y	FAC
2. Unknown grass	20	Y	N.L.
3. Phalaris arundinaceae	5		FACW
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	35	= Total Cover	

Woody Vine Stratum (Plot size: 4m)			
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum 70

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)
Total Number of Dominant Species Across All Strata: 3 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 67% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes x** **No ___**

Remarks:

SOIL

Sampling Point: WP23

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-1							Organics	
1-10							Silty clay	
10-14	10YR 5/1	75	10YR 6/6	25	C	M	Silty clay	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
- ___ Loamy Gleyed Matrix (F2)
- X Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** x **No** ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- x Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Stunted or Stressed Plants (D1) (**LRR A**)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
- x Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)
- ___ Raised Ant Mounds (D6) (**LRR A**)
- ___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): _____

Water Table Present? Yes ___ No X Depth (inches): _____

Saturation Present? (includes capillary fringe) Yes ___ No x Depth (inches): _____

Wetland Hydrology Present? **Yes** ___ **No** x

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/29/13
Applicant/Owner: King County State: WA Sampling Point: WP24
Investigator(s): Townsend, Baines Section, Township, Range:
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.652519116 Long: -122.113972437 Datum: NAVD88
Soil Map Unit Name: Earlmont silt loam NWI classification: Palustrine forested
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ___	**Is the Sampled Area within a Wetland?** **Yes x No ___**
Hydric Soil Present?	Yes X	No ___	
Wetland Hydrology Present?	Yes X	No ___	

Remarks:.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
Salix lucida	100	Y	FACW
2.			
3.			
4.			
	100	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1.			
2.			
3.			
4.			
5.			
	0	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Phalaris arundinaceae	60	Y	FACW
2. Iris pseudacorus	40	Y	OBL
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	100	= Total Cover	

Woody Vine Stratum (Plot size: 4m)			
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)
Total Number of Dominant Species Across All Strata: 3 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes x No ___**

Remarks:

SOIL

Sampling Point: WP24

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-1							Organics	
1-14	10YR 2/1	60	10YR 4/6	40			Silty clay	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
- ___ Loamy Gleyed Matrix (F2)
- X Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** x **No** ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- x High Water Table (A2)
- x Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Stunted or Stressed Plants (D1) (**LRR A**)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
- x Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)
- ___ Raised Ant Mounds (D6) (**LRR A**)
- ___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes		No	X	Depth (inches):	
Water Table Present?	Yes	X	No		Depth (inches):	6
Saturation Present? (includes capillary fringe)	Yes	x	No		Depth (inches):	surface

Wetland Hydrology Present? **Yes** x **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/29/13
Applicant/Owner: King County State: WA Sampling Point: WP25
Investigator(s): Townsend, Baines Section, Township, Range:
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.652143063 Long: -122.114522263 Datum: NAVD88
Soil Map Unit Name: Earlmont silt loam NWI classification: Palustrine emergent
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ___	**Is the Sampled Area within a Wetland?** **Yes** ___ **No** x
Hydric Soil Present?	Yes ___	No X	
Wetland Hydrology Present?	Yes ___	No X	

Remarks:.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
2.			
3.			
4.			
	0	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1. Rubus armeniacus	25	Y	FACU
2.			
3.			
4.			
5.			
	25	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Agrostis gigantea	30	Y	FAC
2. Ranunculus repens	20	Y	FAC
3. Phalaris arundinacea	40	Y	FACW
4. Cirsium arvense	15		FAC
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	105	= Total Cover	

Woody Vine Stratum (Plot size: 4m)		
1.		
2.		
	0	= Total Cover

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)
Total Number of Dominant Species Across All Strata: 4 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 75% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** x **No** ___

Remarks:

SOIL

Sampling Point: WP25

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-1							Organics	
1-14	10YR 4/2	90	10YR 4/3	10	C	M	Silty clay	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):
Type: ___
Depth (inches): ___

Hydric Soil Present? **Yes** ___ **No** x

Remarks: Mottling not distinct to meet F3 indicator

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
x Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): ___
Water Table Present? Yes ___ No X Depth (inches): ___
Saturation Present? (includes capillary fringe) Yes ___ No X Depth (inches): ___

Wetland Hydrology Present? **Yes** ___ **No** x

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/29/13
Applicant/Owner: King County State: WA Sampling Point: WP26
Investigator(s): Townsend, Baines Section, Township, Range:
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.653081081 Long: -122.114318595 Datum: NAVD88
Soil Map Unit Name: Earlmont silt loam NWI classification: Palustrine forested
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ___	**Is the Sampled Area within a Wetland?** **Yes x No ___**
Hydric Soil Present?	Yes X	No ___	
Wetland Hydrology Present?	Yes X	No ___	

Remarks:.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
2.			
3.			
4.			
	0	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1. Rubus armeniacus	10	Y	FACU
2. Urtica dioica	5		FAC
3.			
4.			
5.			
	15	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Phalaris arundinaceae	100	Y	FACW
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	100	= Total Cover	

Woody Vine Stratum (Plot size: 4m)		
1.		
2.		
	0	= Total Cover

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC:	1	(A)
Total Number of Dominant Species Across All Strata:	2	(B)
Percent of Dominant Species That Are OBL, FACW, or FAC:	50%	(A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species	100	x 2 =	200
FAC species	5	x 3 =	15
FACU species	10	x 4 =	40
UPL species		x 5 =	
Column Totals:	115 (A)		255 (B)

Prevalence Index = B/A = 2.2

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- ___ 2 - Dominance Test is >50%
- x 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes x No ___**

Remarks:

SOIL

Sampling Point: WP26

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-2							Organics	
2-10							Silty clay	
10-14	10YR 3/2	65	10YR 5/6	35	C	M	Silty clay	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
- ___ Loamy Gleyed Matrix (F2)
- x Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** x **No** ___

Remarks: Mottling not distinct to meet F3 indicator

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- x Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Stunted or Stressed Plants (D1) (**LRR A**)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)
- ___ Raised Ant Mounds (D6) (**LRR A**)
- ___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): _____

Water Table Present? Yes ___ No X Depth (inches): _____

Saturation Present? (includes capillary fringe) Yes ___ No X Depth (inches): _____

Wetland Hydrology Present? **Yes** x **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/29/13
Applicant/Owner: King County State: WA Sampling Point: WP27
Investigator(s): Townsend, Baines Section, Township, Range:
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.652894448 Long: -122.114593098 Datum: NAVD88
Soil Map Unit Name: Earlmont silt loam NWI classification: Palustrine emergent
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes	X	No	
Hydric Soil Present?	Yes		No	x
Wetland Hydrology Present?	Yes		No	x

Is the Sampled Area within a Wetland? **Yes** ___ **No** x

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
2.			
3.			
4.			
	0	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1.			
2.			
3.			
4.			
5.			
	0	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Phalaris arundinaceae	100	Y	FACW
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	100	= Total Cover	

Woody Vine Stratum (Plot size: 4m)			
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)
Total Number of Dominant Species Across All Strata: 1 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- X 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** x **No** ___

Remarks:

SOIL

Sampling Point: WP27

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-1							Organics	
1-6							Silty clay	
6-12							Clayey silt	
12-14	10YR 4/2	80	10YR 5/3	20	C	M	Clayey silt	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):
Type: _____
Depth (inches): _____

Hydric Soil Present? **Yes** ___ **No** x

Remarks: Mottling not distinct to meet indicator F3

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): _____
Water Table Present? Yes ___ No X Depth (inches): _____
Saturation Present? (includes capillary fringe) Yes ___ No X Depth (inches): _____

Wetland Hydrology Present? **Yes** ___ **No** x

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/29/13
Applicant/Owner: King County State: WA Sampling Point: WP28
Investigator(s): Townsend, Baines Section, Township, Range:
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.651463793 Long: -122.113003258 Datum: NAVD88
Soil Map Unit Name: Kitsap silt loam, 2-8% slopes NWI classification: Palustrine emergent
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present? Yes X No ___
Hydric Soil Present? Yes X No ___
Wetland Hydrology Present? Yes x No ___

Is the Sampled Area within a Wetland? Yes x No ___

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Salix sitchensis	25	Y	FACW
2. Salix lucida	10		FACW
3.			
4.			
	35	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1. Rubus armeniacus	10	Y	FACU
2.			
3.			
4.			
5.			
	10	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Phalaris arundinaceae	100	Y	FACW
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	100	= Total Cover	

Woody Vine Stratum (Plot size: 4m)		
1.		
2.		
	0	= Total Cover

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)
Total Number of Dominant Species Across All Strata: 3 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 67% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- X 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes x No ___

Remarks:

SOIL

Sampling Point: WP28

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Redox Features Type[1]	Redox Features Loc[2]	Texture	Remarks

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- x Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** x **No** ___

Remarks: Could not get soil sample as it was so wet to be liquid, generally organic.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- X High Water Table (A2)
- X Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Stunted or Stressed Plants (D1) (**LRR A**)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)
- ___ Raised Ant Mounds (D6) (**LRR A**)
- ___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes	___	No	X	Depth (inches): ___
Water Table Present?	Yes	X	No	___	Depth (inches): Surface
Saturation Present? (includes capillary fringe)	Yes	X	No	___	Depth (inches): surface

Wetland Hydrology Present? **Yes** x **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/29/13
Applicant/Owner: King County State: WA Sampling Point: WP29
Investigator(s): Townsend, Baines Section, Township, Range:
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.651461552 Long: -122.112951191 Datum: NAVD88
Soil Map Unit Name: Kitsap silt loam, 2-8% slopes NWI classification: Palustrine emergent
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ___	**Is the Sampled Area within a Wetland?** **Yes** ___ **No** x
Hydric Soil Present?	Yes X	No ___	
Wetland Hydrology Present?	Yes ___	No x	

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Fraxinus latifolia	30	Y	FACW
2.			
3.			
4.			
	30	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1. Rubus armeniacus	20	Y	FACU
2. Cornus stolonifera	20	Y	FAC
3.			
4.			
5.			
	40	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Phalaris arundinaceae	90	Y	FACW
2. Equisetum telmateia	5		FACW
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	95	= Total Cover	

Woody Vine Stratum (Plot size: 4m)			
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)
Total Number of Dominant Species Across All Strata: 4 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 75% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- X 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** x **No** ___

Remarks:

SOIL

Sampling Point: WP29

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Redox Features Type[1]	Redox Features Loc[2]	Texture	Remarks
0-4							Organic/duff	
4-12	10YR 3/2						Clayey silt	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- x Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
- ___ Loamy Gleyed Matrix (F2)
- x Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** x **No** ___

Remarks: Rock present from road/parking lot fill; no mottling but depleted matrix, kind of suspect whether really hydric or not.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Stunted or Stressed Plants (D1) (**LRR A**)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)
- ___ Raised Ant Mounds (D6) (**LRR A**)
- ___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes	___	No	X	Depth (inches): _____
Water Table Present?	Yes	___	No	X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes	___	No	x	Depth (inches): _____

Wetland Hydrology Present? **Yes** ___ **No** x

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/29/13
Applicant/Owner: King County State: WA Sampling Point: WP30
Investigator(s): Townsend, Baines Section, Township, Range:
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.650600506 Long: -122.113199443 Datum: NAVD88
Soil Map Unit Name: Kitsap silt loam, 2-8% slopes NWI classification: None
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ___	**Is the Sampled Area within a Wetland?** **Yes** ___ **No** x
Hydric Soil Present?	Yes X	No ___	
Wetland Hydrology Present?	Yes ___	No x	

Remarks: No hydrology present, weak soil and hydrophytic vegetation indicators

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Acer macrophyllum	10	Y	FACU
2. Salix sitchensis	10	Y	FACW
3.			
4.			
	20	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1. Rubus armeniacus	20	Y	FACU
2.			
3.			
4.			
5.			
	20	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Phalaris arundinaceae	100	Y	FACW
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	100	= Total Cover	

Woody Vine Stratum (Plot size: 4m)			
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)
Total Number of Dominant Species Across All Strata: 4 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 50% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species	110	x 2 =	220
FAC species		x 3 =	
FACU species	30	x 4 =	120
UPL species		x 5 =	
Column Totals:	140 (A)		340 (B)

Prevalence Index = B/A = 2.4

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- ___ 2 - Dominance Test is >50%
- X 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** x **No** ___

Remarks:

SOIL

Sampling Point: WP30

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-1							Organic/duff	
1-12	10YR 3/2	90	10YR 4/4	10	C	M	Clayey silt	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- x Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
- ___ Loamy Gleyed Matrix (F2)
- x Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):

Type: ___

Depth (inches): ___

Hydric Soil Present? **Yes** x **No** ___

Remarks:.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Stunted or Stressed Plants (D1) (**LRR A**)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)
- ___ Raised Ant Mounds (D6) (**LRR A**)
- ___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes	___	No	X	Depth (inches): ___
Water Table Present?	Yes	___	No	X	Depth (inches): ___
Saturation Present? (includes capillary fringe)	Yes	___	No	x	Depth (inches): ___

Wetland Hydrology Present? **Yes** ___ **No** x

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/29/13
Applicant/Owner: King County State: WA Sampling Point: WP31
Investigator(s): Townsend, Baines Section, Township, Range:
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.651587418 Long: -122.111794395 Datum: NAVD88
Soil Map Unit Name: Tukwila muck NWI classification: Palustrine emergent
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ___	**Is the Sampled Area within a Wetland?** **Yes x No ___**
Hydric Soil Present?	Yes X	No ___	
Wetland Hydrology Present?	Yes x	No ___	

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0 = Total Cover		

Sapling/Shrub Stratum (Plot size: 4m)			
1.			
2.			
3.			
4.			
5.			
	0 = Total Cover		

Herb Stratum (Plot size: 2m)			
1. Phalaris arundinaceae	100	Y	FACW
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	100 = Total Cover		

Woody Vine Stratum (Plot size: 4m)			
1.			
2.			
	0 = Total Cover		

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)
Total Number of Dominant Species Across All Strata: 1 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- X 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes x No ___**

Remarks:

SOIL

Sampling Point: WP31

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-4							Organic/roots	
4-12	10YR 2/2	100					Silty clay	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- x Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
- ___ Loamy Gleyed Matrix (F2)
- x Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** x **No** ___

Remarks:.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- x Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Stunted or Stressed Plants (D1) (**LRR A**)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)
- ___ Raised Ant Mounds (D6) (**LRR A**)
- ___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes	___	No	X	Depth (inches): ___
Water Table Present?	Yes	___	No	X	Depth (inches): ___
Saturation Present? (includes capillary fringe)	Yes	x	No	___	Depth (inches): 6

Wetland Hydrology Present? **Yes** x **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/29/13
Applicant/Owner: King County State: WA Sampling Point: WP32
Investigator(s): Townsend, Baines Section, Township, Range:
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.651143435 Long: -122.111535357 Datum: NAVD88
Soil Map Unit Name: Tukwila muck NWI classification: None
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ___	**Is the Sampled Area within a Wetland?**	**Yes** ___ **No** x
Hydric Soil Present?	Yes X	No ___		
Wetland Hydrology Present?	Yes ___	No X		

Remarks: No hydrology and weak soil indicators – site dominated by Phalaris

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Salix sitchensis	20	Y	FACW
2.			
3.			
4.			
	20	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1. Rubus armeniacus	10	Y	FACU
2.			
3.			
4.			
5.			
	10	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Phalaris arundinaceae	100	Y	FACW
2. Agrostis stolonifera	20	Y	FAC
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	120	= Total Cover	

Woody Vine Stratum (Plot size: 4m)		
1.		
2.		
	0	= Total Cover

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)
Total Number of Dominant Species Across All Strata: 4 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 75% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- X 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** x **No** ___

Remarks:

SOIL

Sampling Point: WP32

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-2							Organic/roots	
2-12	10YR 3/2	80	10YR 4/4	20			Silty clay	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
x Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):
Type: ___
Depth (inches): ___

Hydric Soil Present? **Yes** x **No** ___

Remarks: Mottling is faint but meets F3 indicator.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes	___	No	X	Depth (inches): ___
Water Table Present?	Yes	___	No	X	Depth (inches): ___
Saturation Present? (includes capillary fringe)	Yes	___	No	x	Depth (inches): 6

Wetland Hydrology Present? **Yes** ___ **No** x

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/29/13
Applicant/Owner: King County State: WA Sampling Point: WP33
Investigator(s): Townsend, Baines Section, Township, Range:
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.651999443 Long: -122.110085643 Datum: NAVD88
Soil Map Unit Name: Tukwila muck NWI classification: Palustrine forested
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ___	**Is the Sampled Area within a Wetland?** **Yes x No ___**
Hydric Soil Present?	Yes X	No ___	
Wetland Hydrology Present?	Yes X	No ___	

Remarks

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Fraxinus latifolia	20	Y	FACW
2.			
3.			
4.			
	20	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1.			
2.			
3.			
4.			
5.			
	0	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Phalaris arundinaceae	100	Y	FACW
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	100	= Total Cover	

Woody Vine Stratum (Plot size: 4m)			
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)
Total Number of Dominant Species Across All Strata: 2 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- X 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes x No ___**

Remarks:

SOIL

Sampling Point: WP33

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-3							Organic/roots	
3-12	10YR 2/1	100					Clayey silt	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
- ___ Loamy Gleyed Matrix (F2)
- x Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** x **No** ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- X High Water Table (A2)
- X Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Stunted or Stressed Plants (D1) (**LRR A**)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)
- ___ Raised Ant Mounds (D6) (**LRR A**)
- ___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes	___	No	X	Depth (inches): ___
Water Table Present?	Yes	X	No	___	Depth (inches): 12
Saturation Present? (includes capillary fringe)	Yes	X	No	___	Depth (inches): Surface

Wetland Hydrology Present? **Yes** x **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/29/13
Applicant/Owner: King County State: WA Sampling Point: WP34
Investigator(s): Townsend, Baines Section, Township, Range:
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.659528904 Long: -122.120542002 Datum: NAVD88
Soil Map Unit Name: Pilchuck loamy fine sand NWI classification: Palustrine scrub/shrub
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes	X	No	
Hydric Soil Present?	Yes		No	X
Wetland Hydrology Present?	Yes		No	X

Is the Sampled Area within a Wetland? **Yes** ___ **No** x

Remarks

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1.			
2.			
3.			
4.			
5.			
	0	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Phalaris arundinaceae (mowed)	50	Y	FACW
2. Agrostis stolonifera (mowed)	100	Y	FAC
3. Unidentified grass (mowed)	50	Y	N.L.
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	200	= Total Cover	

Woody Vine Stratum (Plot size: 4m)		
1.		
2.		
	0	= Total Cover

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)
Total Number of Dominant Species Across All Strata: 3 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 67% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- X 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** x **No** ___

Remarks:

SOIL

Sampling Point: WP34

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-1							Organic/roots	
1-12	10YR 5/3	100					Medium sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):
Type: _____
Depth (inches): _____

Hydric Soil Present? **Yes** ___ **No** x

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): _____
Water Table Present? Yes ___ No X Depth (inches): _____
Saturation Present? (includes capillary fringe) Yes ___ No X Depth (inches): _____

Wetland Hydrology Present? **Yes** ___ **No** x

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/29/13
Applicant/Owner: King County State: WA Sampling Point: WP35
Investigator(s): Townsend, Baines Section, Township, Range:
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.659431984 Long: -122.120651359 Datum: NAVD88
Soil Map Unit Name: Pilchuck loamy fine sand NWI classification: Palustrine scrub/shrub
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ___	**Is the Sampled Area within a Wetland?** **Yes x No ___**
Hydric Soil Present?	Yes X	No ___	
Wetland Hydrology Present?	Yes X	No ___	

Remarks

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1.			
2.			
3.			
4.			
5.			
	0	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Phalaris arundinaceae (mowed)	50	Y	FACW
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	50	= Total Cover	

Woody Vine Stratum (Plot size: 4m)			
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)
Total Number of Dominant Species Across All Strata: 1 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- X 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes x No ___**

Remarks:

SOIL

Sampling Point: WP35

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-4							Organic/roots	
4-6							Silt	
6-14	Gley1 3/10Y						Silty sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- x Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** x **No** ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- X Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Stunted or Stressed Plants (D1) (**LRR A**)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)
- ___ Raised Ant Mounds (D6) (**LRR A**)
- ___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes	___	No	X	Depth (inches): ___
Water Table Present?	Yes	___	No	X	Depth (inches): ___
Saturation Present? (includes capillary fringe)	Yes	X	No	___	Depth (inches): surface

Wetland Hydrology Present? **Yes** x **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/29/13
Applicant/Owner: King County State: WA Sampling Point: WP36
Investigator(s): Townsend, Baines Section, Township, Range:
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.658646997 Long: -122.118186375 Datum: NAVD88
Soil Map Unit Name: Pilchuck loamy fine sand NWI classification: Palustrine scrub/shrub
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ___	**Is the Sampled Area within a Wetland?** **Yes** ___ **No** x
Hydric Soil Present?	Yes ___	No X	
Wetland Hydrology Present?	Yes ___	No X	

Remarks

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1.			
2.			
3.			
4.			
5.			
	0	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Agrostis gigantea	100	Y	FAC
2. Poa pratensis	50	Y	FAC
3. Phalaris arundinaceae	10		FACW
4. Traxacum officinale	5		FACU
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	50	= Total Cover	

Woody Vine Stratum (Plot size: 4m)			
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum 0

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)
Total Number of Dominant Species Across All Strata: 2 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- X 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** x **No** ___

Remarks:

SOIL

Sampling Point: WP36

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-2							Organic enriched sand	
2-14	10YR 4/2						Medium sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):
Type: _____
Depth (inches): _____

Hydric Soil Present? **Yes** ___ **No** x

Remarks: Doesn't quite meet indicator S6

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): _____
Water Table Present? Yes ___ No X Depth (inches): _____
Saturation Present? (includes capillary fringe) Yes ___ No x Depth (inches): _____

Wetland Hydrology Present? **Yes** ___ **No** x

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 10/29/13
Applicant/Owner: King County State: WA Sampling Point: WP37
Investigator(s): Townsend, Baines Section, Township, Range:
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: 47.658617815 Long: -122.122886758 Datum: NAVD88
Soil Map Unit Name: Pilchuck loamy fine sand NWI classification: Palustrine scrub/shrub
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? Y (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes	X	No	
Hydric Soil Present?	Yes		No	X
Wetland Hydrology Present?	Yes	X	No	

Is the Sampled Area within a Wetland? **Yes** x **No** ___

Remarks: Strong vegetation and hydrology indicators provides preponderance of evidence that site is a wetland. Soils have been modified – includes quarry spalls and soil indicators would likely be difficult to find.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1.			
2.			
3.			
4.			
5.			
	0	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Phalaris arundinaceae	5		FACW
2. Poa pratensis	20	Y	FAC
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	25	= Total Cover	

Woody Vine Stratum (Plot size: 4m)		
1.		
2.		
	0	= Total Cover

% Bare Ground in Herb Stratum 75

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)
Total Number of Dominant Species Across All Strata: 1 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- X 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** x **No** ___

Remarks:

SOIL

Sampling Point: WP37

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-2							Organic enriched sand	
2-14	10YR 4/1						Quarry spalls w/silt	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** ___ **No** x

Remarks: Does not meet indicator F3 without mottles. However, observation of standing water is a strong indication of wetland presence.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- x High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Stunted or Stressed Plants (D1) (**LRR A**)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)
- ___ Raised Ant Mounds (D6) (**LRR A**)
- ___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes		No	X	Depth (inches):	
Water Table Present?	Yes	x	No		Depth (inches):	~10
Saturation Present? (includes capillary fringe)	Yes	x	No		Depth (inches):	~10

Wetland Hydrology Present? **Yes** x **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: Couldn't dig through quarry spalls, standing water adjacent

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 6/11/14
Applicant/Owner: King County State: WA Sampling Point: WA
Investigator(s): Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: Long: Datum: NAVD88
Soil Map Unit Name: Earlmont silt loam NWI classification: PEMC
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No (If no, explain in Remarks.)
Are Vegetation , Soil , or Hydrology significantly disturbed? Are "Normal Circumstances" present? Yes x No
Are Vegetation , Soil , or Hydrology naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes x	No	**Is the Sampled Area within a Wetland?**	**Yes x No**
Hydric Soil Present?	Yes x	No		
Wetland Hydrology Present?	Yes x	No		

Remarks: Plot located in herbaceous dominated area to east of Tosh Creek

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1.			
2.			
3.			
4.			
5.			
	0	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Juncus effusus	90	Y	FACW
2. Iris pseudacorus	20		OBL
3. Schedonorus arundinaceus	5		FAC
4. Phalaris arundinacea	10		FACW
5. Carex obnupta	10		OBL
6. Carex stipata	10		OBL
7.			
8.			
9.			
10.			
11.			
	145	= Total Cover	

Woody Vine Stratum (Plot size: 4m)		
1.		
2.		
	0	= Total Cover

% Bare Ground in Herb Stratum

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)
Total Number of Dominant Species Across All Strata: 1 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- 3 - Prevalence Index is ≤3.0[1]
- 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- 5 - Wetland Non-Vascular Plants[1]
- Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes x No

Remarks:

SOIL

Sampling Point: WA

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-10	10YR 3/2		10YR 5/8	10	RM	M	Silt loam	
10-14	10YR 6/1		10YR 6/8	20	C	M	Diatomaceous	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
- ___ Loamy Gleyed Matrix (F2)
- x Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ___ 2 cm Muck (A10)
- ___ Red Parent Material (TF2)
- ___ Very Shallow Dark Surface (TF12)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** x **No** ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1)
- ___ Sediment Deposits (B2)
- ___ Drift Deposits (B3)
- ___ Algal Mat or Crust (B4)
- ___ Iron Deposits (B5)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Sparsely Vegetated Concave Surface (B8)
- ___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
- ___ Salt Crust (B11)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Stunted or Stressed Plants (D1) (**LRR A**)
- x Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Geomorphic Position (D2)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)
- ___ Raised Ant Mounds (D6) (**LRR A**)
- ___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): _____

Water Table Present? Yes ___ No X Depth (inches): _____

Saturation Present? (includes capillary fringe) Yes ___ No X Depth (inches): _____

Wetland Hydrology Present? **Yes** x **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available: Piezometers installed in October 2013, P3 in vicinity of plot, had groundwater at or within 1 foot of surface from December 2013 to beginning of May 2014.

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 6/11/14
Applicant/Owner: King County State: WA Sampling Point: WB
Investigator(s): Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: Long: Datum: NAVD88
Soil Map Unit Name: Earlmont silt loam NWI classification: PEMC
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes x	No ___	**Is the Sampled Area within a Wetland?**	**Yes x No ___**
Hydric Soil Present?	Yes x	No ___		
Wetland Hydrology Present?	Yes x	No ___		

Remarks: Plot located in herbaceous dominated area to east of Tosh Creek

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1.			
2.			
3.			
4.			
5.			
	0	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Schedonorus arundinaceus	25	Y	FAC
2. Holcus lanatus	10		FAC
3. Agrostis stolonifera	50	Y	FAC
4. Carex stipata	10		OBL
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	95	= Total Cover	

Woody Vine Stratum (Plot size: 4m)		
1.		
2.		
	0	= Total Cover

% Bare Ground in Herb Stratum ___

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)
Total Number of Dominant Species Across All Strata: 2 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A = ___

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes x No ___

Remarks:

SOIL

Sampling Point: WB

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-12	10YR 3/2		5YR 3/6	10	RM	M	Silt loam	
12-14	10YR 3/2		10YR 6/1 10YR 6/8	20	C	M	Diatomaceous	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
x Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):
Type: ___
Depth (inches): ___

Hydric Soil Present? **Yes** x **No** ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
x Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): ___
Water Table Present? Yes ___ No X Depth (inches): ___
Saturation Present? (includes capillary fringe) Yes ___ No X Depth (inches): ___

Wetland Hydrology Present? **Yes** x **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available: Piezometers installed in October 2013, P3 in vicinity of plot, had groundwater at or within 1 foot of surface from December 2013 to beginning of May 2014.

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 6/11/14
Applicant/Owner: King County State: WA Sampling Point: WC
Investigator(s): Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: Long: Datum: NAVD88
Soil Map Unit Name: Earlmont silt loam NWI classification: PEMC
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No (If no, explain in Remarks.)
Are Vegetation , Soil , or Hydrology significantly disturbed? Are "Normal Circumstances" present? Yes x No
Are Vegetation , Soil , or Hydrology naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes x	No	**Is the Sampled Area within a Wetland?**	**Yes x No**
Hydric Soil Present?	Yes x	No		
Wetland Hydrology Present?	Yes x	No		

Remarks: Plot located in herbaceous dominated area to east of Tosh Creek

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1.			
2.			
3.			
4.			
5.			
	0	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Schedonorus arundinaceus	20		FAC
2. Poa pratensis	40	Y	FAC
3. Agrostis stolonifera	40	Y	FAC
4. Vicia americana	5		FAC
5. Cirsium arvense	25	Y	FAC
6.			
7.			
8.			
9.			
10.			
11.			
	130	= Total Cover	

Woody Vine Stratum (Plot size: 4m)		
1.		
2.		
	0	= Total Cover

% Bare Ground in Herb Stratum

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)
Total Number of Dominant Species Across All Strata: 3 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- [ ] 1 - Rapid Test for Hydrophytic Vegetation
- [x] 2 - Dominance Test is >50%
- [ ] 3 - Prevalence Index is ≤3.0[1]
- [ ] 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- [ ] 5 - Wetland Non-Vascular Plants[1]
- [ ] Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes x No**

Remarks:

SOIL

Sampling Point: WC

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-10	10YR 2/2						Silt loam	
10-14	10YR 6/1		10YR 5/8	20	C	M	Sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
x Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):
Type: _____
Depth (inches): _____

Hydric Soil Present? **Yes** x **No** ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
x Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): _____
Water Table Present? Yes ___ No X Depth (inches): _____
Saturation Present? (includes capillary fringe) Yes ___ No X Depth (inches): _____

Wetland Hydrology Present? **Yes** x **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available: Piezometers installed in October 2013, P3 in vicinity of plot, had groundwater at or within 1 foot of surface from December 2013 to beginning of May 2014.

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 6/11/14
Applicant/Owner: King County State: WA Sampling Point: WD
Investigator(s): Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: Long: Datum: NAVD88
Soil Map Unit Name: Earlmont silt loam NWI classification: PEMC
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes	x	No	
Hydric Soil Present?	Yes		No	X
Wetland Hydrology Present?	Yes		No	X

Is the Sampled Area within a Wetland? **Yes** ___ **No** x

Remarks: Plot located in herbaceous dominated area to east of Tosh Creek

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1.			
2.			
3.			
4.			
5.			
	0	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Schedonorus arundinaceus	30	Y	FAC
2. Poa pratensis	30	Y	FAC
3. Agrostis stolonifera	40	Y	FAC
4. Vicia americana	5		FAC
5. Cirsium arvense	10		FAC
6.			
7.			
8.			
9.			
10.			
11.			
	115	= Total Cover	

Woody Vine Stratum (Plot size: 4m)			
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum ___

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)
Total Number of Dominant Species Across All Strata: 3 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A = ___

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** x **No** ___

Remarks:

SOIL

Sampling Point: WD

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-10	10YR 3/3						Sandy loam	
10-14	10YR 6/1						Sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):
Type: _____
Depth (inches): _____

Hydric Soil Present? **Yes** ___ **No** x

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): _____
Water Table Present? Yes ___ No X Depth (inches): _____
Saturation Present? (includes capillary fringe) Yes ___ No X Depth (inches): _____

Wetland Hydrology Present? **Yes** ___ **No** x

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available: Distinctly upslope of Piezometer3, no hydric soil indicators above 14 inches.

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 6/11/14
Applicant/Owner: King County State: WA Sampling Point: WE
Investigator(s): Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: Long: Datum: NAVD88
Soil Map Unit Name: Earlmont silt loam NWI classification: PEMC
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes x	No ___	**Is the Sampled Area within a Wetland?**	**Yes x No ___**
Hydric Soil Present?	Yes X	No ___		
Wetland Hydrology Present?	Yes x	No ___		

Remarks: Plot located in herbaceous dominated area to east of Tosh Creek. Boundary determined to be Rubus bed immediately to east of this plot

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Rubus armeniacus	10	Y	FACU
2.			
3.			
4.			
5.			
	0	= Total Cover	

Herb Stratum (Plot size: 2m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Schedonorus arundinaceus	20	Y	FAC
2. Poa pratensis	30	Y	FAC
3. Agrostis stolonifera	30	Y	FAC
4. Cirsium arvense	5		FAC
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	85	= Total Cover	

Woody Vine Stratum (Plot size: 4m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum ___

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)
Total Number of Dominant Species Across All Strata: 4 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 75% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A = ___

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes x No ___**

Remarks:

SOIL

Sampling Point: WE

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-10	10YR 2/2						Loam	
10-14	10YR 6/1		10YR 5/8	10	RM	M	Silt	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
x Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):
Type: ___
Depth (inches): ___

Hydric Soil Present? **Yes** x **No** ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
x Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): ___
Water Table Present? Yes ___ No X Depth (inches): ___
Saturation Present? (includes capillary fringe) Yes ___ No X Depth (inches): ___

Wetland Hydrology Present? **Yes** x **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available: Piezometers installed in October 2013, P3 in vicinity of plot, had groundwater at or within 1 foot of surface from December 2013 to beginning of May 2014

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 6/11/14
Applicant/Owner: King County State: WA Sampling Point: W2A
Investigator(s): Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: Long: Datum: NAVD88
Soil Map Unit Name: Earlmont silt loam NWI classification: PEMC
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No (If no, explain in Remarks.)
Are Vegetation , Soil , or Hydrology significantly disturbed? Are "Normal Circumstances" present? Yes x No
Are Vegetation , Soil , or Hydrology naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes	x	No	
Hydric Soil Present?	Yes	X	No	
Wetland Hydrology Present?	Yes	x	No	

Is the Sampled Area within a Wetland? Yes x No

Remarks: Plot located in herbaceous dominated area to east of Tosh Creek.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Fraxinus latifolia	10	Y	FACW
2.			
3.			
4.			
	10	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1. Rubus armeniacus	10	Y	FACU
2.			
3.			
4.			
5.			
	10	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Juncus effusus	75	Y	FACW
2. Equisetum arvense	5		FAC
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	80	= Total Cover	

Woody Vine Stratum (Plot size: 4m)		
1.		
2.		
	0	= Total Cover

% Bare Ground in Herb Stratum

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)
Total Number of Dominant Species Across All Strata: 3 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 67% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- 3 - Prevalence Index is ≤3.0[1]
- 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- 5 - Wetland Non-Vascular Plants[1]
- Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes x No

Remarks:

SOIL

Sampling Point: W2A

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-10	10YR 3/1						Loam	
10-14	10YR 3/1		10YR6/1 10YR6/8	50	RM	M	Silt	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
x Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):
Type: ___
Depth (inches): ___

Hydric Soil Present? **Yes** x **No** ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
x Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present?	Yes	___	No	X	Depth (inches): ___
Water Table Present?	Yes	___	No	X	Depth (inches): ___
Saturation Present? (includes capillary fringe)	Yes	___	No	X	Depth (inches): ___

Wetland Hydrology Present? **Yes** x **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available: Piezometers installed in October 2013, P1 in vicinity of plot, had groundwater within 1 foot of surface from February to April 2014

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 6/11/14
Applicant/Owner: King County State: WA Sampling Point: W2B
Investigator(s): Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: Long: Datum: NAVD88
Soil Map Unit Name: Earlmont silt loam NWI classification: PEMC
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes	x	No	
Hydric Soil Present?	Yes	X	No	
Wetland Hydrology Present?	Yes	x	No	

Is the Sampled Area within a Wetland? **Yes** x **No** ___

Remarks: Plot located in herbaceous dominated area to east of Tosh Creek.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1.			
2.			
3.			
4.			
5.			
	0	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Schedonorus arundinaceus	10		FAC
2. Holcus lanatus	20	Y	FAC
3. Juncus ensifolius	10		FACW
4. Poa pratensis	25	Y	FAC
5. Agrostis stolonifera	30	Y	FAC
6. Cirsium arvense	5		FAC
7.			
8.			
9.			
10.			
11.			
	100	= Total Cover	

Woody Vine Stratum (Plot size: 4m)		
1.		
2.		
	0	= Total Cover

% Bare Ground in Herb Stratum ___

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)
Total Number of Dominant Species Across All Strata: 3 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A = ___

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** x **No** ___

Remarks:

SOIL

Sampling Point: W2B

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-10	10YR 3/1						Silty loam	
10-14	10YR 3/1		10YR 5/8	10	RM	M	Silty loam	
12	10YR 6/1		10YR 5/8	30	RM	M	Diatomaceous	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
x Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):
Type: ___
Depth (inches): ___

Hydric Soil Present? **Yes** x **No** ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
x Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): ___
Water Table Present? Yes ___ No X Depth (inches): ___
Saturation Present? (includes capillary fringe) Yes ___ No X Depth (inches): ___

Wetland Hydrology Present? **Yes** x **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available: Piezometers installed in October 2013, P1 in vicinity of plot, had groundwater within 1 foot of surface from February to April 2014

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 6/11/14
Applicant/Owner: King County State: WA Sampling Point: W2C
Investigator(s): Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: Long: Datum: NAVD88
Soil Map Unit Name: Earlmont silt loam NWI classification: PEMC
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No (If no, explain in Remarks.)
Are Vegetation , Soil , or Hydrology significantly disturbed? Are "Normal Circumstances" present? Yes x No
Are Vegetation , Soil , or Hydrology naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes x	No	**Is the Sampled Area within a Wetland?** **Yes x No**
Hydric Soil Present?	Yes X	No	
Wetland Hydrology Present?	Yes x	No	

Remarks: Plot located in herbaceous dominated area to east of Tosh Creek.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1. Rubus armeniacus	5	Y	FACU
2.			
3.			
4.			
5.			
	5	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Schedonorus arundinaceus	30	Y	FAC
2. Juncus effusus	40	Y	FACW
3. Agrostis stolonifera	30	Y	FAC
4. Poa pratensis	10		FAC
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	110	= Total Cover	

Woody Vine Stratum (Plot size: 4m)		
1.		
2.		
	0	= Total Cover

% Bare Ground in Herb Stratum

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)
Total Number of Dominant Species Across All Strata: 4 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 75% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- 3 - Prevalence Index is ≤3.0[1]
- 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- 5 - Wetland Non-Vascular Plants[1]
- Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes x No**

Remarks:

SOIL

Sampling Point: W2C

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-10	10YR 3/1						Silty loam	
10-14	10YR 3/1		10YR 6/1 5YR 5/8	30	RM	M	Silty loam w diatomaceous	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
x Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):
Type: ___
Depth (inches): ___

Hydric Soil Present? **Yes** x **No** ___

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
x Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): ___
Water Table Present? Yes ___ No X Depth (inches): ___
Saturation Present? (includes capillary fringe) Yes ___ No X Depth (inches): ___

Wetland Hydrology Present? **Yes** x **No** ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available: Piezometers installed in October 2013, P1 in vicinity of plot, had groundwater within 1 foot of surface from February to April 2014

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 6/11/14
Applicant/Owner: King County State: WA Sampling Point: W2D
Investigator(s): Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: Long: Datum: NAVD88
Soil Map Unit Name: Earlmont silt loam NWI classification: PEMC
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes x	No ___	**Is the Sampled Area within a Wetland?**	**Yes** ___ **No** x
Hydric Soil Present?	Yes ___	No x		
Wetland Hydrology Present?	Yes ___	No x		

Remarks: Plot located in herbaceous dominated area to east of Tosh Creek.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Rubus armeniacus	10	Y	FACU
2.			
3.			
4.			
5.			
	10	= Total Cover	

Herb Stratum (Plot size: 2m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Holcus lanatus	50	Y	FAC
2. Agrostis stolonifera	30	Y	FAC
3. Poa pratensis	20	Y	FAC
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	100	= Total Cover	

Woody Vine Stratum (Plot size: 4m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum ___

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)
Total Number of Dominant Species Across All Strata: 4 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 75% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A = ___

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** x **No** ___

Remarks:

SOIL

Sampling Point: W2D

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-12	10YR 3/1						Silty loam	
12-14	10YR 1/1		10YR 6/8	5	RM	M	Diatomaceous	Mottles very faint

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):
Type: _____
Depth (inches): _____

Hydric Soil Present? **Yes** ___ **No** x

Remarks: Mottles only very faint and below 12 inches

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): _____
Water Table Present? Yes ___ No X Depth (inches): _____
Saturation Present? (includes capillary fringe) Yes ___ No X Depth (inches): _____

Wetland Hydrology Present? **Yes** ___ **No** x

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Willowmoor/Marymoor City/County: King County Sampling Date: 6/11/14
Applicant/Owner: King County State: WA Sampling Point: W3A
Investigator(s): Martz Section, Township, Range: T25N, R5E, Section13
Landform (hillslope, terrace, etc.): Floodplain Local relief (concave, convex, none): None Slope (%): <1
Subregion (LRR): Northwest Forests and Coast Lat: Long: Datum: NAVD88
Soil Map Unit Name: Earlmont silt loam NWI classification: PEMC
Are climatic / hydrologic conditions on the site typical for this time of year? Yes x No ___ (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes x No ___
Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes x	No ___	**Is the Sampled Area within a Wetland?**	**Yes ___ No x**
Hydric Soil Present?	Yes ___	No x		
Wetland Hydrology Present?	Yes ___	No x		

Remarks: Plot located in herbaceous dominated area to east of Tosh Creek. This plot appears to be high enough above the piezometers to be beyond groundwater influence

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	0	= Total Cover	

Sapling/Shrub Stratum (Plot size: 4m)			
1.			
2.			
3.			
4.			
5.			
	0	= Total Cover	

Herb Stratum (Plot size: 2m)			
1. Poa pratensis	30	Y	FAC
2. Schedonorus arundinaceus	20	Y	FAC
3. Cirsium arvense	20	Y	FAC
4. Vicia americana	5		FAC
5. Agrostis stolonifera	20	Y	FAC
6.			
7.			
8.			
9.			
10.			
11.			
	95	= Total Cover	

Woody Vine Stratum (Plot size: 4m)		
1.		
2.		
	0	= Total Cover

% Bare Ground in Herb Stratum ___

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 4 (A)
Total Number of Dominant Species Across All Strata: 4 (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: 100% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	(A)		(B)

Prevalence Index = B/A = ___

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- x 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ 5 - Wetland Non-Vascular Plants[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes x No ___

Remarks:

SOIL

Sampling Point: W3A

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Redox Features Type[1]	Redox Features Loc[2]	Texture	Remarks
0-14	10YR 3/2						Silty loam	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1) (**except MLRA 1**)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

___ 2 cm Muck (A10)
___ Red Parent Material (TF2)
___ Very Shallow Dark Surface (TF12)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic

Restrictive Layer (if present):
Type: _____
Depth (inches): _____

Hydric Soil Present? **Yes** ___ **No** x

Remarks: Mottles only very faint and below 12 inches

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)
___ Sediment Deposits (B2)
___ Drift Deposits (B3)
___ Algal Mat or Crust (B4)
___ Iron Deposits (B5)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Sparsely Vegetated Concave Surface (B8)
___ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
___ Salt Crust (B11)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Stunted or Stressed Plants (D1) (**LRR A**)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Saturation Visible on Aerial Imagery (C9)
___ Geomorphic Position (D2)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)
___ Raised Ant Mounds (D6) (**LRR A**)
___ Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present? Yes ___ No X Depth (inches): _____
Water Table Present? Yes ___ No X Depth (inches): _____
Saturation Present? (includes capillary fringe) Yes ___ No X Depth (inches): _____

Wetland Hydrology Present? **Yes** ___ **No** x

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

Appendix C: Wetland Functional Assessment Forms

Wetland name or number A

WETLAND RATING FORM – WESTERN WASHINGTON

Version 2 - Updated July 2006 to increase accuracy and reproducibility among users
Updated Oct 2008 with the new WDFW definitions for priority habitats

Name of wetland (if known): MARYMOOR A Date of site visit: 10/28/13

Rated by_____ Trained by Ecology? Yes__No__ Date of training____

SEC: 24N TWNSHP: 5E RNGE: 11 Is S/T/R in Appendix D? Yes__ No X

Map of wetland unit: Figure ____ Estimated size _____

SUMMARY OF RATING

Category based on FUNCTIONS provided by wetland

I__ II__ III X IV__

Category I = Score >=70
Category II = Score 51-69
Category III = Score 30-50
Category IV = Score < 30

Score for Water Quality Functions	24
Score for Hydrologic Functions	10
Score for Habitat Functions	16
TOTAL score for Functions	50

50

Category based on SPECIAL CHARACTERISTICS of wetland

I__ II__ **Does not Apply** X

Final Category (choose the "highest" category from above) III

Summary of basic information about the wetland unit

Wetland Unit has Special Characteristics		Wetland HGM Class used for Rating	
Estuarine		Depressional	X
Natural Heritage Wetland		Riverine	
Bog		Lake-fringe	
Mature Forest		Slope	
Old Growth Forest		Flats	
Coastal Lagoon		Freshwater Tidal	
Interdunal			
None of the above	X	Check if unit has multiple HGM classes present	X

Wetland name or number A

Does the wetland unit being rated meet any of the criteria below?

If you answer YES to any of the questions below you will need to protect the wetland according to the regulations regarding the special characteristics found in the wetland.

Check List for Wetlands That May Need Additional Protection (in addition to the protection recommended for its category)	YES	NO
SP1. *Has the wetland unit been documented as a habitat for any Federally listed Threatened or Endangered* ***animal or plant*** *species (T/E species)?* For the purposes of this rating system, "documented" means the wetland is on the appropriate state or federal database.		
SP2. *Has the wetland unit been documented as habitat for any State listed Threatened or Endangered* ***animal*** *species?* For the purposes of this rating system, "documented" means the wetland is on the appropriate state database. Note: Wetlands with State listed plant species are categorized as Category I Natural Heritage Wetlands.(see p. 19 of data form).		
SP3. *Does the wetland unit contain individuals of Priority species listed by the WDFW for the state?*	X	
SP4. *Does the wetland unit have a local significance in addition to its functions?* For example, the wetland has been identified in the Shoreline Master Program, the Critical Areas Ordinance, or in a local management plan as having special significance.		

To complete the next part of the data sheet you will need to determine the Hydrogeomorphic Class of the wetland being rated.

The hydrogeomorphic classification groups wetlands into those that function in similar ways. This simplifies the questions needed to answer how well the wetland functions. The Hydrogeomorphic Class of a wetland can be determined using the key below. See p. 24 for more detailed instructions on classifying wetlands.

Wetland name or number A

Classification of Wetland Units in Western Washington

If the hydrologic criteria listed in each question do not apply to the entire unit being rated, you probably have a unit with multiple HGM classes. In this case, identify which hydrologic criteria in questions 1-7 apply, and go to Question 8.

1. Are the water levels in the entire unit usually controlled by tides (i.e. except during floods)?
NO – go to 2 YES – the wetland class is **Tidal Fringe**

If yes, is the salinity of the water during periods of annual low flow below 0.5 ppt (parts per thousand)? **YES – Freshwater Tidal Fringe NO – Saltwater Tidal Fringe (Estuarine)**

*If your wetland can be classified as a Freshwater Tidal Fringe use the forms for **Riverine** wetlands. If it is Saltwater Tidal Fringe it is rated as an **Estuarine** wetland.* Wetlands that were called estuarine in the first and second editions of the rating system are called Salt Water Tidal Fringe in the Hydrogeomorphic Classification. Estuarine wetlands were categorized separately in the earlier editions, and this separation is being kept in this revision. To maintain consistency between editions, the term "Estuarine" wetland is kept. Please note, however, that the characteristics that define Category I and II estuarine wetlands have changed (see p.).

2. The entire wetland unit is flat and precipitation is the only source (>90%) of water to it. Groundwater and surface water runoff are NOT sources of water to the unit.
NO – go to 3 YES – The wetland class is **Flats**

If your wetland can be classified as a "Flats" wetland, use the form for **Depressional** wetlands.

3. Does the entire wetland unit **meet both** of the following criteria?
___The vegetated part of the wetland is on the shores of a body of permanent open water (without any vegetation on the surface) at least 20 acres (8 ha) in size;
___At least 30% of the open water area is deeper than 6.6 ft (2 m)?
NO – go to 4 YES – The wetland class is **Lake-fringe (Lacustrine Fringe)**

4. Does the entire wetland unit **meet all** of the following criteria?
___The wetland is on a slope (*slope can be very gradual*),
___The water flows through the wetland in one direction (unidirectional) and usually comes from seeps. It may flow subsurface, as sheetflow, or in a swale without distinct banks.
___The water leaves the wetland **without being impounded**?
NOTE: *Surface water does not pond in these type of wetlands except occasionally in very small and shallow depressions or behind hummocks (depressions are usually <3ft diameter and less than 1 foot deep).*
NO – go to 5 YES – The wetland class is **Slope**

Wetland name or number A

5. Does the entire wetland unit **meet all** of the following criteria?
✓ The unit is in a valley, or stream channel, where it gets inundated by overbank flooding from that stream or river
___ The overbank flooding occurs at least once every two years.
NOTE: The riverine unit can contain depressions that are filled with water when the river is not flooding.
NO – go to 6 YES – The wetland class is **Riverine**

6. Is the entire wetland unit in a topographic depression in which water ponds, or is saturated to the surface, at some time during the year. *This means that any outlet, if present, is higher than the interior of the wetland.*
NO – go to 7 YES – The wetland class is **Depressional**

7. Is the entire wetland unit located in a very flat area with no obvious depression and no overbank flooding. The unit does not pond surface water more than a few inches. The unit seems to be maintained by high groundwater in the area. The wetland may be ditched, but has no obvious natural outlet.
NO – go to 8 YES – The wetland class is **Depressional**

8. Your wetland unit seems to be difficult to classify and probably contains several different HGM clases. For example, seeps at the base of a slope may grade into a riverine floodplain, or a small stream within a depressional wetland has a zone of flooding along its sides. GO BACK AND IDENTIFY WHICH OF THE HYDROLOGIC REGIMES DESCRIBED IN QUESTIONS 1-7 APPLY TO DIFFERENT AREAS IN THE UNIT (make a rough sketch to help you decide). Use the following table to identify the appropriate class to use for the rating system if you have several HGM classes present within your wetland. NOTE: Use this table only if the class that is recommended in the second column represents 10% or more of the total area of the wetland unit being rated. If the area of the class listed in column 2 is less than 10% of the unit; classify the wetland using the class that represents more than 90% of the total area.

HGM Classes within the wetland unit being rated	*HGM Class to Use in Rating*
Slope + Riverine	~~Riverine~~
Slope + Depressional	Depressional
Slope + Lake-fringe	~~Lake-fringe~~
Depressional + Riverine along stream within boundary	Depressional
Depressional + Lake-fringe	Depressional
Salt Water Tidal Fringe and any other class of freshwater wetland	Treat as ESTUARINE under wetlands with special characteristics

If you are unable still to determine which of the above criteria apply to your wetland, or if you have more than 2 HGM classes within a wetland boundary, classify the wetland as **Depressional** for the rating.

Wetland name or number A

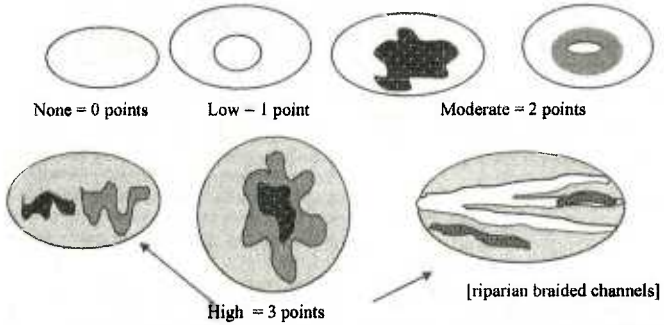
These questions apply to wetlands of all HGM classes. HABITAT FUNCTIONS - Indicators that unit functions to provide important habitat	Points (only 1 score per box)
H 1. Does the wetland unit have the potential to provide habitat for many species?	
H 1.1 Vegetation structure *(see p. 72)* *Check the types of vegetation classes present (as defined by Cowardin)- Size threshold for each class is ¼ acre or more than 10% of the area if unit is smaller than 2.5 acres.* ___Aquatic bed ___Emergent plants ___Scrub/shrub (areas where shrubs have >30% cover) ✓ Forested (areas where trees have >30% cover) barely 30% ? *If the unit has a forested class check if:* ✓ The forested class has 3 out of 5 strata (canopy, sub-canopy, shrubs, herbaceous, moss/ground-cover) that each cover 20% within the forested polygon *Add the number of vegetation structures that qualify. If you have:* 4 structures or more — points = 4 3 structures — points = 2 2 structures — points = 1 1 structure — points = 0 Map of Cowardin vegetation classes	Figure ___ 1
H 1.2. Hydroperiods *(see p. 73)* *Check the types of water regimes (hydroperiods) present within the wetland. The water regime has to cover more than 10% of the wetland or ¼ acre to count. (see text for descriptions of hydroperiods)* ___Permanently flooded or inundated — 4 or more types present — points = 3 ✓ Seasonally flooded or inundated — 3 types present — points = 2 ___Occasionally flooded or inundated — 2 types present — point = 1 ✓ Saturated only — 1 type present — points = 0 ___Permanently flowing stream or river in, or adjacent to, the wetland ___Seasonally flowing stream in, or adjacent to, the wetland ***Luke-fringe wetland* = 2 points** ***Freshwater tidal wetland* = 2 points** Map of hydroperiods	Figure ___ 1
H 1.3. Richness of Plant Species *(see p. 75)* Count the number of plant species in the wetland that cover at least 10 ft². *(different patches of the same species can be combined to meet the size threshold)* *You do not have to name the species.* *Do not include Eurasian Milfoil, reed canarygrass, purple loosestrife, Canadian Thistle* If you counted: > 19 species — points = 2 5 - 19 species — points = 1 < 5 species — points = 0 *List species below if you want to:*	1

Total for page _____

Wetland name or number A

H 1.4. Interspersion of habitats *(see p. 76)* — Figure ___

Decide from the diagrams below whether interspersion between Cowardin vegetation classes (described in H 1.1), or the classes and unvegetated areas (can include open water or mudflats) is high, medium, low, or none.



NOTE: If you have four or more classes or three vegetation classes and open water the rating is always "high". Use map of Cowardin vegetation classes

2

H 1.5. Special Habitat Features: *(see p. 77)*

Check the habitat features that are present in the wetland. The number of checks is the number of points you put into the next column.

___Large, downed, woody debris within the wetland (>4in. diameter and 6 ft long).
___Standing snags (diameter at the bottom > 4 inches) in the wetland
___Undercut banks are present for at least 6.6 ft (2m) and/or overhanging vegetation extends at least 3.3 ft (1m) over a stream (or ditch) in, or contiguous with the unit, for at least 33 ft (10m)
___Stable steep banks of fine material that might be used by beaver or muskrat for denning (>30degree slope) OR signs of recent beaver activity are present *(cut shrubs or trees that have not yet turned grey/brown)*
___At least ¼ acre of thin-stemmed persistent vegetation or woody branches are present in areas that are permanently or seasonally inundated *(structures for egg-laying by amphibians)*
___Invasive plants cover less than 25% of the wetland area in each stratum of plants

NOTE: The 20% stated in early printings of the manual on page 78 is an error.

0

H 1. TOTAL Score - potential for providing habitat
Add the scores from H1.1, H1.2, H1.3, H1.4, H1.5 — 5

Comments

Wetland name or number A

H 2. Does the wetland unit have the opportunity to provide habitat for many species?	
H 2.1 Buffers *(see p. 80)* *Choose the description that best represents condition of buffer of wetland unit. The highest scoring criterion that applies to the wetland is to be used in the rating. See text for definition of "undisturbed."* — 100 m (330ft) of relatively undisturbed vegetated areas, rocky areas, or open water >95% of circumference. No structures are within the undisturbed part of buffer. (relatively undisturbed also means no-grazing, no landscaping, no daily human use) **Points = 5** — 100 m (330 ft) of relatively undisturbed vegetated areas, rocky areas, or open water > 50% circumference. **Points = 4** — 50 m (170ft) of relatively undisturbed vegetated areas, rocky areas, or open water >95% circumference. **Points = 4** — 100 m (330ft) of relatively undisturbed vegetated areas, rocky areas, or open water > 25% circumference, . **Points = 3** ✓ 50 m (170ft) of relatively undisturbed vegetated areas, rocky areas, or open water for > 50% circumference. **Points = 3** **If buffer does not meet any of the criteria above** — No paved areas (except paved trails) or buildings within 25 m (80ft) of wetland > 95% circumference. Light to moderate grazing, or lawns are OK. **Points = 2** — No paved areas or buildings within 50m of wetland for >50% circumference. Light to moderate grazing, or lawns are OK. **Points = 2** — Heavy grazing in buffer. **Points = 1** — Vegetated buffers are <2m wide (6.6ft) for more than 95% of the circumference (e.g. tilled fields, paving, basalt bedrock extend to edge of wetland **Points = 0.** — Buffer does not meet any of the criteria above. **Points = 1** Aerial photo showing buffers	Figure ___ 3
H 2.2 Corridors and Connections *(see p. 81)* H 2.2.1 Is the wetland part of a relatively undisturbed and unbroken vegetated corridor (either riparian or upland) that is at least 150 ft wide, has at least 30% cover of shrubs, forest or native undisturbed prairie, that connects to estuaries, other wetlands or undisturbed uplands that are at least 250 acres in size? *(dams in riparian corridors, heavily used gravel roads, paved roads, are considered breaks in the corridor).* **YES - 4 points** *(go to H 2.3)* NO - go to H 2.2.2 H 2.2.2 Is the wetland part of a relatively undisturbed and unbroken vegetated corridor (either riparian or upland) that is at least 50ft wide, has at least 30% cover of shrubs or forest, and connects to estuaries, other wetlands or undisturbed uplands that are at least 25 acres in size? **OR** a **Lake-fringe** wetland, if it does not have an undisturbed corridor as in the question above? YES = **2 points** *(go to H 2.3)* NO - H 2.2.3 H 2.2.3 Is the wetland: within 5 mi (8km) of a brackish or salt water estuary OR within 3 mi of a large field or pasture (>40 acres) OR within 1 mi of a lake greater than 20 acres? YES = **1 point** NO = **0 points**	4

Total for page_____

Wetland name or number A

H 2.3 Near or adjacent to other priority habitats listed by WDFW ***(see new and complete descriptions of WDFW priority habitats, and the counties in which they can be found, in the PHS report http://wdfw.wa.gov/hab/phslist.htm)*** Which of the following priority habitats are within 330ft (100m) of the wetland unit? *NOTE: the connections do not have to be relatively undisturbed.* ____**Aspen Stands:** Pure or mixed stands of aspen greater than 0.4 ha (1 acre). X **Biodiversity Areas and Corridors**: Areas of habitat that are relatively important to various species of native fish and wildlife *(full descriptions in WDFW PHS report p. 152).* ____**Herbaceous Balds:** Variable size patches of grass and forbs on shallow soils over bedrock. ____**Old-growth/Mature forests:** (Old-growth west of Cascade crest) Stands of at least 2 tree species, forming a multi-layered canopy with occasional small openings; with at least 20 trees/ha (8 trees/acre) > 81 cm (32 in) dbh or > 200 years of age. (Mature forests) Stands with average diameters exceeding 53 cm (21 in) dbh; crown cover may be less that 100%; crown cover may be less that 100%; decay, decadence, numbers of snags, and quantity of large downed material is generally less than that found in old-growth; 80 - 200 years old west of the Cascade crest. ____**Oregon white Oak:** Woodlands Stands of pure oak or oak/conifer associations where canopy coverage of the oak component is important *(full descriptions in WDFW PHS report p. 158).* ____**Riparian**: The area adjacent to aquatic systems with flowing water that contains elements of both aquatic and terrestrial ecosystems which mutually influence each other. ____**Westside Prairies:** Herbaceous, non-forested plant communities that can either take the form of a dry prairie or a wet prairie *(full descriptions in WDFW PHS report p. 161).* ____**Instream:** The combination of physical, biological, and chemical processes and conditions that interact to provide functional life history requirements for instream fish and wildlife resources. ____**Nearshore**: Relatively undisturbed nearshore habitats. These include Coastal Nearshore, Open Coast Nearshore, and Puget Sound Nearshore. *(full descriptions of habitats and the definition of relatively undisturbed are in WDFW report: pp. 167-169 and glossary in Appendix A).* ____**Caves:** A naturally occurring cavity, recess, void, or system of interconnected passages under the earth in soils, rock, ice, or other geological formations and is large enough to contain a human. ____**Cliffs:** Greater than 7.6 m (25 ft) high and occurring below 5000 ft. ____**Talus:** Homogenous areas of rock rubble ranging in average size 0.15 - 2.0 m (0.5 - 6.5 ft), composed of basalt, andesite, and/or sedimentary rock, including riprap slides and mine tailings. May be associated with cliffs. ____**Snags and Logs:** Trees are considered snags if they are dead or dying and exhibit sufficient decay characteristics to enable cavity excavation/use by wildlife. Priority snags have a diameter at breast height of > 51 cm (20 in) in western Washington and are > 2 m (6.5 ft) in height. Priority logs are > 30 cm (12 in) in diameter at the largest end, and > 6 m (20 ft) long. If wetland has **3 or more** priority habitats = **4 points** If wetland has **2** priority habitats = **3 points** If wetland has **1** priority habitat = **1 point** No habitats = 0 points *Note: All vegetated wetlands are by definition a priority habitat but are not included in this list. Nearby wetlands are addressed in question H 2.4)*	1

Wetland name or number A

H 2.4 Wetland Landscape *(choose the one description of the landscape around the wetland that best fits)* ***(see p. 84)*** There are at least 3 other wetlands within ½ mile, and the connections between them are relatively undisturbed (light grazing between wetlands OK, as is lake shore with some boating, but connections should NOT be bisected by paved roads, fill, fields, or other development. points = 5 The wetland is Lake-fringe on a lake with little disturbance and there are 3 other lake-fringe wetlands within ½ mile points = 5 There are at least 3 other wetlands within ½ mile, BUT the connections between them are disturbed points = 3 The wetland is Lake-fringe on a lake **with** disturbance and there are 3 other lake-fringe wetland within ½ mile points = 3 There is at least 1 wetland within ½ mile. points = 2 There are no wetlands within ½ mile. points = 0	3
H 2. TOTAL Score - opportunity for providing habitat *Add the scores from H2.1, H2.2, H2.3, H2.4*	11
TOTAL for H 1 from page 14	5
Total Score for Habitat Functions – add the points for H 1, H 2 and record the result on p. 1	16

Wetland name or number A

CATEGORIZATION BASED ON SPECIAL CHARACTERISTICS

Please determine if the wetland meets the attributes described below and circle the appropriate answers and Category.

Wetland Type *Check off any criteria that apply to the wetland. Circle the Category when the appropriate criteria are met.*	**Category**
SC 1.0 Estuarine wetlands ***(see p. 86)*** Does the wetland unit meet the following criteria for Estuarine wetlands? — The dominant water regime is tidal, — Vegetated, and — With a salinity greater than 0.5 ppt. YES = Go to SC 1.1 NO ___	
SC 1.1 Is the wetland unit within a National Wildlife Refuge, National Park, National Estuary Reserve, Natural Area Preserve, State Park or Educational, Environmental, or Scientific Reserve designated under WAC 332-30-151? YES – Category I NO go to SC 1.2	Cat. I
SC 1.2 Is the wetland unit at least 1 acre in size and meets at least two of the following three conditions? YES = Category I NO = Category II — The wetland is relatively undisturbed (has no diking, ditching, filling, cultivation, grazing, and has less than 10% cover of non-native plant species. If the non-native *Spartina* spp. are the only species that cover more than 10% of the wetland, then the wetland should be given a dual rating (I/II). The area of Spartina would be rated a Category II while the relatively undisturbed upper marsh with native species would be a Category I. Do not, however, exclude the area of Spartina in determining the size threshold of 1 acre. — At least ¾ of the landward edge of the wetland has a 100 ft buffer of shrub, forest, or un-grazed or un-mowed grassland. — The wetland has at least 2 of the following features: tidal channels, depressions with open water, or contiguous freshwater wetlands.	**Cat. I** **Cat. II** **Dual rating I/II**

T25N R5E S11,13,14 NOT ON LIST

Wetland name or number A

SC 2.0 Natural Heritage Wetlands *(see p. 87)* — **Cat. I**

Natural Heritage wetlands have been identified by the Washington Natural Heritage Program/DNR as either high quality undisturbed wetlands or wetlands that support state Threatened, Endangered, or Sensitive plant species.

SC 2.1 Is the wetland unit being rated in a Section/Township/Range that contains a Natural Heritage wetland? *(this question is used to screen out most sites before you need to contact WNHP/DNR)*

S/T/R information from Appendix D ___ or accessed from WNHP/DNR web site X

YES____ – contact WNHP/DNR (see p. 79) and go to SC 2.2 NO X

SC 2.2 Has DNR identified the wetland as a high quality undisturbed wetland or as or as a site with state threatened or endangered plant species?

YES = Category I NO ____not a Heritage Wetland

SC 3.0 Bogs *(see p. 87)*

Does the wetland unit (**or any part of the unit**) meet both the criteria for soils and vegetation in bogs? *Use the key below to identify if the wetland is a bog.* ***If you answer yes you will still need to rate the wetland based on its functions.***

1. Does the unit have organic soil horizons (i.e. layers of organic soil), either peats or mucks, that compose 16 inches or more of the first 32 inches of the soil profile? (See Appendix B for a field key to identify organic soils)? Yes - go to Q. 3 No - go to Q. 2
2. Does the unit have organic soils, either peats or mucks that are less than 16 inches deep over bedrock, or an impermeable hardpan such as clay or volcanic ash, or that are floating on a lake or pond?

   Yes - go to Q. 3 No - Is not a bog for purpose of rating
3. Does the unit have more than 70% cover of mosses at ground level, AND other plants, if present, consist of the "bog" species listed in Table 3 as a significant component of the vegetation (more than 30% of the total shrub and herbaceous cover consists of species in Table 3)?

   Yes – Is a bog for purpose of rating No - go to Q. 4

   NOTE: If you are uncertain about the extent of mosses in the understory you may substitute that criterion by measuring the pH of the water that seeps into a hole dug at least 16" deep. If the pH is less than 5.0 and the "bog" plant species in Table 3 are present, the wetland is a bog.

4. Is the unit forested (> 30% cover) with sitka spruce, subalpine fir, western red cedar, western hemlock, lodgepole pine, quaking aspen, Englemann's spruce, or western white pine, WITH any of the species (or combination of species) on the bog species plant list in Table 3 as a significant component of the ground cover *(> 30% coverage of the total shrub/herbaceous cover)?*

2 YES = Category I No___ Is not a bog for purpose of rating — **Cat. I**

Wetland name or number A

SC 4.0 Forested Wetlands *(see p. 90)*

Does the wetland unit have at least 1 acre of forest that meet one of these criteria for the Department of Fish and Wildlife's forests as priority habitats? *If you answer yes you will still need to rate the wetland based on its functions.*

— **Old-growth forests**: (west of Cascade crest) Stands of at least two tree species, forming a multi-layered canopy with occasional small openings; with at least 8 trees/acre (20 trees/hectare) that are at least 200 years of age OR have a diameter at breast height (dbh) of 32 inches (81 cm) or more.

NOTE: The criterion for dbh is based on measurements for upland forests. Two-hundred year old trees in wetlands will often have a smaller dbh because their growth rates are often slower. The DFW criterion is and "OR" so old-growth forests do not necessarily have to have trees of this diameter.

— **Mature forests**: (west of the Cascade Crest) Stands where the largest trees are 80 – 200 years old OR have average diameters (dbh) exceeding 21 inches (53cm); crown cover may be less that 100%; decay, decadence, numbers of snags, and quantity of large downed material is generally less than that found in old-growth.

YES = Category I NO ___not a forested wetland with special characteristics — **Cat. I**

SC 5.0 Wetlands in Coastal Lagoons *(see p. 91)*

Does the wetland meet all of the following criteria of a wetland in a coastal lagoon?

— The wetland lies in a depression adjacent to marine waters that is wholly or partially separated from marine waters by sandbanks, gravel banks, shingle, or, less frequently, rocks

— The lagoon in which the wetland is located contains surface water that is saline or brackish (> 0.5 ppt) during most of the year in at least a portion of the lagoon *(needs to be measured near the bottom)*

YES = Go to SC 5.1 NO___ not a wetland in a coastal lagoon

SC 5.1 Does the wetland meets all of the following three conditions?

— The wetland is relatively undisturbed (has no diking, ditching, filling, cultivation, grazing), and has less than 20% cover of invasive plant species (see list of invasiye species on p. 74).

— At least ¾ of the landward edge of the wetland has a 100 ft buffer of shrub, forest, or un-grazed or un-mowed grassland. — **Cat. I**

— The wetland is larger than 1/10 acre (4350 square feet)

YES = Category I NO = Category II — **Cat. II**

Wetland name or number _____

SC 6.0 Interdunal Wetlands *(see p. 93)* Is the wetland unit west of the 1889 line (also called the Western Boundary of Upland Ownership or WBUO)? YES - go to SC 6.1 NO __ not an interdunal wetland for rating ***If you answer yes you will still need to rate the wetland based on its functions.*** In practical terms that means the following geographic areas: • Long Beach Peninsula- lands west of SR 103 • Grayland-Westport- lands west of SR 105 • Ocean Shores-Copalis- lands west of SR 115 and SR 109 SC 6.1 Is the wetland one acre or larger, or is it in a mosaic of wetlands that is once acre or larger? YES = Category II NO – go to SC 6.2 SC 6.2 Is the unit between 0.1 and 1 acre, or is it in a mosaic of wetlands that is between 0.1 and 1 acre? YES = Category III	**Cat. II** **Cat. III**
Category of wetland based on Special Characteristics *Choose the "highest" rating if wetland falls into several categories, and record on p. 1.* If you answered NO for all types enter "Not Applicable" on p.1	

Wetland name or number B

WETLAND RATING FORM – WESTERN WASHINGTON

Version 2 - Updated July 2006 to increase accuracy and reproducibility among users
Updated Oct 2008 with the new WDFW definitions for priority habitats

Name of wetland (if known): MARYMOOR B Date of site visit: 10/28/13

Rated by_____ Trained by Ecology? Yes__ No__ Date of training____

SEC: __ TWNSHP: __ RNGE: __ Is S/T/R in Appendix D? Yes__ No X

Map of wetland unit: **Figure** ___ **Estimated size** ___

SUMMARY OF RATING

Category based on FUNCTIONS provided by wetland

I__ II X III__ IV__

Category I = Score >=70
Category II = Score 51-69
Category III = Score 30-50
Category IV = Score < 30

Score for Water Quality Functions	20
Score for Hydrologic Functions	18
Score for Habitat Functions	22
TOTAL score for Functions	60

Category based on SPECIAL CHARACTERISTICS of wetland

I__ II__ Does not Apply X

Final Category (choose the "highest" category from above) II

Summary of basic information about the wetland unit

Wetland Unit has Special Characteristics		Wetland HGM Class used for Rating	
Estuarine		**Depressional**	
Natural Heritage Wetland		**Riverine**	X
Bog		**Lake-fringe**	
Mature Forest		**Slope**	
Old Growth Forest		**Flats**	
Coastal Lagoon		**Freshwater Tidal**	
Interdunal			
None of the above	X	Check if unit has multiple HGM classes present	

Wetland name or number B

Does the wetland unit being rated meet any of the criteria below?

If you answer YES to any of the questions below you will need to protect the wetland according to the regulations regarding the special characteristics found in the wetland.

Check List for Wetlands That May Need Additional Protection (in addition to the protection recommended for its category)	YES	NO
SP1. *Has the wetland unit been documented as a habitat for any Federally listed Threatened or Endangered* ***animal or plant*** *species (T/E species)?* For the purposes of this rating system, "documented" means the wetland is on the appropriate state or federal database.		
SP2. *Has the wetland unit been documented as habitat for any State listed Threatened or Endangered* ***animal*** *species?* For the purposes of this rating system, "documented" means the wetland is on the appropriate state database. Note: Wetlands with State listed plant species are categorized as Category I Natural Heritage Wetlands (see p. 19 of data form).		
SP3. *Does the wetland unit contain individuals of Priority species listed by the WDFW for the state?*	X	
SP4. *Does the wetland unit have a local significance in addition to its functions?* For example, the wetland has been identified in the Shoreline Master Program, the Critical Areas Ordinance, or in a local management plan as having special significance.		

To complete the next part of the data sheet you will need to determine the Hydrogeomorphic Class of the wetland being rated.

The hydrogeomorphic classification groups wetlands into those that function in similar ways. This simplifies the questions needed to answer how well the wetland functions. The Hydrogeomorphic Class of a wetland can be determined using the key below. See p. 24 for more detailed instructions on classifying wetlands.

Wetland name or number B

Classification of Wetland Units in Western Washington

If the hydrologic criteria listed in each question do not apply to the entire unit being rated, you probably have a unit with multiple HGM classes. In this case, identify which hydrologic criteria in questions 1-7 apply, and go to Question 8.

1. Are the water levels in the entire unit usually controlled by tides (i.e. except during floods)?
NO - go to 2 **YES – the wetland class is Tidal Fringe**

If yes, is the salinity of the water during periods of annual low flow below 0.5 ppt (parts per thousand)? **YES – Freshwater Tidal Fringe NO – Saltwater Tidal Fringe (Estuarine)**

*If your wetland can be classified as a Freshwater Tidal Fringe use the forms for **Riverine** wetlands. If it is Saltwater Tidal Fringe it is rated as an **Estuarine** wetland.* Wetlands that were called estuarine in the first and second editions of the rating system are called Salt Water Tidal Fringe in the Hydrogeomorphic Classification. Estuarine wetlands were categorized separately in the earlier editions, and this separation is being kept in this revision. To maintain consistency between editions, the term "Estuarine" wetland is kept. Please note, however, that the characteristics that define Category I and II estuarine wetlands have changed (see p.).

2. The entire wetland unit is flat and precipitation is the only source (>90%) of water to it. Groundwater and surface water runoff are NOT sources of water to the unit.
NO – go to 3 **YES** – The wetland class is **Flats**

If your wetland can be classified as a "Flats" wetland, use the form for **Depressional** wetlands.

3. Does the entire wetland unit **meet both** of the following criteria?
___The vegetated part of the wetland is on the shores of a body of permanent open water (without any vegetation on the surface) at least 20 acres (8 ha) in size;
___At least 30% of the open water area is deeper than 6.6 ft (2 m)?
NO - go to 4 **YES** – The wetland class is **Lake-fringe (Lacustrine Fringe)**

4. Does the entire wetland unit **meet all** of the following criteria?
___The wetland is on a slope (*slope can be very gradual*),
___The water flows through the wetland in one direction (unidirectional) and usually comes from seeps. It may flow subsurface, as sheetflow, or in a swale without distinct banks.
___**The water leaves the wetland without being impounded?**
NOTE: *Surface water does not pond in these type of wetlands except occasionally in very small and shallow depressions or behind hummocks (depressions are usually <3ft diameter and less than 1 foot deep).*
NO - go to 5 **YES** – The wetland class is **Slope**

Wetland name or number B

5. Does the entire wetland unit **meet all** of the following criteria?
✓ The unit is in a valley, or stream channel, where it gets inundated by overbank flooding from that stream or river
✓ The overbank flooding occurs at least once every two years.
NOTE: The riverine unit can contain depressions that are filled with water when the river is not flooding.
NO - go to 6 **YES** – The wetland class is **Riverine**

6. Is the entire wetland unit in a topographic depression in which water ponds, or is saturated to the surface, at some time during the year. *This means that any outlet, if present, is higher than the interior of the wetland.*
NO - go to 7 **YES** – The wetland class is **Depressional**

7. Is the entire wetland unit located in a very flat area with no obvious depression and no overbank flooding. The unit does not pond surface water more than a few inches. The unit seems to be maintained by high groundwater in the area. The wetland may be ditched, but has no obvious natural outlet.
NO - go to 8 **YES** – The wetland class is **Depressional**

8. Your wetland unit seems to be difficult to classify and probably contains several different HGM clases. For example, seeps at the base of a slope may grade into a riverine floodplain, or a small stream within a depressional wetland has a zone of flooding along its sides. GO BACK AND IDENTIFY WHICH OF THE HYDROLOGIC REGIMES DESCRIBED IN QUESTIONS 1-7 APPLY TO DIFFERENT AREAS IN THE UNIT (make a rough sketch to help you decide). Use the following table to identify the appropriate class to use for the rating system if you have several HGM classes present within your wetland. NOTE: Use this table only if the class that is recommended in the second column represents 10% or more of the total area of the wetland unit being rated. If the area of the class listed in column 2 is less than 10% of the unit; classify the wetland using the class that represents more than 90% of the total area.

HGM Classes within the wetland unit being rated	*HGM Class to Use in Rating*
Slope + Riverine	Riverine
Slope + Depressional	Depressional
Slope + Lake-fringe	Lake-fringe
Depressional + Riverine along stream within boundary	Depressional
Depressional + Lake-fringe	Depressional
Salt Water Tidal Fringe and any other class of freshwater wetland	Treat as ESTUARINE under wetlands with special characteristics

If you are unable still to determine which of the above criteria apply to your wetland, or if you have more than 2 HGM classes within a wetland boundary, classify the wetland as **Depressional** for the rating.

Wetland name or number A

D	Depressional and Flats Wetlands WATER QUALITY FUNCTIONS - Indicators that the wetland unit functions to improve water quality	Points (only 1 score per box)
D	**D 1. Does the wetland unit have the potential to improve water quality?**	*(see p.38)*
D	D 1.1 Characteristics of surface water flows out of the wetland: Unit is a depression with no surface water leaving it (no outlet) points = 3 Unit has an intermittently flowing, OR highly constricted permanently flowing outlet points = 2 Unit has an unconstricted, or slightly constricted, surface outlet (*permanently flowing*) points = 1 Unit is a "flat" depression (Q. 7 on key), or in the Flats class, with permanent surface outflow **and no obvious natural outlet** and/or outlet is a man-made ditch points = 1 (*If ditch is not permanently flowing treat unit as "intermittently flowing"*) Provide photo or drawing	Figure ___ 3
D	S 1.2 The soil 2 inches below the surface (or duff layer) is clay or organic *(use NRCS definitions)* YES points = 4 NO points = 0	0
D	D 1.3 Characteristics of persistent vegetation (emergent, shrub, and/or forest Cowardin class) Wetland has persistent, ungrazed, vegetation > = 95% of area points = 5 Wetland has persistent, ungrazed, vegetation > = 1/2 of area points = 3 Wetland has persistent, ungrazed vegetation > = 1/10 of area points = 1 Wetland has persistent, ungrazed vegetation <1/10 of area points = 0 Map of Cowardin vegetation classes	Figure ___ 5
D	D1.4 Characteristics of seasonal ponding or inundation. *This is the area of the wetland unit that is ponded for at least 2 months, but dries out sometime during the year. Do not count the area that is permanently ponded. Estimate area as the average condition 5 out of 10 yrs.* Area seasonally ponded is > ½ total area of wetland points = 4 Area seasonally ponded is > ¼ total area of wetland points = 2 Area seasonally ponded is < ¼ total area of wetland points = 0 Map of Hydroperiods	Figure ___ 4
D	**Total for D 1** *Add the points in the boxes above*	12
D	**D 2. Does the wetland unit have the opportunity to improve water quality?** Answer YES if you know or believe there are pollutants in groundwater or surface water coming into the wetland that would otherwise reduce water quality in streams, lakes or groundwater downgradient from the wetland. *Note which of the following conditions provide the sources of pollutants. A unit may have pollutants coming from several sources, but any single source would qualify as opportunity.* — Grazing in the wetland or within 150 ft X Untreated stormwater discharges to wetland — Tilled fields or orchards within 150 ft of wetland X A stream or culvert discharges into wetland that drains developed areas, residential areas, farmed fields, roads, or clear-cut logging X Residential, urban areas, golf courses are within 150 ft of wetland — Wetland is fed by groundwater high in phosphorus or nitrogen Other_____ YES multiplier is 2 NO multiplier is 1	*(see p. 44)* multiplier 2
D	**TOTAL - Water Quality Functions** Multiply the score from D1 by D2 ***Add score to table on p. 1***	24

Wetland name or number A

D	Depressional and Flats Wetlands HYDROLOGIC FUNCTIONS - Indicators that the wetland unit functions to reduce flooding and stream degradation	Points (only 1 score per box)
	D 3. Does the wetland unit have the potential to reduce flooding and erosion?	*(see p.46)*
D	D 3.1 Characteristics of surface water flows out of the wetland unit Unit is a depression with no surface water leaving it (no outlet) points = 4 Unit has an intermittently flowing, OR highly constricted permanently flowing outlet points = 2 Unit is a "flat" depression (Q. 7 on key), or in the Flats class, with permanent surface outflow **and no obvious natural outlet** and/or outlet is a man-made ditch points = 1 (*If ditch is not permanently flowing treat unit as "intermittently flowing"*) Unit has an unconstricted, or slightly constricted, surface outlet (*permanently flowing*) points = 0	4
D	D 3.2 Depth of storage during wet periods *Estimate the height of ponding above the bottom of the outlet. For units with no outlet measure from the surface of permanent water or deepest part (if dry).* Marks of ponding are 3 ft or more above the surface or bottom of outlet points = 7 The wetland is a "headwater" wetland" points = 5 Marks of ponding between 2 ft to < 3 ft from surface or bottom of outlet points = 5 Marks are at least 0.5 ft to < 2 ft from surface or bottom of outlet points = 3 Unit is flat (yes to Q. 2 or Q. 7 on key) but has small depressions on the surface that trap water points = 1 Marks of ponding less than 0.5 ft points = 0	1
D	D 3.3 Contribution of wetland unit to storage in the watershed *Estimate the ratio of the area of upstream basin contributing surface water to the wetland to the area of the wetland unit itself.* The area of the basin is less than 10 times the area of unit points = 5 The area of the basin is 10 to 100 times the area of the unit points = 3 The area of the basin is more than 100 times the area of the unit points = 0 Entire unit is in the FLATS class points = 5	0
D	**Total for D 3** *Add the points in the boxes above*	5
D	**D 4. Does the wetland unit have the opportunity to reduce flooding and erosion?** Answer YES if the unit is in a location in the watershed where the flood storage, or reduction in water velocity, it provides helps protect downstream property and aquatic resources from flooding or excessive and/or erosive flows. Answer NO if the water coming into the wetland is controlled by a structure such as flood gate, tide gate, flap valve, reservoir etc. OR you estimate that more than 90% of the water in the wetland is from groundwater in areas where damaging groundwater flooding does not occur. *Note which of the following indicators of opportunity apply.* — Wetland is in a headwater of a river or stream that has flooding problems — Wetland drains to a river or stream that has flooding problems X Wetland has no outlet and impounds surface runoff water that might otherwise flow into a river or stream that has flooding problems — Other_____ YES multiplier is 2 NO multiplier is 1	*(see p. 49)* multiplier 2
D	**TOTAL - Hydrologic Functions** Multiply the score from D 3 by D 4 ***Add score to table on p. 1***	10

Wetland name or number B

R	**Riverine and Freshwater Tidal Fringe Wetlands** WATER QUALITY FUNCTIONS - Indicators that wetland functions to improve water quality	**Points** (only 1 score per box)
R	**R 1. Does the wetland unit have the potential to improve water quality?**	*(see p.52)*
R	R 1.1 Area of surface depressions within the riverine wetland that can trap sediments during a flooding event: Depressions cover >3/4 area of wetland points = 8 Depressions cover > 1/2 area of wetland points = 4 **If depressions > ½ of area of unit draw polygons on aerial photo or map** Depressions present but cover < 1/2 area of wetland points = 2 No depressions present points = 0	Figure ___ 4
R	R 1.2 Characteristics of the vegetation in the unit (areas with >90% cover at person height): Trees or shrubs > 2/3 the area of the unit points = 8 Trees or shrubs > 1/3 area of the unit points = 6 Ungrazed, herbaceous plants > 2/3 area of unit points = 6 Ungrazed herbaceous plants > 1/3 area of unit points = 3 Trees, shrubs, and ungrazed herbaceous < 1/3 area of unit points = 0 Aerial photo or map showing polygons of different vegetation types	Figure ___ 6
R	*Add the points in the boxes above*	10
R	**R 2. Does the wetland unit have the opportunity to improve water quality?** Answer YES if you know or believe there are pollutants in groundwater or surface water coming into the wetland that would otherwise reduce water quality in streams, lakes or groundwater downgradient from the wetland? *Note which of the following conditions provide the sources of pollutants. A unit may have pollutants coming from several sources, but any single source would qualify as opportunity.* — Grazing in the wetland or within 150ft X Untreated stormwater discharges to wetland — Tilled fields or orchards within 150 feet of wetland — A stream or culvert discharges into wetland that drains developed areas, residential areas, farmed fields, roads, or clear-cut logging X Residential, urban areas, golf courses are within 150 ft of wetland X The river or stream linked to the wetland has a contributing basin where human activities have raised levels of sediment, toxic compounds or nutrients in the river water above standards for water quality X Other Wetland periodically mowed (YES) multiplier is 2 NO multiplier is 1	*(see p.53)* multiplier 2
R	**TOTAL - Water Quality Functions** Multiply the score from R 1 by R 2 ***Add score to table on p. 1***	20

Comments

Wetland name or number B

R	**Riverine and Freshwater Tidal Fringe Wetlands** HYDROLOGIC FUNCTIONS - Indicators that wetland functions to reduce flooding and stream erosion	**Points** (only 1 score per box)
	R 3. Does the wetland unit have the potential to reduce flooding and erosion?	*(see p.54)*
R	R 3.1 Characteristics of the overbank storage the unit provides: *Estimate the average width of the wetland unit perpendicular to the direction of the flow and the width of the stream or river channel (distance between banks). Calculate the ratio: (average width of unit)/(average width of stream between banks).* If the ratio is more than 20 points = 9 If the ratio is between 10 – 20 points = 6 If the ratio is 5 - <10 points = 4 If the ratio is 1 - <5 points = 2 If the ratio is < 1 points = 1 Aerial photo or map showing average widths	Figure ___ 2
R	R 3.2 Characteristics of vegetation that slow down water velocities during floods: *Treat large woody debris as "forest or shrub". Choose the points appropriate for the best description.* (polygons need to have >90% cover at person height NOT Cowardin classes): Forest or shrub for >1/3 area OR herbaceous plants > 2/3 area points = 7 Forest or shrub for > 1/10 area OR herbaceous plants > 1/3 area points = 4 Vegetation does not meet above criteria points = 0 Aerial photo or map showing polygons of different vegetation types	Figure ___ 7
R	*Add the points in the boxes above*	9
R	**R 4. Does the wetland unit have the opportunity to reduce flooding and erosion?** Answer YES if the unit is in a location in the watershed where the flood storage, or reduction in water velocity, it provides helps protect downstream property and aquatic resources from flooding or excessive and/or erosive flows. *Note which of the following conditions apply.* X There are human structures and activities downstream (roads, buildings, bridges, farms) that can be damaged by flooding. X There are natural resources downstream (e.g. salmon redds) that can be damaged by flooding — Other ___ *(Answer NO if the major source of water to the wetland is controlled by a reservoir or the wetland is tidal fringe along the sides of a dike)* (YES) multiplier is 2 NO multiplier is 1	*(see p.57)* multiplier 2
R	**TOTAL - Hydrologic Functions** Multiply the score from R 3 by R 4 ***Add score to table on p. 1***	18

Comments

Wetland name or number B

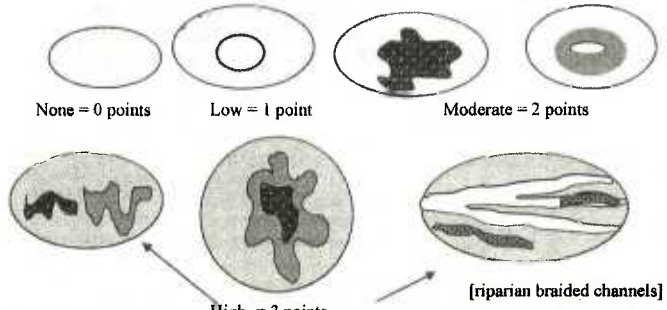
These questions apply to wetlands of all HGM classes. HABITAT FUNCTIONS - Indicators that unit functions to provide important habitat	Points (only 1 score per box)
H 1. Does the wetland unit have the potential to provide habitat for many species?	
H 1.1 Vegetation structure *(see p. 72)* *Check the types of vegetation classes present (as defined by Cowardin)- Size threshold for each class is ¼ acre or more than 10% of the area if unit is smaller than 2.5 acres.* X Aquatic bed X Emergent plants X Scrub/shrub (areas where shrubs have >30% cover) ____Forested (areas where trees have >30% cover) *If the unit has a forested class check if:* ____The forested class has 3 out of 5 strata (canopy, sub-canopy, shrubs, herbaceous, moss/ground-cover) that each cover 20% within the forested polygon *Add the number of vegetation structures that qualify. If you have:* 4 structures or more — points = 4 3 structures — points = 2 2 structures — points = 1 1 structure — points = 0 Map of Cowardin vegetation classes	Figure ___ 2
H 1.2. Hydroperiods *(see p. 73)* *Check the types of water regimes (hydroperiods) present within the wetland. The water regime has to cover more than 10% of the wetland or ¼ acre to count. (see text for descriptions of hydroperiods)* X Permanently flooded or inundated — 4 or more types present — points = 3 X Seasonally flooded or inundated — 3 types present — points = 2 X Occasionally flooded or inundated — 2 types present — point = 1 X Saturated only — 1 type present — points = 0 X Permanently flowing stream or river in, or adjacent to, the wetland X Seasonally flowing stream in, or adjacent to, the wetland ***Lake-fringe wetland* = 2 points** ***Freshwater tidal wetland* = 2 points** Map of hydroperiods	Figure ___ 3
H 1.3. Richness of Plant Species *(see p. 75)* Count the number of plant species in the wetland that cover at least 10 ft^2. *(different patches of the same species can be combined to meet the size threshold)* *You do not have to name the species.* *Do not include Eurasian Milfoil, reed canarygrass, purple loosestrife, Canadian Thistle* If you counted: > 19 species — points = 2 5 - 19 species — points = 1 < 5 species — points = 0 *List species below if you want to:*	1

Total for page 6

Wetland name or number B

H 1.4. Interspersion of habitats *(see p. 76)* — Figure ___ 3

Decide from the diagrams below whether interspersion between Cowardin vegetation classes (described in H 1.1), or the classes and unvegetated areas (can include open water or mudflats) is high, medium, low, or none.



→ NOTE: If you have four or more classes or three vegetation classes and open water the rating is always "high". Use map of Cowardin vegetation classes

H 1.5. Special Habitat Features: *(see p. 77)* — 1

Check the habitat features that are present in the wetland. The number of checks is the number of points you put into the next column.

____Large, downed, woody debris within the wetland (>4in. diameter and 6 ft long).

____Standing snags (diameter at the bottom > 4 inches) in the wetland

____Undercut banks are present for at least 6.6 ft (2m) and/or overhanging vegetation extends at least 3.3 ft (1m) over a stream (or ditch) in, or contiguous with the unit, for at least 33 ft (10m)

X Stable steep banks of fine material that might be used by beaver or muskrat for denning (>30degree slope) OR signs of recent beaver activity are present *(cut shrubs or trees that have not yet turned grey/brown)*

____At least ¼ acre of thin-stemmed persistent vegetation or woody branches are present in areas that are permanently or seasonally inundated.*(structures for egg-laying by amphibians)*

____Invasive plants cover less than 25% of the wetland area in each stratum of plants

NOTE: The 20% stated in early printings of the manual on page 78 is an error.

H 1. TOTAL Score - potential for providing habitat
Add the scores from H1.1, H1.2, H1.3, H1.4, H1.5 — 10

Comments

Wetland name or number B

H 2. Does the wetland unit have the opportunity to provide habitat for many species?	
H 2.1 Buffers *(see p. 80)* *Choose the description that best represents condition of buffer of wetland unit. The highest scoring criterion that applies to the wetland is to be used in the rating. See text for definition of "undisturbed."* — 100 m (330ft) of relatively undisturbed vegetated areas, rocky areas, or open water >95% of circumference. No structures are within the undisturbed part of buffer. (relatively undisturbed also means no-grazing, no landscaping, no daily human use) **Points = 5** X 100 m (330 ft) of relatively undisturbed vegetated areas, rocky areas, or open water > 50% circumference. **Points = 4** — 50 m (170ft) of relatively undisturbed vegetated areas, rocky areas, or open water >95% circumference. **Points = 4** — 100 m (330ft) of relatively undisturbed vegetated areas, rocky areas, or open water > 25% circumference, . **Points = 3** — 50 m (170ft) of relatively undisturbed vegetated areas, rocky areas, or open water for > 50% circumference. **Points = 3** **If buffer does not meet any of the criteria above** — No paved areas (except paved trails) or buildings within 25 m (80ft) of wetland > 95% circumference. Light to moderate grazing, or lawns are OK. **Points = 2** — No paved areas or buildings within 50m of wetland for >50% circumference. Light to moderate grazing, or lawns are OK. **Points = 2** — Heavy grazing in buffer. **Points = 1** — Vegetated buffers are <2m wide (6.6ft) for more than 95% of the circumference (e.g. tilled fields, paving, basalt bedrock extend to edge of wetland **Points = 0.** — Buffer does not meet any of the criteria above. **Points = 1** Aerial photo showing buffers	Figure ___ 4
H 2.2 Corridors and Connections *(see p. 81)* H 2.2.1 Is the wetland part of a relatively undisturbed and unbroken vegetated corridor (either riparian or upland) that is at least 150 ft wide, has at least 30% cover of shrubs, forest or native undisturbed prairie, that connects to estuaries, other wetlands or undisturbed uplands that are at least 250 acres in size? (*dams in riparian corridors, heavily used gravel roads, paved roads, are considered breaks in the corridor*). YES = **4 points** (*go to H 2.3*) NO = go to H 2.2.2 H 2.2.2 Is the wetland part of a relatively undisturbed and unbroken vegetated corridor (either riparian or upland) that is at least 50ft wide, has at least 30% cover of shrubs or forest, and connects to estuaries, other wetlands or undisturbed uplands that are at least 25 acres in size? **OR** a **Lake-fringe** wetland, if it does not have an undisturbed corridor as in the question above? YES = **2 points** (*go to H 2.3*) NO = H 2.2.3 H 2.2.3 Is the wetland: within 5 mi (8km) of a brackish or salt water estuary OR within 3 mi of a large field or pasture (>40 acres) OR within 1 mi of a lake greater than 20 acres? YES = **1 point** NO = **0 points**	4

Total for page 8

Wetland name or number B

H 2.3 Near or adjacent to other priority habitats listed by WDFW ***(see new and complete descriptions of WDFW priority habitats, and the counties in which they can be found, in the PHS report http://wdfw.wa.gov/hab/phslist.htm)*** Which of the following priority habitats are within 330ft (100m) of the wetland unit? *NOTE: the connections do not have to be relatively undisturbed.* ___**Aspen Stands:** Pure or mixed stands of aspen greater than 0.4 ha (1 acre). X **Biodiversity Areas and Corridors**: Areas of habitat that are relatively important to various species of native fish and wildlife (*full descriptions in WDFW PHS report p. 152*). ___**Herbaceous Balds:** Variable size patches of grass and forbs on shallow soils over bedrock. ___**Old-growth/Mature forests:** (Old-growth west of Cascade crest) Stands of at least 2 tree species, forming a multi-layered canopy with occasional small openings; with at least 20 trees/ha (8 trees/acre) > 81 cm (32 in) dbh or > 200 years of age. (Mature forests) Stands with average diameters exceeding 53 cm (21 in) dbh; crown cover may be less that 100%; crown cover may be less that 100%; decay, decadence, numbers of snags, and quantity of large downed material is generally less than that found in old-growth; 80 - 200 years old west of the Cascade crest. ___**Oregon white Oak:** Woodlands Stands of pure oak or oak/conifer associations where canopy coverage of the oak component is important (*full descriptions in WDFW PHS report p. 158*). ___**Riparian**: The area adjacent to aquatic systems with flowing water that contains elements of both aquatic and terrestrial ecosystems which mutually influence each other. ___**Westside Prairies:** Herbaceous, non-forested plant communities that can either take the form of a dry prairie or a wet prairie (*full descriptions in WDFW PHS report p. 161*). ___**Instream:** The combination of physical, biological, and chemical processes and conditions that interact to provide functional life history requirements for instream fish and wildlife resources. ___**Nearshore**: Relatively undisturbed nearshore habitats. These include Coastal Nearshore, Open Coast Nearshore, and Puget Sound Nearshore. (*full descriptions of habitats and the definition of relatively undisturbed are in WDFW report: pp. 167-169 and glossary in Appendix A).* ___**Caves:** A naturally occurring cavity, recess, void, or system of interconnected passages under the earth in soils, rock, ice, or other geological formations and is large enough to contain a human. ___**Cliffs:** Greater than 7.6 m (25 ft) high and occurring below 5000 ft. ___**Talus:** Homogenous areas of rock rubble ranging in average size 0.15 - 2.0 m (0.5 - 6.5 ft), composed of basalt, andesite, and/or sedimentary rock, including riprap slides and mine tailings. May be associated with cliffs. ___**Snags and Logs:** Trees are considered snags if they are dead or dying and exhibit sufficient decay characteristics to enable cavity excavation/use by wildlife. Priority snags have a diameter at breast height of > 51 cm (20 in) in western Washington and are > 2 m (6.5 ft) in height. Priority logs are > 30 cm (12 in) in diameter at the largest end, and > 6 m (20 ft) long. If wetland has **3 or more** priority habitats = **4 points** If wetland has **2** priority habitats = **3 points** If wetland has **1** priority habitat = **1 point** No habitats = 0 points *Note: All vegetated wetlands are by definition a priority habitat but are not included in this list. Nearby wetlands are addressed in question H 2.4)*	1

Wetland name or number B

H 2.4 Wetland Landscape *(choose the **one** description of the landscape around the wetland that best fits)* ***(see p. 84)*** There are at least 3 other wetlands within ½ mile, and the connections between them are relatively undisturbed (light grazing between wetlands OK, as is lake shore with some boating, but connections should NOT be bisected by paved roads, fill, fields, or other development. points = 5 The wetland is Lake-fringe on a lake with little disturbance and there are 3 other lake-fringe wetlands within ½ mile points = 5 There are at least 3 other wetlands within ½ mile, BUT the connections between them are disturbed points = 3 The wetland is Lake-fringe on a lake **with** disturbance and there are 3 other lake-fringe wetland within ½ mile points = 3 There is at least 1 wetland within ½ mile. points = 2 There are no wetlands within ½ mile. points = 0	3
H 2. TOTAL Score - opportunity for providing habitat *Add the scores from H2.1,H2.2, H2.3, H2.4*	12
TOTAL for H 1 from page 14	10
Total Score for Habitat Functions – add the points for H 1, H 2 and record the result on p. 1	22

Wetland name or number B

CATEGORIZATION BASED ON SPECIAL CHARACTERISTICS

Please determine if the wetland meets the attributes described below and circle the appropriate answers and Category.

Wetland Type *Check off any criteria that apply to the wetland. Circle the Category when the appropriate criteria are met.*	**Category**
SC 1.0 Estuarine wetlands ***(see p. 86)*** Does the wetland unit meet the following criteria for Estuarine wetlands? — The dominant water regime is tidal, — Vegetated, and — With a salinity greater than 0.5 ppt. YES – Go to SC 1.1 NO ___	
SC 1.1 Is the wetland unit within a National Wildlife Refuge, National Park, National Estuary Reserve, Natural Area Preserve, State Park or Educational, Environmental, or Scientific Reserve designated under WAC 332-30-151? YES = Category I NO go to SC 1.2	**Cat. I**
SC 1.2 Is the wetland unit at least 1 acre in size and meets at least two of the following three conditions? YES = Category I NO = Category II — The wetland is relatively undisturbed (has no diking, ditching, filling, cultivation, grazing, and has less than 10% cover of non-native plant species. If the non-native *Spartina* spp. are the only species that cover more than 10% of the wetland, then the wetland should be given a dual rating (I/II). The area of Spartina would be rated a Category II while the relatively undisturbed upper marsh with native species would be a Category I. Do not, however, exclude the area of Spartina in determining the size threshold of 1 acre. — At least ¾ of the landward edge of the wetland has a 100 ft buffer of shrub, forest, or un-grazed or un-mowed grassland. — The wetland has at least 2 of the following features: tidal channels, depressions with open water, or contiguous freshwater wetlands.	**Cat. I** **Cat. II** **Dual rating I/II**

Wetland name or number B

SC 2.0 Natural Heritage Wetlands *(see p. 87)* Natural Heritage wetlands have been identified by the Washington Natural Heritage Program/DNR as either high quality undisturbed wetlands or wetlands that support state Threatened, Endangered, or Sensitive plant species. SC 2.1 Is the wetland unit being rated in a Section/Township/Range that contains a Natural Heritage wetland? *(this question is used to screen out most sites before you need to contact WNHP/DNR)* S/T/R information from Appendix D ___ or accessed from WNHP/DNR web site X YES____ – contact WNHP/DNR (see p. 79) and go to SC 2.2 NO X SC 2.2 Has DNR identified the wetland as a high quality undisturbed wetland or as or as a site with state threatened or endangered plant species? YES = Category I NO ___not a Heritage Wetland	Cat. I
SC 3.0 Bogs *(see p. 87)* Does the wetland unit **(or any part of the unit)** meet both the criteria for soils and vegetation in bogs? *Use the key below to identify if the wetland is a bog.* ***If you answer yes you will still need to rate the wetland based on its functions.*** 1. Does the unit have organic soil horizons (i.e. layers of organic soil), either peats or mucks, that compose 16 inches or more of the first 32 inches of the soil profile? (See Appendix B for a field key to identify organic soils)? Yes - go to Q. 3 No - go to Q. 2 2. Does the unit have organic soils, either peats or mucks that are less than 16 inches deep over bedrock, or an impermeable hardpan such as clay or volcanic ash, or that are floating on a lake or pond? Yes - go to Q. 3 No - Is not a bog for purpose of rating 3. Does the unit have more than 70% cover of mosses at ground level, AND other plants, if present, consist of the "bog" species listed in Table 3 as a significant component of the vegetation (more than 30% of the total shrub and herbaceous cover consists of species in Table 3)? Yes – Is a bog for purpose of rating No - go to Q. 4 NOTE: If you are uncertain about the extent of mosses in the understory you may substitute that criterion by measuring the pH of the water that seeps into a hole dug at least 16" deep. If the pH is less than 5.0 and the "bog" plant species in Table 3 are present, the wetland is a bog. 4. Is the unit forested (> 30% cover) with sitka spruce, subalpine fir, western red cedar, western hemlock, lodgepole pine, quaking aspen, Englemann's spruce, or western white pine, WITH any of the species (or combination of species) on the bog species plant list in Table 3 as a significant component of the ground cover *(> 30% coverage of the total shrub/herbaceous cover)?* YES = Category I No___ Is not a bog for purpose of rating	Cat. I

Wetland name or number B

SC 4.0 Forested Wetlands *(see p. 90)* Does the wetland unit have at least 1 acre of forest that meet one of these criteria for the Department of Fish and Wildlife's forests as priority habitats? *If you answer yes you will still need to rate the wetland based on its functions.* — **Old-growth forests**: (west of Cascade crest) Stands of at least two tree species, forming a multi-layered canopy with occasional small openings; with at least 8 trees/acre (20 trees/hectare) that are at least 200 years of age OR have a diameter at breast height (dbh) of 32 inches (81 cm) or more. NOTE: The criterion for dbh is based on measurements for upland forests. Two-hundred year old trees in wetlands will often have a smaller dbh because their growth rates are often slower. The DFW criterion is and "OR" so old-growth forests do not necessarily have to have trees of this diameter. — **Mature forests**: (west of the Cascade Crest) Stands where the largest trees are 80 – 200 years old OR have average diameters (dbh) exceeding 21 inches (53cm); crown cover may be less that 100%; decay, decadence, numbers of snags, and quantity of large downed material is generally less than that found in old-growth. YES = Category I NO ___not a forested wetland with special characteristics	Cat. I
SC 5.0 Wetlands in Coastal Lagoons *(see p. 91)* Does the wetland meet all of the following criteria of a wetland in a coastal lagoon? — The wetland lies in a depression adjacent to marine waters that is wholly or partially separated from marine waters by sandbanks, gravel banks, shingle, or, less frequently, rocks — The lagoon in which the wetland is located contains surface water that is saline or brackish (> 0.5 ppt) during most of the year in at least a portion of the lagoon *(needs to be measured near the bottom)* YES = Go to SC 5.1 NO___ not a wetland in a coastal lagoon SC 5.1 Does the wetland meets all of the following three conditions? — The wetland is relatively undisturbed (has no diking, ditching, filling, cultivation, grazing), and has less than 20% cover of invasive plant species (see list of invasive species on p. 74). — At least ¾ of the landward edge of the wetland has a 100 ft buffer of shrub, forest, or un-grazed or un-mowed grassland. — The wetland is larger than 1/10 acre (4350 square feet) YES = Category I NO = Category II	Cat. I Cat. II

Wetland name or number B

SC 6.0 Interdunal Wetlands *(see p. 93)* Is the wetland unit west of the 1889 line (also called the Western Boundary of Upland Ownership or WBUO)? YES - go to SC 6.1 NO __ not an interdunal wetland for rating ***If you answer yes you will still need to rate the wetland based on its functions.*** In practical terms that means the following geographic areas: • Long Beach Peninsula- lands west of SR 103 • Grayland-Westport- lands west of SR 105 • Ocean Shores-Copalis- lands west of SR 115 and SR 109 SC 6.1 Is the wetland one acre or larger, or is it in a mosaic of wetlands that is once acre or larger? YES = Category II NO – go to SC 6.2 SC 6.2 Is the unit between 0.1 and 1 acre, or is it in a mosaic of wetlands that is between 0.1 and 1 acre? YES = Category III	**Cat. II** **Cat. III**
Category of wetland based on Special Characteristics *Choose the "highest" rating if wetland falls into several categories, and record on p. 1.* If you answered NO for all types enter "Not Applicable" on p.1	

Wetland name or number C

WETLAND RATING FORM – WESTERN WASHINGTON

Version 2 - Updated July 2006 to increase accuracy and reproducibility among users
Updated Oct 2008 with the new WDFW definitions for priority habitats

Name of wetland (if known): _____ Date of site visit: 10/28/13

Rated by _____ Trained by Ecology? Yes__No___ Date of training_____

SEC: ___ TWNSHP: ____ RNGE: ____ Is S/T/R in Appendix D? Yes___ No X

Map of wetland unit: Figure ____ Estimated size _____

SUMMARY OF RATING

Category based on FUNCTIONS provided by wetland

I___ II X III___ IV___

Category I = Score >=70
Category II = Score 51-69
Category III = Score 30-50
Category IV = Score < 30

Score for Water Quality Functions	20
Score for Hydrologic Functions	18
Score for Habitat Functions	22
TOTAL score for Functions	60

Category based on SPECIAL CHARACTERISTICS of wetland

I___ II___ Does not Apply X

Final Category (choose the "highest" category from above) II

Summary of basic information about the wetland unit

Wetland Unit has Special Characteristics		Wetland HGM Class used for Rating	
Estuarine		Depressional	
Natural Heritage Wetland		Riverine	X
Bog		Lake-fringe	
Mature Forest		Slope	
Old Growth Forest		Flats	
Coastal Lagoon		Freshwater Tidal	
Interdunal			
None of the above	X	Check if unit has multiple HGM classes present	

Wetland name or number C

Does the wetland unit being rated meet any of the criteria below?

If you answer YES to any of the questions below you will need to protect the wetland according to the regulations regarding the special characteristics found in the wetland.

Check List for Wetlands That May Need Additional Protection (in addition to the protection recommended for its category)	YES	NO
SP1. *Has the wetland unit been documented as a habitat for any Federally listed Threatened or Endangered* ***animal or plant*** *species (T/E species)?* For the purposes of this rating system, "documented" means the wetland is on the appropriate state or federal database.		
SP2. *Has the wetland unit been documented as habitat for any State listed Threatened or Endangered* ***animal*** *species?* For the purposes of this rating system, "documented" means the wetland is on the appropriate state database. Note: Wetlands with State listed plant species are categorized as Category I Natural Heritage Wetlands (see p. 19 of data form).		
SP3. *Does the wetland unit contain individuals of Priority species listed by the WDFW for the state?*	X	
SP4. *Does the wetland unit have a local significance in addition to its functions?* For example, the wetland has been identified in the Shoreline Master Program, the Critical Areas Ordinance, or in a local management plan as having special significance.		

To complete the next part of the data sheet you will need to determine the Hydrogeomorphic Class of the wetland being rated.

The hydrogeomorphic classification groups wetlands into those that function in similar ways. This simplifies the questions needed to answer how well the wetland functions. The Hydrogeomorphic Class of a wetland can be determined using the key below. See p. 24 for more detailed instructions on classifying wetlands.

Wetland name or number C

Classification of Wetland Units in Western Washington

If the hydrologic criteria listed in each question do not apply to the entire unit being rated, you probably have a unit with multiple HGM classes. In this case, identify which hydrologic criteria in questions 1-7 apply, and go to Question 8.

1. Are the water levels in the entire unit usually controlled by tides (i.e. except during floods)?
NO – go to 2 **YES** – the wetland class is **Tidal Fringe**

If yes, is the salinity of the water during periods of annual low flow below 0.5 ppt (parts per thousand)? **YES – Freshwater Tidal Fringe NO – Saltwater Tidal Fringe (Estuarine)**

*If your wetland can be classified as a Freshwater Tidal Fringe use the forms for **Riverine** wetlands. If it is Saltwater Tidal Fringe it is rated as an **Estuarine** wetland.* Wetlands that were called estuarine in the first and second editions of the rating system are called Salt Water Tidal Fringe in the Hydrogeomorphic Classification. Estuarine wetlands were categorized separately in the earlier editions, and this separation is being kept in this revision. To maintain consistency between editions, the term "Estuarine" wetland is kept. Please note, however, that the characteristics that define Category I and II estuarine wetlands have changed (see p.).

2. The entire wetland unit is flat and precipitation is the only source (>90%) of water to it. Groundwater and surface water runoff are NOT sources of water to the unit.
NO – go to 3 **YES** – The wetland class is **Flats**

If your wetland can be classified as a "Flats" wetland, use the form for **Depressional** wetlands.

3. Does the entire wetland unit **meet both** of the following criteria?
___The vegetated part of the wetland is on the shores of a body of permanent open water (without any vegetation on the surface) at least 20 acres (8 ha) in size;
___At least 30% of the open water area is deeper than 6.6 ft (2 m)?
NO – go to 4 **YES** – The wetland class is **Lake-fringe (Lacustrine Fringe)**

4. Does the entire wetland unit **meet all** of the following criteria?
___The wetland is on a slope (*slope can be very gradual*),
___The water flows through the wetland in one direction (unidirectional) and usually comes from seeps. It may flow subsurface, as sheetflow, or in a swale without distinct banks.
___The water leaves the wetland **without being impounded**?
NOTE: *Surface water does not pond in these type of wetlands except occasionally in very small and shallow depressions or behind hummocks (depressions are usually <3ft diameter and less than 1 foot deep).*
NO - go to 5 **YES** – The wetland class is **Slope**

Wetland name or number C

5. Does the entire wetland unit **meet all** of the following criteria?
___The unit is in a valley, or stream channel, where it gets inundated by overbank flooding from that stream or river
___The overbank flooding occurs at least once every two years.
NOTE: The riverine unit can contain depressions that are filled with water when the river is not flooding.
NO - go to 6 **YES** – The wetland class is **Riverine**

6. Is the entire wetland unit in a topographic depression in which water ponds, or is saturated to the surface, at some time during the year. *This means that any outlet, if present, is higher than the interior of the wetland.*
NO – go to 7 **YES** – The wetland class is **Depressional**

7. Is the entire wetland unit located in a very flat area with no obvious depression and no overbank flooding. The unit does not pond surface water more than a few inches. The unit seems to be maintained by high groundwater in the area. The wetland may be ditched, but has no obvious natural outlet.
NO – go to 8 **YES** – The wetland class is **Depressional**

8. Your wetland unit seems to be difficult to classify and probably contains several different HGM clases. For example, seeps at the base of a slope may grade into a riverine floodplain, or a small stream within a depressional wetland has a zone of flooding along its sides. GO BACK AND IDENTIFY WHICH OF THE HYDROLOGIC REGIMES DESCRIBED IN QUESTIONS 1-7 APPLY TO DIFFERENT AREAS IN THE UNIT (make a rough sketch to help you decide). Use the following table to identify the appropriate class to use for the rating system if you have several HGM classes present within your wetland. NOTE: Use this table only if the class that is recommended in the second column represents 10% or more of the total area of the wetland unit being rated. If the area of the class listed in column 2 is less than 10% of the unit; classify the wetland using the class that represents more than 90% of the total area.

HGM Classes within the wetland unit being rated	*HGM Class to Use in Rating*
Slope + Riverine	Riverine
Slope + Depressional	Depressional
Slope + Lake-fringe	Lake-fringe
Depressional + Riverine along stream within boundary	Depressional
Depressional + Lake-fringe	Depressional
Salt Water Tidal Fringe and any other class of freshwater wetland	Treat as ESTUARINE under wetlands with special characteristics

If you are unable still to determine which of the above criteria apply to your wetland, or if you have more than 2 HGM classes within a wetland boundary, classify the wetland as **Depressional** for the rating.

Wetland name or number C

R	**Riverine and Freshwater Tidal Fringe Wetlands** WATER QUALITY FUNCTIONS - Indicators that wetland functions to improve water quality	**Points** (only 1 score per box)
R	**R 1. Does the wetland unit have the potential to improve water quality?**	*(see p.52)*
R	R 1.1 Area of surface depressions within the riverine wetland that can trap sediments during a flooding event: Depressions cover >3/4 area of wetland points = 8 Depressions cover > 1/2 area of wetland points = 4 **If depressions > ½ of area of unit draw polygons on aerial photo or map** Depressions present but cover < 1/2 area of wetland points = 2 No depressions present points = 0	Figure ___ 4
R	R 1.2 Characteristics of the vegetation in the unit (areas with >90% cover at person height): Trees or shrubs > 2/3 the area of the unit points = 8 Trees or shrubs > 1/3 area of the unit points = 6 Ungrazed, herbaceous plants > 2/3 area of unit points = 6 Ungrazed herbaceous plants > 1/3 area of unit points = 3 Trees, shrubs, and ungrazed herbaceous < 1/3 area of unit points = 0 **Aerial photo or map showing polygons of different vegetation types**	Figure ___ 6
R	*Add the points in the boxes above*	10
R	**R 2. Does the wetland unit have the opportunity to improve water quality?** Answer YES if you know or believe there are pollutants in groundwater or surface water coming into the wetland that would otherwise reduce water quality in streams, lakes or groundwater downgradient from the wetland? *Note which of the following conditions provide the sources of pollutants. A unit may have pollutants coming from several sources, but any single source would qualify as opportunity.* — Grazing in the wetland or within 150ft X Untreated stormwater discharges to wetland — Tilled fields or orchards within 150 feet of wetland — A stream or culvert discharges into wetland that drains developed areas, residential areas, farmed fields, roads, or clear-cut logging X Residential, urban areas, golf courses are within 150 ft of wetland X The river or stream linked to the wetland has a contributing basin where human activities have raised levels of sediment, toxic compounds or nutrients in the river water above standards for water quality X Other wetland previously mowed (YES) multiplier is 2 NO multiplier is 1	*(see p.53)* multiplier 2
R	**TOTAL - Water Quality Functions** Multiply the score from R 1 by R 2 ***Add score to table on p. 1***	20

Comments

Wetland name or number C

R	**Riverine and Freshwater Tidal Fringe Wetlands** HYDROLOGIC FUNCTIONS - Indicators that wetland functions to reduce flooding and stream erosion	**Points** (only 1 score per box)
	R 3. Does the wetland unit have the potential to reduce flooding and erosion?	*(see p.54)*
R	R 3.1 Characteristics of the overbank storage the unit provides: *Estimate the average width of the wetland unit perpendicular to the direction of the flow and the width of the stream or river channel (distance between banks). Calculate the ratio: (average width of unit)/(average width of stream between banks).* If the ratio is more than 20 points = 9 If the ratio is between 10 – 20 points = 6 If the ratio is 5 - <10 points = 4 If the ratio is 1 - <5 points = 2 If the ratio is < 1 points = 1 **Aerial photo or map showing average widths**	Figure ___ 2
R	R 3.2 Characteristics of vegetation that slow down water velocities during floods: *Treat large woody debris as "forest or shrub". Choose the points appropriate for the best description.* (polygons need to have >90% cover at person height NOT Cowardin classes): Forest or shrub for >1/3 area OR herbaceous plants > 2/3 area points = 7 Forest or shrub for > 1/10 area OR herbaceous plants > 1/3 area points = 4 Vegetation does not meet above criteria points = 0 **Aerial photo or map showing polygons of different vegetation types**	Figure ___ 7
R	*Add the points in the boxes above*	9
R	**R 4. Does the wetland unit have the opportunity to reduce flooding and erosion?** Answer YES if the unit is in a location in the watershed where the flood storage, or reduction in water velocity, it provides helps protect downstream property and aquatic resources from flooding or excessive and/or erosive flows. *Note which of the following conditions apply.* X There are human structures and activities downstream (roads, buildings, bridges, farms) that can be damaged by flooding. X There are natural resources downstream (e.g. salmon redds) that can be damaged by flooding — Other_____ *(Answer NO if the major source of water to the wetland is controlled by a reservoir or the wetland is tidal fringe along the sides of a dike)* (YES) multiplier is 2 NO multiplier is 1	*(see p.57)* multiplier 2
R	**TOTAL - Hydrologic Functions** Multiply the score from R 3 by R 4 ***Add score to table on p. 1***	18

Comments

Wetland name or number C

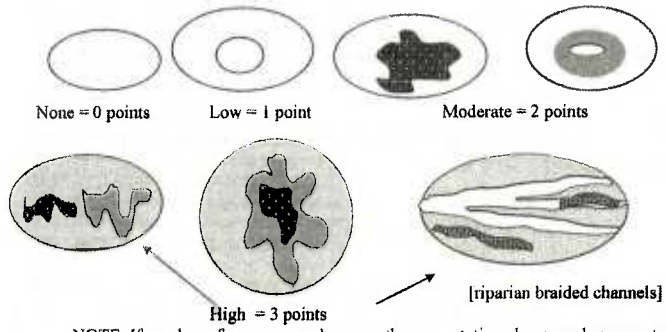
These questions apply to wetlands of all HGM classes. HABITAT FUNCTIONS - Indicators that unit functions to provide important habitat	Points (only 1 score per box)
H 1. Does the wetland unit have the potential to provide habitat for many species?	
H 1.1 Vegetation structure *(see p. 72)* *Check the types of vegetation classes present (as defined by Cowardin)- Size threshold for each class is ¼ acre or more than 10% of the area if unit is smaller than 2.5 acres.* X Aquatic bed X Emergent plants X Scrub/shrub (areas where shrubs have >30% cover) ___ Forested (areas where trees have >30% cover) *If the unit has a forested class check if:* ___ The forested class has 3 out of 5 strata (canopy, sub-canopy, shrubs, herbaceous, moss/ground-cover) that each cover 20% within the forested polygon *Add the number of vegetation structures that qualify. If you have:* 4 structures or more — points = 4 3 structures — points = 2 2 structures — points = 1 1 structure — points = 0 Map of Cowardin vegetation classes	Figure ___ 2
H 1.2. Hydroperiods *(see p. 73)* *Check the types of water regimes (hydroperiods) present within the wetland. The water regime has to cover more than 10% of the wetland or ¼ acre to count. (see text for descriptions of hydroperiods)* X Permanently flooded or inundated — 4 or more types present — points = 3 X Seasonally flooded or inundated — 3 types present — points = 2 X Occasionally flooded or inundated — 2 types present — point = 1 X Saturated only — 1 type present — points = 0 X Permanently flowing stream or river in, or adjacent to, the wetland X Seasonally flowing stream in, or adjacent to, the wetland ***Lake-fringe wetland* = 2 points** ***Freshwater tidal wetland* = 2 points** Map of hydroperiods	Figure ___ 3
H 1.3. Richness of Plant Species *(see p. 75)* Count the number of plant species in the wetland that cover at least 10 ft^2. *(different patches of the same species can be combined to meet the size threshold)* *You do not have to name the species:* *Do not include Eurasian Milfoil, reed canarygrass, purple loosestrife, Canadian Thistle* If you counted: > 19 species — points = 2 5 - 19 species — points = 1 < 5 species — points = 0 *List species below if you want to:*	1

Total for page 6

Wetland name or number C

H 1.4. Interspersion of habitats *(see p. 76)* — Figure ___ 3

Decide from the diagrams below whether interspersion between Cowardin vegetation classes (described in H 1.1), or the classes and unvegetated areas (can include open water or mudflats) is high, medium, low, or none.



NOTE: If you have four or more classes or three vegetation classes and open water the rating is always "high". Use map of Cowardin vegetation classes

H 1.5. Special Habitat Features: *(see p. 77)* — 1

Check the habitat features that are present in the wetland. The number of checks is the number of points you put into the next column.

___ Large, downed, woody debris within the wetland (>4in. diameter and 6 ft long).
___ Standing snags (diameter at the bottom > 4 inches) in the wetland
___ Undercut banks are present for at least 6.6 ft (2m) and/or overhanging vegetation extends at least 3.3 ft (1m) over a stream (or ditch) in, or contiguous with the unit, for at least 33 ft (10m)
___ Stable steep banks of fine material that might be used by beaver or muskrat for denning (>30degree slope) OR signs of recent beaver activity are present *(cut shrubs or trees that have not yet turned grey/brown)*
___ At least ¼ acre of thin-stemmed persistent vegetation or woody branches are present in areas that are permanently or seasonally inundated.*(structures for egg-laying by amphibians)*
___ Invasive plants cover less than 25% of the wetland area in each stratum of plants

NOTE: The 20% stated in early printings of the manual on page 78 is an error.

H 1. TOTAL Score - potential for providing habitat
Add the scores from H1.1, H1.2, H1.3, H1.4, H1.5 — 10

Comments

Wetland name or number C

H 2. Does the wetland unit have the opportunity to provide habitat for many species?	
H 2.1 Buffers *(see p. 80)* *Choose the description that best represents condition of buffer of wetland unit. The highest scoring criterion that applies to the wetland is to be used in the rating. See text for definition of "undisturbed."* — 100 m (330ft) of relatively undisturbed vegetated areas, rocky areas, or open water >95% of circumference. No structures are within the undisturbed part of buffer. (relatively undisturbed also means no-grazing, no landscaping, no daily human use) **Points = 5** X 100 m (330 ft) of relatively undisturbed vegetated areas, rocky areas, or open water > 50% circumference. **Points = 4** — 50 m (170ft) of relatively undisturbed vegetated areas, rocky areas, or open water >95% circumference. **Points = 4** — 100 m (330ft) of relatively undisturbed vegetated areas, rocky areas, or open water > 25% circumference, . **Points = 3** — 50 m (170ft) of relatively undisturbed vegetated areas, rocky areas, or open water for > 50% circumference. **Points = 3** **If buffer does not meet any of the criteria above** — No paved areas (except paved trails) or buildings within 25 m (80ft) of wetland > 95% circumference. Light to moderate grazing, or lawns are OK. **Points = 2** — No paved areas or buildings within 50m of wetland for >50% circumference. Light to moderate grazing, or lawns are OK. **Points = 2** — Heavy grazing in buffer. **Points = 1** — Vegetated buffers are <2m wide (6.6ft) for more than 95% of the circumference (e.g. tilled fields, paving, basalt bedrock extend to edge of wetland **Points = 0.** — Buffer does not meet any of the criteria above. **Points = 1** Aerial photo showing buffers	Figure ___ 4
H 2.2 Corridors and Connections *(see p. 81)* H 2.2.1 Is the wetland part of a relatively undisturbed and unbroken vegetated corridor (either riparian or upland) that is at least 150 ft wide, has at least 30% cover of shrubs, forest or native undisturbed prairie, that connects to estuaries, other wetlands or undisturbed uplands that are at least 250 acres in size? (*dams in riparian corridors, heavily used gravel roads, paved roads, are considered breaks in the corridor*). YES = **4 points** (*go to H 2.3*) NO = go to H 2.2.2 H 2.2.2 Is the wetland part of a relatively undisturbed and unbroken vegetated corridor (either riparian or upland) that is at least 50ft wide, has at least 30% cover of shrubs or forest, and connects to estuaries, other wetlands or undisturbed uplands that are at least 25 acres in size? **OR** a **Lake-fringe** wetland, if it does not have an undisturbed corridor as in the question above? YES = **2 points** (*go to H 2.3*) NO = H 2.2.3 H 2.2.3 Is the wetland: within 5 mi (8km) of a brackish or salt water estuary OR within 3 mi of a large field or pasture (>40 acres) OR within 1 mi of a lake greater than 20 acres? YES = **1 point** NO = **0 points**	4

Total for page 8

Wetland name or number C

H 2.3 Near or adjacent to other priority habitats listed by WDFW ***(see new and complete descriptions of WDFW priority habitats, and the counties in which they can be found, in the PHS report http://wdfw.wa.gov/hab/phslist.htm)*** Which of the following priority habitats are within 330ft (100m) of the wetland unit? *NOTE: the connections do not have to be relatively undisturbed.* ___**Aspen Stands:** Pure or mixed stands of aspen greater than 0.4 ha (1 acre). X **Biodiversity Areas and Corridors**: Areas of habitat that are relatively important to various species of native fish and wildlife (*full descriptions in WDFW PHS report p. 152*). ___**Herbaceous Balds:** Variable size patches of grass and forbs on shallow soils over bedrock. ___**Old-growth/Mature forests:** (Old-growth west of Cascade crest) Stands of at least 2 tree species, forming a multi-layered canopy with occasional small openings; with at least 20 trees/ha (8 trees/acre) > 81 cm (32 in) dbh or > 200 years of age. (Mature forests) Stands with average diameters exceeding 53 cm (21 in) dbh; crown cover may be less that 100%; crown cover may be less that 100%; decay, decadence, numbers of snags, and quantity of large downed material is generally less than that found in old-growth; 80 - 200 years old west of the Cascade crest. ___**Oregon white Oak:** Woodlands Stands of pure oak or oak/conifer associations where canopy coverage of the oak component is important (*full descriptions in WDFW PHS report p. 158*). ___**Riparian**: The area adjacent to aquatic systems with flowing water that contains elements of both aquatic and terrestrial ecosystems which mutually influence each other. ___**Westside Prairies:** Herbaceous, non-forested plant communities that can either take the form of a dry prairie or a wet prairie (*full descriptions in WDFW PHS report p. 161*). ___**Instream:** The combination of physical, biological, and chemical processes and conditions that interact to provide functional life history requirements for instream fish and wildlife resources. ___**Nearshore**: Relatively undisturbed nearshore habitats. These include Coastal Nearshore, Open Coast Nearshore, and Puget Sound Nearshore. (*full descriptions of habitats and the definition of relatively undisturbed are in WDFW report: pp. 167-169 and glossary in Appendix A).* ___**Caves:** A naturally occurring cavity, recess, void, or system of interconnected passages under the earth in soils, rock, ice, or other geological formations and is large enough to contain a human. ___**Cliffs:** Greater than 7.6 m (25 ft) high and occurring below 5000 ft. ___**Talus:** Homogenous areas of rock rubble ranging in average size 0.15 - 2.0 m (0.5 - 6.5 ft), composed of basalt, andesite, and/or sedimentary rock, including riprap slides and mine tailings. May be associated with cliffs. ___**Snags and Logs:** Trees are considered snags if they are dead or dying and exhibit sufficient decay characteristics to enable cavity excavation/use by wildlife. Priority snags have a diameter at breast height of > 51 cm (20 in) in western Washington and are > 2 m (6.5 ft) in height. Priority logs are > 30 cm (12 in) in diameter at the largest end, and > 6 m (20 ft) long. If wetland has **3 or more** priority habitats = **4 points** If wetland has **2** priority habitats = **3 points** If wetland has **1 priority habitat = 1 point** No habitats = 0 points *Note: All vegetated wetlands are by definition a priority habitat but are not included in this list. Nearby wetlands are addressed in question H 2.4)*	1

Wetland name or number C

H 2.4 Wetland Landscape *(choose the **one** description of the landscape around the wetland that best fits)* ***(see p. 84)*** There are at least 3 other wetlands within ½ mile, and the connections between them are relatively undisturbed (light grazing between wetlands OK, as is lake shore with some boating, but connections should NOT be bisected by paved roads, fill, fields, or other development. points = 5 The wetland is Lake-fringe on a lake with little disturbance and there are 3 other lake-fringe wetlands within ½ mile points = 5 There are at least 3 other wetlands within ½ mile, BUT the connections between them are disturbed points = 3 The wetland is Lake-fringe on a lake **with** disturbance and there are 3 other lake-fringe wetland within ½ mile points = 3 There is at least 1 wetland within ½ mile. points = 2 There are no wetlands within ½ mile. points = 0	3
H 2. TOTAL Score - opportunity for providing habitat *Add the scores from H2.1,H2.2, H2.3, H2.4*	12
TOTAL for H 1 from page 14	10
Total Score for Habitat Functions – add the points for H 1, H 2 and record the result on p. 1	22

Wetland name or number C

CATEGORIZATION BASED ON SPECIAL CHARACTERISTICS

Please determine if the wetland meets the attributes described below and circle the appropriate answers and Category.

Wetland Type *Check off any criteria that apply to the wetland. Circle the Category when the appropriate criteria are met.*	**Category**
SC 1.0 Estuarine wetlands *(see p. 86)* Does the wetland unit meet the following criteria for Estuarine wetlands? — The dominant water regime is tidal, — Vegetated, and — With a salinity greater than 0.5 ppt. YES = Go to SC 1.1 NO ___	
SC 1.1 Is the wetland unit within a National Wildlife Refuge, National Park, National Estuary Reserve, Natural Area Preserve, State Park or Educational, Environmental, or Scientific Reserve designated under WAC 332-30-151? YES = Category I NO go to SC 1.2	**Cat. I**
SC 1.2 Is the wetland unit at least 1 acre in size and meets at least two of the following three conditions? YES = Category I NO = Category II — The wetland is relatively undisturbed (has no diking, ditching, filling, cultivation, grazing, and has less than 10% cover of non-native plant species. If the non-native *Spartina* spp. are the only species that cover more than 10% of the wetland, then the wetland should be given a dual rating (I/II). The area of Spartina would be rated a Category II while the relatively undisturbed upper marsh with native species would be a Category I. Do not, however, exclude the area of Spartina in determining the size threshold of 1 acre. — At least ¾ of the landward edge of the wetland has a 100 ft buffer of shrub, forest, or un-grazed or un-mowed grassland. — The wetland has at least 2 of the following features: tidal channels, depressions with open water, or contiguous freshwater wetlands.	**Cat. I** **Cat. II** **Dual rating I/II**

Wetland name or number C

SC 2.0 Natural Heritage Wetlands *(see p. 87)* Natural Heritage wetlands have been identified by the Washington Natural Heritage Program/DNR as either high quality undisturbed wetlands or wetlands that support state Threatened, Endangered, or Sensitive plant species. SC 2.1 Is the wetland unit being rated in a Section/Township/Range that contains a Natural Heritage wetland? *(this question is used to screen out most sites before you need to contact WNHP/DNR)* S/T/R information from Appendix D ___ or accessed from WNHP/DNR web site X YES____ – contact WNHP/DNR (see p. 79) and go to SC 2.2 NO X SC 2.2 Has DNR identified the wetland as a high quality undisturbed wetland or as or as a site with state threatened or endangered plant species? YES = Category I NO ____not a Heritage Wetland	Cat. I
SC 3.0 Bogs *(see p. 87)* Does the wetland unit **(or any part of the unit)** meet both the criteria for soils and vegetation in bogs? *Use the key below to identify if the wetland is a bog.* ***If you answer yes you will still need to rate the wetland based on its functions.*** 1. Does the unit have organic soil horizons (i.e. layers of organic soil), either peats or mucks, that compose 16 inches or more of the first 32 inches of the soil profile? (See Appendix B for a field key to identify organic soils)? Yes - go to Q. 3 No - go to Q. 2 2. Does the unit have organic soils, either peats or mucks that are less than 16 inches deep over bedrock, or an impermeable hardpan such as clay or volcanic ash, or that are floating on a lake or pond? Yes - go to Q. 3 No - Is not a bog for purpose of rating 3. Does the unit have more than 70% cover of mosses at ground level, AND other plants, if present, consist of the "bog" species listed in Table 3 as a significant component of the vegetation (more than 30% of the total shrub and herbaceous cover consists of species in Table 3)? Yes – Is a bog for purpose of rating No - go to Q. 4 NOTE: If you are uncertain about the extent of mosses in the understory you may substitute that criterion by measuring the pH of the water that seeps into a hole dug at least 16" deep. If the pH is less than 5.0 and the "bog" plant species in Table 3 are present, the wetland is a bog. 1. Is the unit forested (> 30% cover) with sitka spruce, subalpine fir, western red cedar, western hemlock, lodgepole pine, quaking aspen, Englemann's spruce, or western white pine, WITH any of the species (or combination of species) on the bog species plant list in Table 3 as a significant component of the ground cover *(> 30% coverage of the total shrub/herbaceous cover)?* 2. YES = Category I No___ Is not a bog for purpose of rating	Cat. I

Wetland name or number C

SC 4.0 Forested Wetlands *(see p. 90)* Does the wetland unit have at least 1 acre of forest that meet one of these criteria for the Department of Fish and Wildlife's forests as priority habitats? *If you answer yes you will still need to rate the wetland based on its functions.* — **Old-growth forests**: (west of Cascade crest) Stands of at least two tree species, forming a multi-layered canopy with occasional small openings; with at least 8 trees/acre (20 trees/hectare) that are at least 200 years of age OR have a diameter at breast height (dbh) of 32 inches (81 cm) or more. NOTE: The criterion for dbh is based on measurements for upland forests. Two-hundred year old trees in wetlands will often have a smaller dbh because their growth rates are often slower. The DFW criterion is and "OR" so old-growth forests do not necessarily have to have trees of this diameter. — **Mature forests**: (west of the Cascade Crest) Stands where the largest trees are 80 – 200 years old OR have average diameters (dbh) exceeding 21 inches (53cm); crown cover may be less that 100%; decay, decadence, numbers of snags, and quantity of large downed material is generally less than that found in old-growth. YES = Category I NO ___not a forested wetland with special characteristics	Cat. I
SC 5.0 Wetlands in Coastal Lagoons *(see p. 91)* Does the wetland meet all of the following criteria of a wetland in a coastal lagoon? — The wetland lies in a depression adjacent to marine waters that is wholly or partially separated from marine waters by sandbanks, gravel banks, shingle, or, less frequently, rocks — The lagoon in which the wetland is located contains surface water that is saline or brackish (> 0.5 ppt) during most of the year in at least a portion of the lagoon *(needs to be measured near the bottom)* YES = Go to SC 5.1 NO___ not a wetland in a coastal lagoon SC 5.1 Does the wetland meets all of the following three conditions? — The wetland is relatively undisturbed (has no diking, ditching, filling, cultivation, grazing), and has less than 20% cover of invasive plant species (see list of invasive species on p. 74). — At least ¾ of the landward edge of the wetland has a 100 ft buffer of shrub, forest, or un-grazed or un-mowed grassland. — The wetland is larger than 1/10 acre (4350 square feet) YES = Category I NO = Category II	Cat. I Cat. II

Wetland name or number C

SC 6.0 Interdunal Wetlands *(see p. 93)* Is the wetland unit west of the 1889 line (also called the Western Boundary of Upland Ownership or WBUO)? YES - go to SC 6.1 NO __ not an interdunal wetland for rating ***If you answer yes you will still need to rate the wetland based on its functions.*** In practical terms that means the following geographic areas: • Long Beach Peninsula- lands west of SR 103 • Grayland-Westport- lands west of SR 105 • Ocean Shores-Copalis- lands west of SR 115 and SR 109 SC 6.1 Is the wetland one acre or larger, or is it in a mosaic of wetlands that is once acre or larger? YES = Category II NO – go to SC 6.2 SC 6.2 Is the unit between 0.1 and 1 acre, or is it in a mosaic of wetlands that is between 0.1 and 1 acre? YES = Category III	**Cat. II** **Cat. III**
Category of wetland based on Special Characteristics *Choose the "highest" rating if wetland falls into several categories, and record on p. 1.* If you answered NO for all types enter "Not Applicable" on p.1	

Wetland name or number D

WETLAND RATING FORM – WESTERN WASHINGTON

Version 2 - Updated July 2006 to increase accuracy and reproducibility among users
Updated Oct 2008 with the new WDFW definitions for priority habitats

Name of wetland (if known): MARYMOOR D Date of site visit: 10/28/13

Rated by _____ Trained by Ecology? Yes__No___ Date of training_____

SEC: ___ TWNSHP: ___ RNGE: ___ Is S/T/R in Appendix D? Yes___ No X

Map of wetland unit: Figure ____ **Estimated size** _____

SUMMARY OF RATING

Category based on FUNCTIONS provided by wetland

I___ II___ III___ IV X

Category I = Score >=70
Category II = Score 51-69
Category III = Score 30-50
Category IV = Score < 30

Score for Water Quality Functions	16
Score for Hydrologic Functions	4
Score for Habitat Functions	9
TOTAL score for Functions	29

Category based on SPECIAL CHARACTERISTICS of wetland

I___ II___ **Does not Apply**___

Final Category **(choose the "highest" category from above)** IV

Summary of basic information about the wetland unit

Wetland Unit has Special Characteristics		Wetland HGM Class used for Rating	
Estuarine		**Depressional**	X
Natural Heritage Wetland		**Riverine**	
Bog		**Lake-fringe**	
Mature Forest		**Slope**	
Old Growth Forest		**Flats**	
Coastal Lagoon		**Freshwater Tidal**	
Interdunal			
None of the above	X	Check if unit has multiple HGM classes present	

Wetland name or number D

Does the wetland unit being rated meet any of the criteria below?

If you answer YES to any of the questions below you will need to protect the wetland according to the regulations regarding the special characteristics found in the wetland.

Check List for Wetlands That May Need Additional Protection (in addition to the protection recommended for its category)	YES	NO
SP1. *Has the wetland unit been documented as a habitat for any Federally listed Threatened or Endangered* ***animal or plant*** *species (T/E species)?* For the purposes of this rating system, "documented" means the wetland is on the appropriate state or federal database.		
SP2. *Has the wetland unit been documented as habitat for any State listed Threatened or Endangered* ***animal*** *species?* For the purposes of this rating system, "documented" means the wetland is on the appropriate state database. Note: Wetlands with State listed plant species are categorized as Category I Natural Heritage Wetlands (see p. 19 of data form).		
SP3. *Does the wetland unit contain individuals of Priority species listed by the WDFW for the state?*	X	
SP4. *Does the wetland unit have a local significance in addition to its functions?* For example, the wetland has been identified in the Shoreline Master Program, the Critical Areas Ordinance, or in a local management plan as having special significance.		

To complete the next part of the data sheet you will need to determine the Hydrogeomorphic Class of the wetland being rated.

The hydrogeomorphic classification groups wetlands into those that function in similar ways. This simplifies the questions needed to answer how well the wetland functions. The Hydrogeomorphic Class of a wetland can be determined using the key below. See p. 24 for more detailed instructions on classifying wetlands.

Wetland name or number D

Classification of Wetland Units in Western Washington

If the hydrologic criteria listed in each question do not apply to the entire unit being rated, you probably have a unit with multiple HGM classes. In this case, identify which hydrologic criteria in questions 1-7 apply, and go to Question 8.

1. Are the water levels in the entire unit usually controlled by tides (i.e. except during floods)?
NO – go to 2 **YES – the wetland class is Tidal Fringe**

If yes, is the salinity of the water during periods of annual low flow below 0.5 ppt (parts per thousand)? **YES – Freshwater Tidal Fringe** **NO – Saltwater Tidal Fringe (Estuarine)**

*If your wetland can be classified as a Freshwater Tidal Fringe use the forms for **Riverine** wetlands. If it is Saltwater Tidal Fringe it is rated as an **Estuarine** wetland.* Wetlands that were called estuarine in the first and second editions of the rating system are called Salt Water Tidal Fringe in the Hydrogeomorphic Classification. Estuarine wetlands were categorized separately in the earlier editions, and this separation is being kept in this revision. To maintain consistency between editions, the term "Estuarine" wetland is kept. Please note, however, that the characteristics that define Category I and II estuarine wetlands have changed (see p.).

2. The entire wetland unit is flat and precipitation is the only source (>90%) of water to it. Groundwater and surface water runoff are NOT sources of water to the unit.
NO – go to 3 **YES** – The wetland class is **Flats**

If your wetland can be classified as a "Flats" wetland, use the form for **Depressional** wetlands.

3. Does the entire wetland unit **meet both** of the following criteria?
___The vegetated part of the wetland is on the shores of a body of permanent open water (without any vegetation on the surface) at least 20 acres (8 ha) in size;
___At least 30% of the open water area is deeper than 6.6 ft (2 m)?
NO – go to 4 **YES** – The wetland class is **Lake-fringe (Lacustrine Fringe)**

4. Does the entire wetland unit **meet all** of the following criteria?
____The wetland is on a slope (*slope can be very gradual*),
____The water flows through the wetland in one direction (unidirectional) and usually comes from seeps. It may flow subsurface, as sheetflow, or in a swale without distinct banks.
____The water leaves the wetland **without being impounded**?
NOTE: *Surface water does not pond in these type of wetlands except occasionally in very small and shallow depressions or behind hummocks (depressions are usually <3ft diameter and less than 1 foot deep).*
NO – go to 5 **YES** – The wetland class is **Slope**

Wetland name or number D

5. Does the entire wetland unit **meet all** of the following criteria?
____The unit is in a valley, or stream channel, where it gets inundated by overbank flooding from that stream or river
____The overbank flooding occurs at least once every two years.
NOTE: The riverine unit can contain depressions that are filled with water when the river is not flooding.
NO – go to 6 **YES** – The wetland class is **Riverine**

6. Is the entire wetland unit in a topographic depression in which water ponds, or is saturated to the surface, at some time during the year. *This means that any outlet, if present, is higher than the interior of the wetland.*
NO – go to 7 **YES** – The wetland class is **Depressional**

7. Is the entire wetland unit located in a very flat area with no obvious depression and no overbank flooding. The unit does not pond surface water more than a few inches. The unit seems to be maintained by high groundwater in the area. The wetland may be ditched, but has no obvious natural outlet.
NO – go to 8 **YES** – The wetland class is **Depressional**

8. Your wetland unit seems to be difficult to classify and probably contains several different HGM clases. For example, seeps at the base of a slope may grade into a riverine floodplain, or a small stream within a depressional wetland has a zone of flooding along its sides. GO BACK AND IDENTIFY WHICH OF THE HYDROLOGIC REGIMES DESCRIBED IN QUESTIONS 1-7 APPLY TO DIFFERENT AREAS IN THE UNIT (make a rough sketch to help you decide). Use the following table to identify the appropriate class to use for the rating system if you have several HGM classes present within your wetland. NOTE: Use this table only if the class that is recommended in the second column represents 10% or more of the total area of the wetland unit being rated. If the area of the class listed in column 2 is less than 10% of the unit; classify the wetland using the class that represents more than 90% of the total area.

HGM Classes within the wetland unit being rated	*HGM Class to Use in Rating*
Slope + Riverine	Riverine
Slope + Depressional	Depressional
Slope + Lake-fringe	Lake-fringe
Depressional + Riverine along stream within boundary	Depressional
Depressional + Lake-fringe	Depressional
Salt Water Tidal Fringe and any other class of freshwater wetland	Treat as ESTUARINE under wetlands with special characteristics

If you are unable still to determine which of the above criteria apply to your wetland, or if you have more than 2 HGM classes within a wetland boundary, classify the wetland as **Depressional** for the rating.

Wetland name or number D

D	Depressional and Flats Wetlands WATER QUALITY FUNCTIONS - Indicators that the wetland unit functions to improve water quality	Points (only 1 score per box)
D	**D 1. Does the wetland unit have the potential to improve water quality?**	*(see p.38)*
D	D 1.1 Characteristics of surface water flows out of the wetland: Unit is a depression with no surface water leaving it (no outlet) points = 3 Unit has an intermittently flowing, OR highly constricted permanently flowing outlet points = 2 Unit has an unconstricted, or slightly constricted, surface outlet (*permanently flowing*) points = 1 Unit is a "flat" depression (Q. 7 on key), or in the Flats class, with permanent surface outflow **and no obvious natural outlet** and/or outlet is a man-made ditch points = 1 (*If ditch is not permanently flowing treat unit as "intermittently flowing"*) Provide photo or drawing	Figure ___ 3
D	S 1.2 The soil 2 inches below the surface (or duff layer) is clay or organic *(use NRCS definitions)* YES points = 4 NO points = 0	0
D	D 1.3 Characteristics of persistent vegetation (emergent, shrub, and/or forest Cowardin class) Wetland has persistent, ungrazed, vegetation > = 95% of area points = 5 Wetland has persistent, ungrazed, vegetation > = 1/2 of area points = 3 Wetland has persistent, ungrazed vegetation > = 1/10 of area points = 1 Wetland has persistent, ungrazed vegetation <1/10 of area points = 0 Map of Cowardin vegetation classes	Figure ___ 5
D	D1.4 Characteristics of seasonal ponding or inundation. *This is the area of the wetland unit that is ponded for at least 2 months, but dries out sometime during the year. Do not count the area that is permanently ponded. Estimate area as the average condition 5 out of 10 yrs.* Area seasonally ponded is > ½ total area of wetland points = 4 Area seasonally ponded is > ¼ total area of wetland points = 2 Area seasonally ponded is < ¼ total area of wetland points = 0 Map of Hydroperiods	Figure ___ 0
D	**Total for D 1** *Add the points in the boxes above*	8
D	**D 2. Does the wetland unit have the opportunity to improve water quality?** Answer YES if you know or believe there are pollutants in groundwater or surface water coming into the wetland that would otherwise reduce water quality in streams, lakes or groundwater downgradient from the wetland. *Note which of the following conditions provide the sources of pollutants. A unit may have pollutants coming from several sources, but any single source would qualify as opportunity.* — Grazing in the wetland or within 150 ft X Untreated stormwater discharges to wetland — Tilled fields or orchards within 150 ft of wetland X A stream or culvert discharges into wetland that drains developed areas, residential areas, farmed fields, roads, or clear-cut logging X Residential, urban areas, golf courses are within 150 ft of wetland — Wetland is fed by groundwater high in phosphorus or nitrogen — Other _____ YES multiplier is 2 NO multiplier is 1	*(see p. 44)* multiplier 2
D	**TOTAL - Water Quality Functions** Multiply the score from D1 by D2 ***Add score to table on p. 1***	16

Wetland name or number D

D	Depressional and Flats Wetlands HYDROLOGIC FUNCTIONS - Indicators that the wetland unit functions to reduce flooding and stream degradation	Points (only 1 score per box)
	D 3. Does the wetland unit have the potential to reduce flooding and erosion?	*(see p.46)*
D	D 3.1 Characteristics of surface water flows out of the wetland unit Unit is a depression with no surface water leaving it (no outlet) points = 4 Unit has an intermittently flowing, OR highly constricted permanently flowing outlet points = 2 Unit is a "flat" depression (Q. 7 on key), or in the Flats class, with permanent surface outflow **and no obvious natural outlet** and/or outlet is a man-made ditch points = 1 (*If ditch is not permanently flowing treat unit as "intermittently flowing"*) Unit has an unconstricted, or slightly constricted, surface outlet (*permanently flowing*) points = 0	4
D	D 3.2 Depth of storage during wet periods *Estimate the height of ponding above the bottom of the outlet. For units with no outlet measure from the surface of permanent water or deepest part (if dry).* Marks of ponding are 3 ft or more above the surface or bottom of outlet points = 7 The wetland is a "headwater" wetland points = 5 Marks of ponding between 2 ft to < 3 ft from surface or bottom of outlet points = 5 Marks are at least 0.5 ft to < 2 ft from surface or bottom of outlet points = 3 Unit is flat (yes to Q. 2 or Q. 7 on key) but has small depressions on the surface that trap water points = 1 Marks of ponding less than 0.5 ft points = 0	0
D	D 3.3 Contribution of wetland unit to storage in the watershed *Estimate the ratio of the area of upstream basin contributing surface water to the wetland to the area of the wetland unit itself.* The area of the basin is less than 10 times the area of unit points = 5 The area of the basin is 10 to 100 times the area of the unit points = 3 The area of the basin is more than 100 times the area of the unit points = 0 Entire unit is in the FLATS class points = 5	0 ?
D	**Total for D 3** *Add the points in the boxes above*	4
D	**D 4. Does the wetland unit have the opportunity to reduce flooding and erosion?** Answer YES if the unit is in a location in the watershed where the flood storage, or reduction in water velocity, it provides helps protect downstream property and aquatic resources from flooding or excessive and/or erosive flows. Answer NO if the water coming into the wetland is controlled by a structure such as flood gate, tide gate, flap valve, reservoir etc. OR you estimate that more than 90% of the water in the wetland is from groundwater in areas where damaging groundwater flooding does not occur. *Note which of the following indicators of opportunity apply.* — Wetland is in a headwater of a river or stream that has flooding problems — Wetland drains to a river or stream that has flooding problems — Wetland has no outlet and impounds surface runoff water that might otherwise flow into a river or stream that has flooding problems — Other _____ **YES** multiplier is 2 **NO** multiplier is 1	*(see p. 49)* multiplier 1
D	**TOTAL - Hydrologic Functions** Multiply the score from D 3 by D 4 ***Add score to table on p. 1***	4

Wetland name or number D

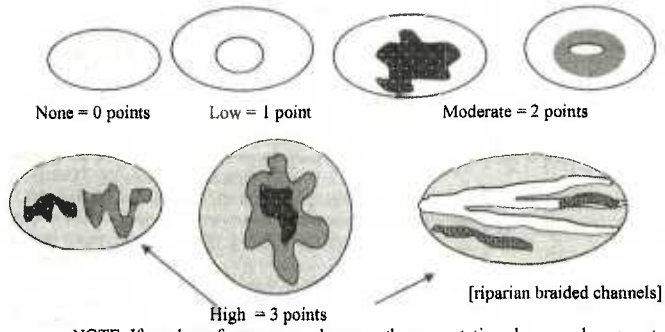
These questions apply to wetlands of all HGM classes. HABITAT FUNCTIONS - Indicators that unit functions to provide important habitat	Points (only 1 score per box)
H 1. Does the wetland unit have the potential to provide habitat for many species?	
H 1.1 Vegetation structure *(see p. 72)* *Check the types of vegetation classes present (as defined by Cowardin)- Size threshold for each class is ¼ acre or more than 10% of the area if unit is smaller than 2.5 acres.* ____Aquatic bed ____Emergent plants ____Scrub/shrub (areas where shrubs have >30% cover) ____Forested (areas where trees have >30% cover) *If the unit has a forested class check if:* ____The forested class has 3 out of 5 strata (canopy, sub-canopy, shrubs, herbaceous, moss/ground-cover) that each cover 20% within the forested polygon *Add the number of vegetation structures that qualify. If you have:* 4 structures or more — points = 4 3 structures — points = 2 2 structures — points = 1 1 structure — points = 0 Map of Cowardin vegetation classes	Figure ___ 0
H 1.2. Hydroperiods *(see p. 73)* *Check the types of water regimes (hydroperiods) present within the wetland. The water regime has to cover more than 10% of the wetland or ¼ acre to count. (see text for descriptions of hydroperiods)* ____Permanently flooded or inundated — 4 or more types present — points = 3 ____Seasonally flooded or inundated — 3 types present — points = 2 ____Occasionally flooded or inundated — 2 types present — point = 1 __X__Saturated only — 1 type present — points = 0 ____Permanently flowing stream or river in, or adjacent to, the wetland ____Seasonally flowing stream in, or adjacent to, the wetland ____***Lake-fringe wetland* = 2 points** ____***Freshwater tidal wetland* = 2 points** Map of hydroperiods	Figure ___ 1
H 1.3. Richness of Plant Species *(see p. 75)* Count the number of plant species in the wetland that cover at least 10 ft^2. *(different patches of the same species can be combined to meet the size threshold)* *You do not have to name the species.* *Do not include Eurasian Milfoil, reed canarygrass, purple loosestrife, Canadian Thistle* If you counted: > 19 species — points = 2 5 - 19 species — points = 1 < 5 species — points = 0 *List species below if you want to:*	0

Total for page 1

Wetland name or number D

H 1.4. Interspersion of habitats *(see p. 76)* — Figure ___

Decide from the diagrams below whether interspersion between Cowardin vegetation classes (described in H 1.1), or the classes and unvegetated areas (can include open water or mudflats) is high, medium, low, or none.



NOTE: If you have four or more classes or three vegetation classes and open water the rating is always "high". Use map of Cowardin vegetation classes

0

H 1.5. Special Habitat Features: *(see p. 77)*

Check the habitat features that are present in the wetland. The number of checks is the number of points you put into the next column.

____Large, downed, woody debris within the wetland (>4in. diameter and 6 ft long).

____Standing snags (diameter at the bottom > 4 inches) in the wetland

____Undercut banks are present for at least 6.6 ft (2m) and/or overhanging vegetation extends at least 3.3 ft (1m) over a stream (or ditch) in, or contiguous with the unit, for at least 33 ft (10m)

____Stable steep banks of fine material that might be used by beaver or muskrat for denning (>30degree slope) OR signs of recent beaver activity are present *(cut shrubs or trees that have not yet turned grey/brown)*

____At least ¼ acre of thin-stemmed persistent vegetation or woody branches are present in areas that are permanently or seasonally inundated.*(structures for egg-laying by amphibians)*

____Invasive plants cover less than 25% of the wetland area in each stratum of plants

NOTE: The 20% stated in early printings of the manual on page 78 is an error.

0

H 1. TOTAL Score - potential for providing habitat
Add the scores from H1.1, H1.2, H1.3, H1.4, H1.5 — 1

Comments

Wetland name or number D

H 2. Does the wetland unit have the opportunity to provide habitat for many species?	
H 2.1 Buffers *(see p. 80)* *Choose the description that best represents condition of buffer of wetland unit. The highest scoring criterion that applies to the wetland is to be used in the rating. See text for definition of "undisturbed."* — 100 m (330ft) of relatively undisturbed vegetated areas, rocky areas, or open water >95% of circumference. No structures are within the undisturbed part of buffer. (relatively undisturbed also means no-grazing, no landscaping, no daily human use) **Points = 5** — 100 m (330 ft) of relatively undisturbed vegetated areas, rocky areas, or open water > 50% circumference. **Points = 4** — 50 m (170ft) of relatively undisturbed vegetated areas, rocky areas, or open water >95% circumference. **Points = 4** — 100 m (330ft) of relatively undisturbed vegetated areas, rocky areas, or open water > 25% circumference, **Points = 3** — 50 m (170ft) of relatively undisturbed vegetated areas, rocky areas, or open water for > 50% circumference. **Points = 3** **If buffer does not meet any of the criteria above** — No paved areas (except paved trails) or buildings within 25 m (80ft) of wetland > 95% circumference. Light to moderate grazing, or lawns are OK. **Points = 2** — No paved areas or buildings within 50m of wetland for >50% circumference. Light to moderate grazing, or lawns are OK. **Points = 2** — Heavy grazing in buffer. **Points = 1** — Vegetated buffers are <2m wide (6.6ft) for more than 95% of the circumference (e.g. tilled fields, paving, basalt bedrock extend to edge of wetland **Points = 0.** — Buffer does not meet any of the criteria above. **Points = 1** Aerial photo showing buffers	**Figure ___** 4
H 2.2 Corridors and Connections *(see p. 81)* H 2.2.1 Is the wetland part of a relatively undisturbed and unbroken vegetated corridor (either riparian or upland) that is at least 150 ft wide, has at least 30% cover of shrubs, forest or native undisturbed prairie, that connects to estuaries, other wetlands or undisturbed uplands that are at least 250 acres in size? *(dams in riparian corridors, heavily used gravel roads, paved roads, are considered breaks in the corridor)* YES = **4 points** *(go to H 2.3)* NO = go to H 2.2.2 H 2.2.2 Is the wetland part of a relatively undisturbed and unbroken vegetated corridor (either riparian or upland) that is at least 50ft wide, has at least 30% cover of shrubs or forest, and connects to estuaries, other wetlands or undisturbed uplands that are at least 25 acres in size? **OR a Lake-fringe** wetland, if it does not have an undisturbed corridor as in the question above? YES = **2 points** *(go to H 2.3)* NO = H 2.2.3 H 2.2.3 Is the wetland: within 5 mi (8km) of a brackish or salt water estuary OR within 3 mi of a large field or pasture (>40 acres) OR within 1 mi of a lake greater than 20 acres? YES = **1 point** NO = **0 points**	0

Total for page_____

Wetland name or number D

H 2.3 Near or adjacent to other priority habitats listed by WDFW ***(see new and complete descriptions of WDFW priority habitats, and the counties in which they can be found, in the PHS report http://wdfw.wa.gov/hab/phslist.htm)*** Which of the following priority habitats are within 330ft (100m) of the wetland unit? *NOTE: the connections do not have to be relatively undisturbed.* ___**Aspen Stands:** Pure or mixed stands of aspen greater than 0.4 ha (1 acre). X**Biodiversity Areas and Corridors**: Areas of habitat that are relatively important to various species of native fish and wildlife *(full descriptions in WDFW PHS report p. 152)*. ___**Herbaceous Balds:** Variable size patches of grass and forbs on shallow soils over bedrock. ___**Old-growth/Mature forests:** (Old-growth west of Cascade crest) Stands of at least 2 tree species, forming a multi-layered canopy with occasional small openings; with at least 20 trees/ha (8 trees/acre) > 81 cm (32 in) dbh or > 200 years of age. (Mature forests) Stands with average diameters exceeding 53 cm (21 in) dbh; crown cover may be less that 100%; crown cover may be less that 100%; decay, decadence, numbers of snags, and quantity of large downed material is generally less than that found in old-growth; 80 - 200 years old west of the Cascade crest. ___**Oregon white Oak:** Woodlands Stands of pure oak or oak/conifer associations where canopy coverage of the oak component is important *(full descriptions in WDFW PHS report p. 158)*. ___**Riparian**: The area adjacent to aquatic systems with flowing water that contains elements of both aquatic and terrestrial ecosystems which mutually influence each other. ___**Westside Prairies:** Herbaceous, non-forested plant communities that can either take the form of a dry prairie or a wet prairie *(full descriptions in WDFW PHS report p. 161)*. ___**Instream:** The combination of physical, biological, and chemical processes and conditions that interact to provide functional life history requirements for instream fish and wildlife resources. ___ **Nearshore**: Relatively undisturbed nearshore habitats. These include Coastal Nearshore, Open Coast Nearshore, and Puget Sound Nearshore. *(full descriptions of habitats and the definition of relatively undisturbed are in WDFW report: pp. 167-169 and glossary in Appendix A)*. ___**Caves:** A naturally occurring cavity, recess, void, or system of interconnected passages under the earth in soils, rock, ice, or other geological formations and is large enough to contain a human. ___**Cliffs:** Greater than 7.6 m (25 ft) high and occurring below 5000 ft. ___**Talus:** Homogenous areas of rock rubble ranging in average size 0.15 - 2.0 m (0.5 - 6.5 ft), composed of basalt, andesite, and/or sedimentary rock, including riprap slides and mine tailings. May be associated with cliffs. ___**Snags and Logs:** Trees are considered snags if they are dead or dying and exhibit sufficient decay characteristics to enable cavity excavation/use by wildlife. Priority snags have a diameter at breast height of > 51 cm (20 in) in western Washington and are > 2 m (6.5 ft) in height. Priority logs are > 30 cm (12 in) in diameter at the largest end, and > 6 m (20 ft) long. If wetland has **3 or more** priority habitats = **4 points** If wetland has **2** priority habitats = **3 points** If wetland has 1 priority habitat = **1 point** No habitats = 0 points *Note: All vegetated wetlands are by definition a priority habitat but are not included in this list. Nearby wetlands are addressed in question H 2.4)*	1

Wetland name or number D

H 2.4 Wetland Landscape *(choose the **one** description of the landscape around the wetland that best fits)* ***(see p. 84)*** There are at least 3 other wetlands within ½ mile, and the connections between them are relatively undisturbed (light grazing between wetlands OK, as is lake shore with some boating, but connections should NOT be bisected by paved roads, fill, fields, or other development. points = 5 The wetland is Lake-fringe on a lake with little disturbance and there are 3 other lake-fringe wetlands within ½ mile points = 5 There are at least 3 other wetlands within ½ mile, BUT the connections between them are disturbed points = 3 The wetland is Lake-fringe on a lake with disturbance and there are 3 other lake-fringe wetland within ½ mile points = 3 There is at least 1 wetland within ½ mile. points = 2 There are no wetlands within ½ mile. points = 0	3
H 2. TOTAL Score - opportunity for providing habitat *Add the scores from H2.1,H2.2, H2.3, H2.4*	8
TOTAL for H 1 from page 14	1
Total Score for Habitat Functions – add the points for H 1, H 2 and record the result on p. 1	9

Wetland name or number D

CATEGORIZATION BASED ON SPECIAL CHARACTERISTICS

Please determine if the wetland meets the attributes described below and circle the appropriate answers and Category.

Wetland Type *Check off any criteria that apply to the wetland. Circle the Category when the appropriate criteria are met.*	**Category**
SC 1.0 Estuarine wetlands *(see p. 86)* Does the wetland unit meet the following criteria for Estuarine wetlands? — The dominant water regime is tidal, — Vegetated, and — With a salinity greater than 0.5 ppt. YES = Go to SC 1.1 NO ___	
SC 1.1 Is the wetland unit within a National Wildlife Refuge, National Park, National Estuary Reserve, Natural Area Preserve, State Park or Educational, Environmental, or Scientific Reserve designated under WAC 332-30-151? YES = Category I NO go to SC 1.2	**Cat. I**
SC 1.2 Is the wetland unit at least 1 acre in size and meets at least two of the following three conditions? YES = Category I NO = Category II — The wetland is relatively undisturbed (has no diking, ditching, filling, cultivation, grazing, and has less than 10% cover of non-native plant species. If the non-native *Spartina* spp. are the only species that cover more than 10% of the wetland, then the wetland should be given a dual rating (I/II). The area of Spartina would be rated a Category II while the relatively undisturbed upper marsh with native species would be a Category I. Do not, however, exclude the area of Spartina in determining the size threshold of 1 acre. — At least ¾ of the landward edge of the wetland has a 100 ft buffer of shrub, forest, or un-grazed or un-mowed grassland. — The wetland has at least 2 of the following features: tidal channels, depressions with open water, or contiguous freshwater wetlands.	**Cat. I** **Cat. II** **Dual rating I/II**

Wetland name or number D

SC 2.0 Natural Heritage Wetlands *(see p. 87)* Natural Heritage wetlands have been identified by the Washington Natural Heritage Program/DNR as either high quality undisturbed wetlands or wetlands that support state Threatened, Endangered, or Sensitive plant species. SC 2.1 Is the wetland unit being rated in a Section/Township/Range that contains a Natural Heritage wetland? *(this question is used to screen out most sites before you need to contact WNHP/DNR)* S/T/R information from Appendix D ___ or accessed from WNHP/DNR web site X YES____ – contact WNHP/DNR (see p. 79) and go to SC 2.2 NO X SC 2.2 Has DNR identified the wetland as a high quality undisturbed wetland or as or as a site with state threatened or endangered plant species? YES = Category I NO ____not a Heritage Wetland	Cat. I
SC 3.0 Bogs *(see p. 87)* Does the wetland unit **(or any part of the unit)** meet both the criteria for soils and vegetation in bogs? *Use the key below to identify if the wetland is a bog.* ***If you answer yes you will still need to rate the wetland based on its functions.*** 1. Does the unit have organic soil horizons (i.e. layers of organic soil), either peats or mucks, that compose 16 inches or more of the first 32 inches of the soil profile? (See Appendix B for a field key to identify organic soils)? Yes - go to Q. 3 No - go to Q. 2 2. Does the unit have organic soils, either peats or mucks that are less than 16 inches deep over bedrock, or an impermeable hardpan such as clay or volcanic ash, or that are floating on a lake or pond? Yes - go to Q. 3 No - Is not a bog for purpose of rating 3. Does the unit have more than 70% cover of mosses at ground level, AND other plants, if present, consist of the "bog" species listed in Table 3 as a significant component of the vegetation (more than 30% of the total shrub and herbaceous cover consists of species in Table 3)? Yes – Is a bog for purpose of rating No - go to Q. 4 NOTE: If you are uncertain about the extent of mosses in the understory you may substitute that criterion by measuring the pH of the water that seeps into a hole dug at least 16" deep. If the pH is less than 5.0 and the "bog" plant species in Table 3 are present, the wetland is a bog. *1.* Is the unit forested (> 30% cover) with sitka spruce, subalpine fir, western red cedar, western hemlock, lodgepole pine, quaking aspen, Englemann's spruce, or western white pine, WITH any of the species (or combination of species) on the bog species plant list in Table 3 as a significant component of the ground cover *(> 30% coverage of the total shrub/herbaceous cover)?* 2. YES = Category I No___ Is not a bog for purpose of rating	Cat. I

Wetland name or number D

SC 4.0 Forested Wetlands *(see p. 90)* Does the wetland unit have at least 1 acre of forest that meet one of these criteria for the Department of Fish and Wildlife's forests as priority habitats? *If you answer yes you will still need to rate the wetland based on its functions.* — **Old-growth forests**: (west of Cascade crest) Stands of at least two tree species, forming a multi-layered canopy with occasional small openings; with at least 8 trees/acre (20 trees/hectare) that are at least 200 years of age OR have a diameter at breast height (dbh) of 32 inches (81 cm) or more. NOTE: The criterion for dbh is based on measurements for upland forests. Two-hundred year old trees in wetlands will often have a smaller dbh because their growth rates are often slower. The DFW criterion is and "OR" so old-growth forests do not necessarily have to have trees of this diameter. — **Mature forests**: (west of the Cascade Crest) Stands where the largest trees are 80 – 200 years old OR have average diameters (dbh) exceeding 21 inches (53cm); crown cover may be less that 100%; decay, decadence, numbers of snags, and quantity of large downed material is generally less than that found in old-growth. YES = Category I NO ___not a forested wetland with special characteristics	Cat. I
SC 5.0 Wetlands in Coastal Lagoons *(see p. 91)* Does the wetland meet all of the following criteria of a wetland in a coastal lagoon? — The wetland lies in a depression adjacent to marine waters that is wholly or partially separated from marine waters by sandbanks, gravel banks, shingle, or, less frequently, rocks — The lagoon in which the wetland is located contains surface water that is saline or brackish (> 0.5 ppt) during most of the year in at least a portion of the lagoon *(needs to be measured near the bottom)* YES = Go to SC 5.1 NO___ not a wetland in a coastal lagoon SC 5.1 Does the wetland meets all of the following three conditions? — The wetland is relatively undisturbed (has no diking, ditching, filling, cultivation, grazing), and has less than 20% cover of invasive plant species (see list of invasive species on p. 74). — At least ¾ of the landward edge of the wetland has a 100 ft buffer of shrub, forest, or un-grazed or un-mowed grassland. — The wetland is larger than 1/10 acre (4350 square feet) YES = Category I NO = Category II	Cat. I Cat. II

Wetland name or number D

SC 6.0 Interdunal Wetlands *(see p. 93)* Is the wetland unit west of the 1889 line (also called the Western Boundary of Upland Ownership or WBUO)? YES - go to SC 6.1 NO X not an interdunal wetland for rating ***If you answer yes you will still need to rate the wetland based on its functions.*** In practical terms that means the following geographic areas: • Long Beach Peninsula- lands west of SR 103 • Grayland-Westport- lands west of SR 105 • Ocean Shores-Copalis- lands west of SR 115 and SR 109 SC 6.1 Is the wetland one acre or larger, or is it in a mosaic of wetlands that is once acre or larger? YES = Category II NO – go to SC 6.2 SC 6.2 Is the unit between 0.1 and 1 acre, or is it in a mosaic of wetlands that is between 0.1 and 1 acre? YES = Category III	**Cat. II** **Cat. III**
Category of wetland based on Special Characteristics *Choose the "highest" rating if wetland falls into several categories, and record on p. 1.* If you answered NO for all types enter "Not Applicable" on p.1	

Wetland name or number E

WETLAND RATING FORM – WESTERN WASHINGTON

Version 2 - Updated July 2006 to increase accuracy and reproducibility among users
Updated Oct 2008 with the new WDFW definitions for priority habitats

Name of wetland (if known): MARYMOOR E Date of site visit: 10/29/13

Rated by_____ Trained by Ecology? Yes__No__ Date of training____

SEC: __ TWNSHP: __ RNGE: __ Is S/T/R in Appendix D? Yes__ No X

Map of wetland unit: Figure ____ Estimated size _____

SUMMARY OF RATING

Category based on FUNCTIONS provided by wetland

I__ II X III__ IV__

Category I – Score >=70
Category II = Score 51-69
Category III = Score 30-50
Category IV = Score < 30

Score for Water Quality Functions	24
Score for Hydrologic Functions	12
Score for Habitat Functions	26
TOTAL score for Functions	62

Category based on SPECIAL CHARACTERISTICS of wetland

I__ II__ Does not Apply X

Final Category (choose the **"highest"** category from above) II

Summary of basic information about the wetland unit

Wetland Unit has Special Characteristics		Wetland HGM Class used for Rating	
Estuarine		Depressional	
Natural Heritage Wetland		Riverine	
Bog		Lake-fringe	X
Mature Forest		Slope	
Old Growth Forest		Flats	
Coastal Lagoon		Freshwater Tidal	
Interdunal			
None of the above	X	Check if unit has multiple HGM classes present	

Wetland name or number E

Does the wetland unit being rated meet any of the criteria below?

If you answer YES to any of the questions below you will need to protect the wetland according to the regulations regarding the special characteristics found in the wetland.

Check List for Wetlands That May Need Additional Protection (in addition to the protection recommended for its category)	YES	NO
SP1. *Has the wetland unit been documented as a habitat for any Federally listed Threatened or Endangered* ***animal or plant*** *species (T/E species)?* For the purposes of this rating system, "documented" means the wetland is on the appropriate state or federal database.		
SP2. *Has the wetland unit been documented as habitat for any State listed Threatened or Endangered* ***animal*** *species?* For the purposes of this rating system, "documented" means the wetland is on the appropriate state database. Note: Wetlands with State listed plant species are categorized as Category I Natural Heritage Wetlands (see p. 19 of data form).		
SP3. *Does the wetland unit contain individuals of Priority species listed by the WDFW for the state?*	X	
SP4. *Does the wetland unit have a local significance in addition to its functions?* For example, the wetland has been identified in the Shoreline Master Program, the Critical Areas Ordinance, or in a local management plan as having special significance.		

To complete the next part of the data sheet you will need to determine the Hydrogeomorphic Class of the wetland being rated.

The hydrogeomorphic classification groups wetlands into those that function in similar ways. This simplifies the questions needed to answer how well the wetland functions. The Hydrogeomorphic Class of a wetland can be determined using the key below. See p. 24 for more detailed instructions on classifying wetlands.

Wetland name or number E

Classification of Wetland Units in Western Washington

If the hydrologic criteria listed in each question do not apply to the entire unit being rated, you probably have a unit with multiple HGM classes. In this case, identify which hydrologic criteria in questions 1-7 apply, and go to Question 8.

1. Are the water levels in the entire unit usually controlled by tides (i.e. except during floods)?
NO – go to 2 **YES – the wetland class is Tidal Fringe**

If yes, is the salinity of the water during periods of annual low flow below 0.5 ppt (parts per thousand)? **YES – Freshwater Tidal Fringe NO – Saltwater Tidal Fringe (Estuarine)**

*If your wetland can be classified as a Freshwater Tidal Fringe use the forms for **Riverine** wetlands. If it is Saltwater Tidal Fringe it is rated as an **Estuarine** wetland.* Wetlands that were called estuarine in the first and second editions of the rating system are called Salt Water Tidal Fringe in the Hydrogeomorphic Classification. Estuarine wetlands were categorized separately in the earlier editions, and this separation is being kept in this revision. To maintain consistency between editions, the term "Estuarine" wetland is kept. Please note, however, that the characteristics that define Category I and II estuarine wetlands have changed (see p.).

2. The entire wetland unit is flat and precipitation is the only source (>90%) of water to it. Groundwater and surface water runoff are NOT sources of water to the unit.
NO – go to 3 **YES** – The wetland class is **Flats**

If your wetland can be classified as a "Flats" wetland, use the form for **Depressional** wetlands.

3. Does the entire wetland unit **meet both** of the following criteria?
___The vegetated part of the wetland is on the shores of a body of permanent open water (without any vegetation on the surface) at least 20 acres (8 ha) in size;
___At least 30% of the open water area is deeper than 6.6 ft (2 m)?
NO – go to 4 **YES – the wetland class is Lake-fringe (Lacustrine Fringe)**

4. Does the entire wetland unit **meet all** of the following criteria?
____The wetland is on a slope (*slope can be very gradual*),
____The water flows through the wetland in one direction (unidirectional) and usually comes from seeps. It may flow subsurface, as sheetflow, or in a swale without distinct banks.
____The water leaves the wetland **without being impounded**?
NOTE: *Surface water does not pond in these type of wetlands except occasionally in very small and shallow depressions or behind hummocks (depressions are usually <3ft diameter and less than 1 foot deep).*
NO - go to 5 **YES – The wetland class is Slope**

Wetland name or number E

5. Does the entire wetland unit **meet all** of the following criteria?
____ The unit is in a valley, or stream channel, where it gets inundated by overbank flooding from that stream or river
____ The overbank flooding occurs at least once every two years.
NOTE: The riverine unit can contain depressions that are filled with water when the river is not flooding.
NO - go to 6 **YES** – The wetland class is **Riverine**

6. Is the entire wetland unit in a topographic depression in which water ponds, or is saturated to the surface, at some time during the year. *This means that any outlet, if present, is higher than the interior of the wetland.*
NO – go to 7 **YES** – The wetland class is **Depressional**

7. Is the entire wetland unit located in a very flat area with no obvious depression and no overbank flooding. The unit does not pond surface water more than a few inches. The unit seems to be maintained by high groundwater in the area. The wetland may be ditched, but has no obvious natural outlet.
NO – go to 8 **YES** – The wetland class is **Depressional**

8. Your wetland unit seems to be difficult to classify and probably contains several different HGM clases. For example, seeps at the base of a slope may grade into a riverine floodplain, or a small stream within a depressional wetland has a zone of flooding along its sides. GO BACK AND IDENTIFY WHICH OF THE HYDROLOGIC REGIMES DESCRIBED IN QUESTIONS 1-7 APPLY TO DIFFERENT AREAS IN THE UNIT (make a rough sketch to help you decide). Use the following table to identify the appropriate class to use for the rating system if you have several HGM classes present within your wetland. NOTE: Use this table only if the class that is recommended in the second column represents 10% or more of the total area of the wetland unit being rated. If the area of the class listed in column 2 is less than 10% of the unit; classify the wetland using the class that represents more than 90% of the total area.

HGM Classes within the wetland unit being rated	*HGM Class to Use in Rating*
Slope + Riverine	Riverine
Slope + Depressional	Depressional
Slope + Lake-fringe	Lake-fringe
Depressional + Riverine along stream within boundary	Depressional
Depressional + Lake-fringe	Depressional
Salt Water Tidal Fringe and any other class of freshwater wetland	Treat as ESTUARINE under wetlands with special characteristics

If you are unable still to determine which of the above criteria apply to your wetland, or if you have more than 2 HGM classes within a wetland boundary, classify the wetland as **Depressional** for the rating.

Wetland name or number E

L	**Lake-fringe Wetlands** WATER QUALITY FUNCTIONS - Indicators that the wetland unit functions to improve water quality	**Points** (only 1 score per box)
L	**L 1. Does the wetland unit have the potential to improve water quality?**	*(see p.59)*
L	L 1.1 Average width of vegetation along the lakeshore *(use polygons of Cowardin classes)*: Vegetation is more than 33ft (10m) wide — points = 6 Vegetation is more than 16 (5m) wide and <33ft — points = 3 Vegetation is more than 6ft (2m) wide and <16 ft — points = 1 Vegetation is less than 6 ft wide — points = 0 **Map of Cowardin classes with widths marked**	Figure ___ 6
L	L 1.2 Characteristics of the vegetation in the wetland: *choose the appropriate description that results in the highest points, and do not include any open water in your estimate of coverage. The herbaceous plants can be either the dominant form or as an understory in a shrub or forest community. These are not Cowardin classes. Area of Cover is total cover in the unit, but it can be in patches. NOTE: Herbaceous does not include aquatic bed.* Cover of herbaceous plants is >90% of the vegetated area — points = 6 Cover of herbaceous plants is >2/3 of the vegetated area — points = 4 Cover of herbaceous plants is >1/3 of the vegetated area — points = 3 Other vegetation that is not aquatic bed or herbaceous covers > 2/3 unit — points = 3 Other vegetation that is not aquatic bed in > 1/3 vegetated area — points = 1 Aquatic bed vegetation and open water cover > 2/3 of the unit — points = 0 **Map with polygons of different vegetation types**	Figure ___ 6
L	*Add the points in the boxes above*	12
L	**L 2. Does the wetland have the opportunity to improve water quality?** Answer YES if you know or believe there are pollutants in the lake water, or polluted surface water flowing through the unit to the lake. *Note which of the following conditions provide the sources of pollutants. A unit may have pollutants coming from several sources, but any single source would qualify as opportunity.* — Wetland is along the shores of a lake or reservoir that does not meet water quality standards — Grazing in the wetland or within 150ft X Polluted water discharges to wetland along upland edge — Tilled fields or orchards within 150 feet of wetland X Residential or urban areas are within 150 ft of wetland — Parks with grassy areas that are maintained, ballfields, golf courses (all within 150 ft. of lake shore) — Power boats with gasoline or diesel engines use the lake Other ___ YES multiplier is 2 NO multiplier is 1	*(see p.61)* multiplier 2
L	**TOTAL - Water Quality Functions** Multiply the score from L1 by L2 ***Add score to table on p. 1***	24

Comments

Wetland name or number E

L	**Lake-fringe Wetlands** HYDROLOGIC FUNCTIONS - Indicators that the wetland unit functions to reduce shoreline erosion	**Points** (only 1 score per box)
L	**L 3. Does the wetland unit have the potential to reduce shoreline erosion?**	*(see p.62)*
L	L 3 Distance along shore and average width of Cowardin classes along the lakeshore (**do not** include aquatic bed): *(choose the highest scoring description that matches conditions in the wetland)* > ¾ of distance is shrubs or forest at least 33 ft (10m) wide — points = 6 > ¾ of distance is shrubs or forest at least 6 ft. (2 m) wide — points = 4 > ¼ distance is shrubs or forest at least 33 ft (10m) wide — points = 4 Vegetation is at least 6 ft (2m) wide (any type except aquatic bed) — points = 2 Vegetation is less than 6 ft (2m) wide (any type except aquatic bed) — points = 0 **Aerial photo or map with Cowardin vegetation classes**	Figure ___ 6
L	*Record the points from the box above*	6
L	**L 4. Does the wetland unit have the opportunity to reduce erosion?** Are there features along the shore that will be impacted if the shoreline erodes? *Note which of the following conditions apply.* X There are human structures and activities along the upland edge of the wetland (buildings, fields) that can be damaged by erosion. X There are undisturbed natural resources along the upland edge of the wetland (e.g. mature forests other wetlands) than can be damaged by shoreline erosion — Other ___ YES multiplier is 2 NO multiplier is 1	*(see p.63)* multiplier 2
L	**TOTAL - Hydrologic Functions** Multiply the score from L 3 by L 4 ***Add score to table on p. 1***	12

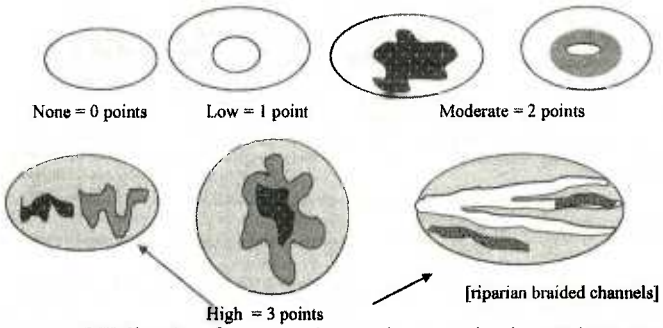
Comments

Wetland name or number E

These questions apply to wetlands of all HGM classes. HABITAT FUNCTIONS - Indicators that unit functions to provide important habitat	**Points** (only 1 score per box)
H 1. Does the wetland unit have the potential to provide habitat for many species?	
H 1.1 Vegetation structure *(see p. 72)* *Check the types of vegetation classes present (as defined by Cowardin)- Size threshold for each class is ¼ acre or more than 10% of the area if unit is smaller than 2.5 acres.* X Aquatic bed X Emergent plants X Scrub/shrub (areas where shrubs have >30% cover) X Forested (areas where trees have >30% cover) *If the unit has a forested class check if:* ___The forested class has 3 out of 5 strata (canopy, sub-canopy, shrubs, herbaceous, moss/ground-cover) that each cover 20% within the forested polygon *Add the number of vegetation structures that qualify. If you have:* 4 structures or more — points = 4 3 structures — points = 2 2 structures — points = 1 1 structure — points = 0 Map of Cowardin vegetation classes	Figure ___ 4
H 1.2. Hydroperiods *(see p. 73)* *Check the types of water regimes (hydroperiods) present within the wetland. The water regime has to cover more than 10% of the wetland or ¼ acre to count. (see text for descriptions of hydroperiods)* X Permanently flooded or inundated — 4 or more types present — points = 3 X Seasonally flooded or inundated — 3 types present — points = 2 X Occasionally flooded or inundated — 2 types present — point = 1 X Saturated only — 1 type present — points = 0 X Permanently flowing stream or river in, or adjacent to, the wetland X Seasonally flowing stream in, or adjacent to, the wetland ***Lake-fringe wetland*** = 2 points ___***Freshwater tidal wetland*** = 2 points Map of hydroperiods	Figure ___ 3
H 1.3. Richness of Plant Species *(see p. 75)* Count the number of plant species in the wetland that cover at least 10 ft^2. *(different patches of the same species can be combined to meet the size threshold)* *You do not have to name the species.* *Do not include Eurasian Milfoil, reed canarygrass, purple loosestrife, Canadian Thistle* If you counted: > 19 species — points = 2 5 - 19 species — points = 1 < 5 species — points = 0 *List species below if you want to:*	1

Total for page _____

Wetland name or number E

H 1.4. Interspersion of habitats *(see p. 76)* Decide from the diagrams below whether interspersion between Cowardin vegetation classes (described in H 1.1), or the classes and unvegetated areas (can include open water or mudflats) is high, medium, low, or none.  None = 0 points — Low = 1 point — Moderate = 2 points High = 3 points — [riparian braided channels] NOTE: If you have four or more classes or three vegetation classes and open water the rating is always "high". **Use map of Cowardin vegetation classes**	Figure ___ 3
H 1.5. Special Habitat Features: *(see p. 77)* *Check the habitat features that are present in the wetland. The number of checks is the number of points you put into the next column.* ___Large, downed, woody debris within the wetland (>4in. diameter and 6 ft long). ___Standing snags (diameter at the bottom > 4 inches) in the wetland ___Undercut banks are present for at least 6.6 ft (2m) and/or overhanging vegetation extends at least 3.3 ft (1m) over a stream (or ditch) in, or contiguous with the unit, for at least 33 ft (10m) ___Stable steep banks of fine material that might be used by beaver or muskrat for denning (>30degree slope) OR signs of recent beaver activity are present *(cut shrubs or trees that have not yet turned grey/brown)* X At least ¼ acre of thin-stemmed persistent vegetation or woody branches are present in areas that are permanently or seasonally inundated. *(structures for egg-laying by amphibians)* ___ Invasive plants cover less than 25% of the wetland area in each stratum of plants *NOTE: The 20% stated in early printings of the manual on page 78 is an error.*	1
H 1. TOTAL Score - potential for providing habitat *Add the scores from H1.1, H1.2, H1.3, H1.4, H1.5*	12

Comments

Wetland name or number E

H 2. Does the wetland unit have the opportunity to provide habitat for many species?	
H 2.1 Buffers *(see p. 80)* *Choose the description that best represents condition of buffer of wetland unit. The highest scoring criterion that applies to the wetland is to be used in the rating. See text for definition of "undisturbed."* — 100 m (330ft) of relatively undisturbed vegetated areas, rocky areas, or open water >95% of circumference. No structures are within the undisturbed part of buffer. (relatively undisturbed also means no-grazing, no landscaping, no daily human use) **Points = 5** — 100 m (330 ft) of relatively undisturbed vegetated areas, rocky areas, or open water > 50% circumference. **Points = 4** — 50 m (170ft) of relatively undisturbed vegetated areas, rocky areas, or open water >95% circumference. **Points = 4** — 100 m (330ft) of relatively undisturbed vegetated areas, rocky areas, or open water > 25% circumference, **Points = 3** — 50 m (170ft) of relatively undisturbed vegetated areas, rocky areas, or open water for > 50% circumference. **Points = 3** **If buffer does not meet any of the criteria above** — No paved areas (except paved trails) or buildings within 25 m (80ft) of wetland > 95% circumference. Light to moderate grazing, or lawns are OK. **Points = 2** — No paved areas or buildings within 50m of wetland for >50% circumference. Light to moderate grazing, or lawns are OK. **Points = 2** — Heavy grazing in buffer. **Points = 1** — Vegetated buffers are <2m wide (6.6ft) for more than 95% of the circumference (e.g. tilled fields, paving, basalt bedrock extend to edge of wetland **Points = 0.** — Buffer does not meet any of the criteria above. **Points = 1** Aerial photo showing buffers	Figure ___ 4
H 2.2 Corridors and Connections *(see p. 81)* H 2.2.1 Is the wetland part of a relatively undisturbed and unbroken vegetated corridor (either riparian or upland) that is at least 150 ft wide, has at least 30% cover of shrubs, forest or native undisturbed prairie, that connects to estuaries, other wetlands or undisturbed uplands that are at least 250 acres in size? (*dams in riparian corridors, heavily used gravel roads, paved roads, are considered breaks in the corridor*). YES = **4 points** (*go to H 2.3*) NO = go to H 2.2.2 H 2.2.2 Is the wetland part of a relatively undisturbed and unbroken vegetated corridor (either riparian or upland) that is at least 50ft wide, has at least 30% cover of shrubs or forest, and connects to estuaries, other wetlands or undisturbed uplands that are at least 25 acres in size? **OR** a **Lake-fringe** wetland, if it does not have an undisturbed corridor as in the question above? YES = **2 points** (*go to H 2.3*) NO = H 2.2.3 H 2.2.3 Is the wetland: within 5 mi (8km) of a brackish or salt water estuary OR within 3 mi of a large field or pasture (>40 acres) OR within 1 mi of a lake greater than 20 acres? YES = **1 point** NO = **0 points**	4

Total for page_____

Wetland name or number E

| H 2.3 Near or adjacent to other priority habitats listed by WDFW *(see new and complete descriptions of WDFW priority habitats, and the counties in which they can be found, in the PHS report http://wdfw.wa.gov/hab/phslist.htm)*
Which of the following priority habitats are within 330ft (100m) of the wetland unit? *NOTE: the connections do not have to be relatively undisturbed.*
___ **Aspen Stands:** Pure or mixed stands of aspen greater than 0.4 ha (1 acre).
X **Biodiversity Areas and Corridors**: Areas of habitat that are relatively important to various species of native fish and wildlife (*full descriptions in WDFW PHS report p. 152*).
___ **Herbaceous Balds:** Variable size patches of grass and forbs on shallow soils over bedrock.
___ **Old-growth/Mature forests:** (Old-growth west of Cascade crest) Stands of at least 2 tree species, forming a multi-layered canopy with occasional small openings; with at least 20 trees/ha (8 trees/acre) > 81 cm (32 in) dbh or > 200 years of age. (Mature forests) Stands with average diameters exceeding 53 cm (21 in) dbh; crown cover may be less that 100%; crown cover may be less that 100%; decay, decadence, numbers of snags, and quantity of large downed material is generally less than that found in old-growth; 80 - 200 years old west of the Cascade crest.
___ **Oregon white Oak:** Woodlands Stands of pure oak or oak/conifer associations where canopy coverage of the oak component is important (*full descriptions in WDFW PHS report p. 158*).
___ **Riparian**: The area adjacent to aquatic systems with flowing water that contains elements of both aquatic and terrestrial ecosystems which mutually influence each other.
___ **Westside Prairies:** Herbaceous, non-forested plant communities that can either take the form of a dry prairie or a wet prairie (*full descriptions in WDFW PHS report p. 161*).
___ **Instream:** The combination of physical, biological, and chemical processes and conditions that interact to provide functional life history requirements for instream fish and wildlife resources.
___ **Nearshore**: Relatively undisturbed nearshore habitats. These include Coastal Nearshore, Open Coast Nearshore, and Puget Sound Nearshore. (*full descriptions of habitats and the definition of relatively undisturbed are in WDFW report: pp. 167-169 and glossary in Appendix A).*
___ **Caves:** A naturally occurring cavity, recess, void, or system of interconnected passages under the earth in soils, rock, ice, or other geological formations and is large enough to contain a human.
___ **Cliffs:** Greater than 7.6 m (25 ft) high and occurring below 5000 ft.
___ **Talus:** Homogenous areas of rock rubble ranging in average size 0.15 - 2.0 m (0.5 - 6.5 ft), composed of basalt, andesite, and/or sedimentary rock, including riprap slides and mine tailings. May be associated with cliffs.
___ **Snags and Logs:** Trees are considered snags if they are dead or dying and exhibit sufficient decay characteristics to enable cavity excavation/use by wildlife. Priority snags have a diameter at breast height of > 51 cm (20 in) in western Washington and are > 2 m (6.5 ft) in height. Priority logs are > 30 cm (12 in) in diameter at the largest end, and > 6 m (20 ft) long.
If wetland has **3 or more** priority habitats = **4 points**
If wetland has **2** priority habitats = **3 points**
If wetland has 1 priority habitat = **1 point** No habitats = 0 points
Note: All vegetated wetlands are by definition a priority habitat but are not included in this list. Nearby wetlands are addressed in question H 2.4) | 1 |

Wetland name or number E

H 2.4 Wetland Landscape *(choose the **one** description of the landscape around the wetland that best fits)* ***(see p. 84)*** There are at least 3 other wetlands within ½ mile, and the connections between them are relatively undisturbed (light grazing between wetlands OK, as is lake shore with some boating, but connections should NOT be bisected by paved roads, fill, fields, or other development. points = 5 The wetland is Lake-fringe on a lake with little disturbance and there are 3 other lake-fringe wetlands within ½ mile points = 5 There are at least 3 other wetlands within ½ mile, BUT the connections between them are disturbed points = 3 The wetland is Lake-fringe on a lake with disturbance and there are 3 other lake-fringe wetland within ½ mile points = 3 There is at least 1 wetland within ½ mile. points = 2 There are no wetlands within ½ mile. points = 0	5
H 2. TOTAL Score - opportunity for providing habitat *Add the scores from H2.1,H2.2, H2.3, H2.4*	14
TOTAL for H 1 from page 14	12
Total Score for Habitat Functions – add the points for H 1, H 2 and record the result on p. 1	26

Wetland name or number E

CATEGORIZATION BASED ON SPECIAL CHARACTERISTICS

Please determine if the wetland meets the attributes described below and circle the appropriate answers and Category.

Wetland Type *Check off any criteria that apply to the wetland. Circle the Category when the appropriate criteria are met.*	**Category**
SC 1.0 Estuarine wetlands ***(see p. 86)*** Does the wetland unit meet the following criteria for Estuarine wetlands? — The dominant water regime is tidal, — Vegetated, and — With a salinity greater than 0.5 ppt. YES = Go to SC 1.1 NO ___	
SC 1.1 Is the wetland unit within a National Wildlife Refuge, National Park, National Estuary Reserve, Natural Area Preserve, State Park or Educational, Environmental, or Scientific Reserve designated under WAC 332-30-151? YES = Category I NO go to SC 1.2	**Cat. I**
SC 1.2 Is the wetland unit at least 1 acre in size and meets at least two of the following three conditions? YES = Category I NO = Category II — The wetland is relatively undisturbed (has no diking, ditching, filling, cultivation, grazing, and has less than 10% cover of non-native plant species. If the non-native *Spartina* spp. are the only species that cover more than 10% of the wetland, then the wetland should be given a dual rating (I/II). The area of Spartina would be rated a Category II while the relatively undisturbed upper marsh with native species would be a Category I. Do not, however, exclude the area of Spartina in determining the size threshold of 1 acre. — At least ¾ of the landward edge of the wetland has a 100 ft buffer of shrub, forest, or un-grazed or un-mowed grassland. — The wetland has at least 2 of the following features: tidal channels, depressions with open water, or contiguous freshwater wetlands.	**Cat. I** **Cat. II** **Dual rating I/II**

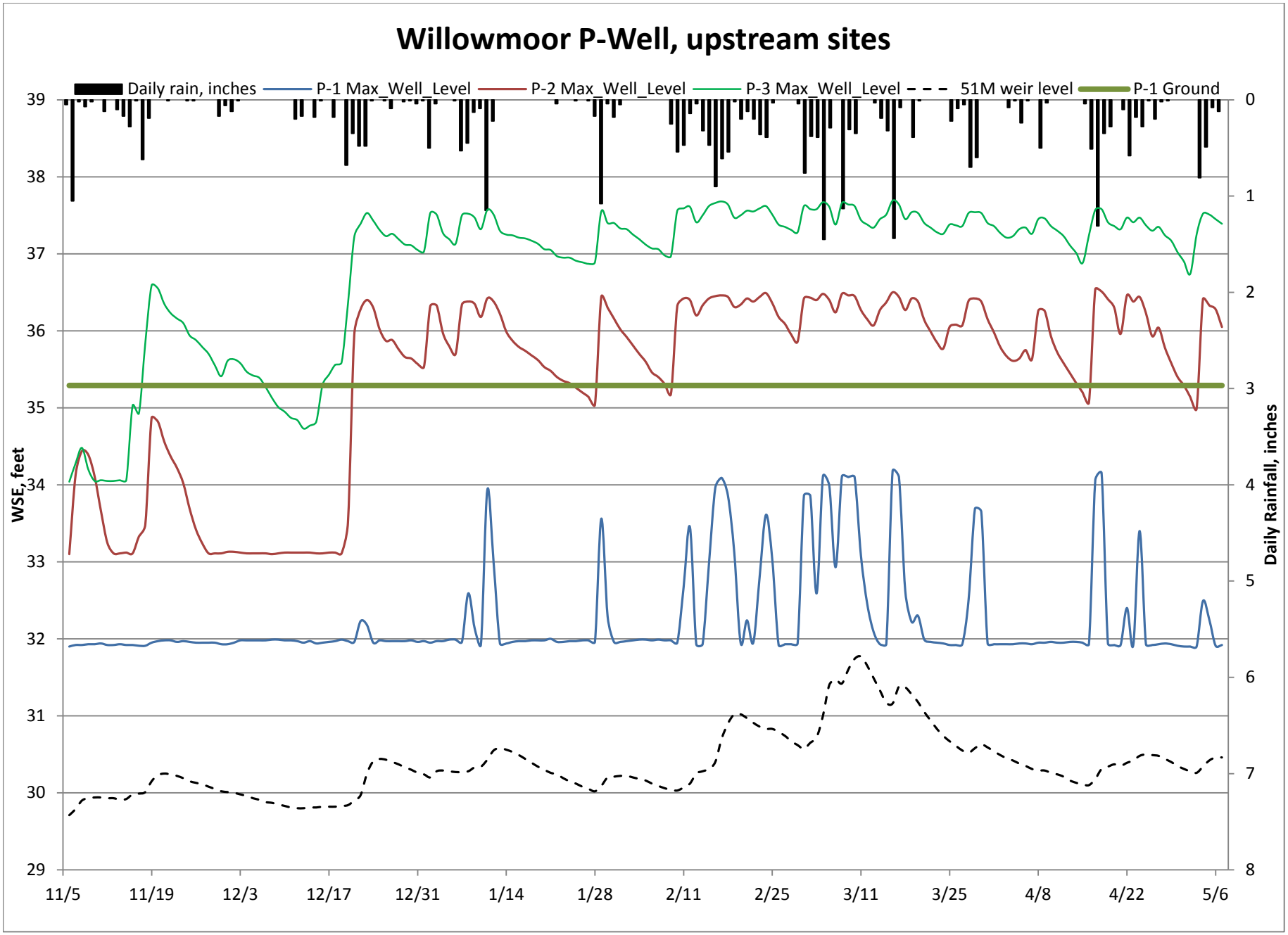
SC 2.0 Natural Heritage Wetlands *(see p. 87)* Natural Heritage wetlands have been identified by the Washington Natural Heritage Program/DNR as either high quality undisturbed wetlands or wetlands that support state Threatened, Endangered, or Sensitive plant species. SC 2.1 Is the wetland unit being rated in a Section/Township/Range that contains a Natural Heritage wetland? *(this question is used to screen out most sites before you need to contact WNHP/DNR)* S/T/R information from Appendix D ___ or accessed from WNHP/DNR web site X YES____ – contact WNHP/DNR (see p. 79) and go to SC 2.2 NO X SC 2.2 Has DNR identified the wetland as a high quality undisturbed wetland or as or as a site with state threatened or endangered plant species? YES = Category I NO ___not a Heritage Wetland	Cat. I
SC 3.0 Bogs *(see p. 87)* Does the wetland unit **(or any part of the unit)** meet both the criteria for soils and vegetation in bogs? *Use the key below to identify if the wetland is a bog.* ***If you answer yes you will still need to rate the wetland based on its functions.*** 1. Does the unit have organic soil horizons (i.e. layers of organic soil), either peats or mucks, that compose 16 inches or more of the first 32 inches of the soil profile? (See Appendix B for a field key to identify organic soils)? Yes - go to Q. 3 No - go to Q. 2 2. Does the unit have organic soils, either peats or mucks that are less than 16 inches deep over bedrock, or an impermeable hardpan such as clay or volcanic ash, or that are floating on a lake or pond? Yes - go to Q. 3 No - Is not a bog for purpose of rating 3. Does the unit have more than 70% cover of mosses at ground level, AND other plants, if present, consist of the "bog" species listed in Table 3 as a significant component of the vegetation (more than 30% of the total shrub and herbaceous cover consists of species in Table 3)? Yes – Is a bog for purpose of rating No - go to Q. 4 NOTE: If you are uncertain about the extent of mosses in the understory you may substitute that criterion by measuring the pH of the water that seeps into a hole dug at least 16" deep. If the pH is less than 5.0 and the "bog" plant species in Table 3 are present, the wetland is a bog. 1. Is the unit forested (> 30% cover) with sitka spruce, subalpine fir, western red cedar, western hemlock, lodgepole pine, quaking aspen, Englemann's spruce, or western white pine, WITH any of the species (or combination of species) on the bog species plant list in Table 3 as a significant component of the ground cover *(> 30% coverage of the total shrub/herbaceous cover)?* 2. YES = Category I No___ Is not a bog for purpose of rating	Cat. I

SC 4.0 Forested Wetlands *(see p. 90)* Does the wetland unit have at least 1 acre of forest that meet one of these criteria for the Department of Fish and Wildlife's forests as priority habitats? *If you answer yes you will still need to rate the wetland based on its functions.* — **Old-growth forests**: (west of Cascade crest) Stands of at least two tree species, forming a multi-layered canopy with occasional small openings; with at least 8 trees/acre (20 trees/hectare) that are at least 200 years of age OR have a diameter at breast height (dbh) of 32 inches (81 cm) or more. NOTE: The criterion for dbh is based on measurements for upland forests. Two-hundred year old trees in wetlands will often have a smaller dbh because their growth rates are often slower. The DFW criterion is and "OR" so old-growth forests do not necessarily have to have trees of this diameter. — **Mature forests**: (west of the Cascade Crest) Stands where the largest trees are 80 – 200 years old OR have average diameters (dbh) exceeding 21 inches (53cm); crown cover may be less that 100%; decay, decadence, numbers of snags, and quantity of large downed material is generally less than that found in old-growth. YES = Category I NO ___not a forested wetland with special characteristics	Cat. I
SC 5.0 Wetlands in Coastal Lagoons *(see p. 91)* Does the wetland meet all of the following criteria of a wetland in a coastal lagoon? — The wetland lies in a depression adjacent to marine waters that is wholly or partially separated from marine waters by sandbanks, gravel banks, shingle, or, less frequently, rocks — The lagoon in which the wetland is located contains surface water that is saline or brackish (> 0.5 ppt) during most of the year in at least a portion of the lagoon *(needs to be measured near the bottom)* YES = Go to SC 5.1 NO___ not a wetland in a coastal lagoon SC 5.1 Does the wetland meets all of the following three conditions? — The wetland is relatively undisturbed (has no diking, ditching, filling, cultivation, grazing), and has less than 20% cover of invasive plant species (see list of invasive species on p. 74). — At least ¾ of the landward edge of the wetland has a 100 ft buffer of shrub, forest, or un-grazed or un-mowed grassland. — The wetland is larger than 1/10 acre (4350 square feet) YES = Category I NO = Category II	Cat. I Cat. II

Wetland name or number _____

SC 6.0 Interdunal Wetlands *(see p. 93)* Is the wetland unit west of the 1889 line (also called the Western Boundary of Upland Ownership or WBUO)? YES - go to SC 6.1 NO __ not an interdunal wetland for rating ***If you answer yes you will still need to rate the wetland based on its functions.*** In practical terms that means the following geographic areas: • Long Beach Peninsula- lands west of SR 103 • Grayland-Westport- lands west of SR 105 • Ocean Shores-Copalis- lands west of SR 115 and SR 109 SC 6.1 Is the wetland one acre or larger, or is it in a mosaic of wetlands that is once acre or larger? YES – Category II NO – go to SC 6.2 SC 6.2 Is the unit between 0.1 and 1 acre, or is it in a mosaic of wetlands that is between 0.1 and 1 acre? YES = Category III	**Cat. II** **Cat. III**
Category of wetland based on Special Characteristics *Choose the "highest" rating if wetland falls into several categories, and record on p. 1.* If you answered NO for all types enter "Not Applicable" on p.1	

Appendix D: Piezometer Data


Willowmoor P-Well, upstream sites
Daily rain, inches
P-1 Max_Well_Level
P-2 Max_Well_Level
P-3 Max_Well_Level
51M weir level
P-1 Ground
WSE, feet
Daily Rainfall, inches
39
38
37
36
35
34
33
32
31
30
29
0
1
2
3
4
5
6
7
8
11/5
11/19
12/3
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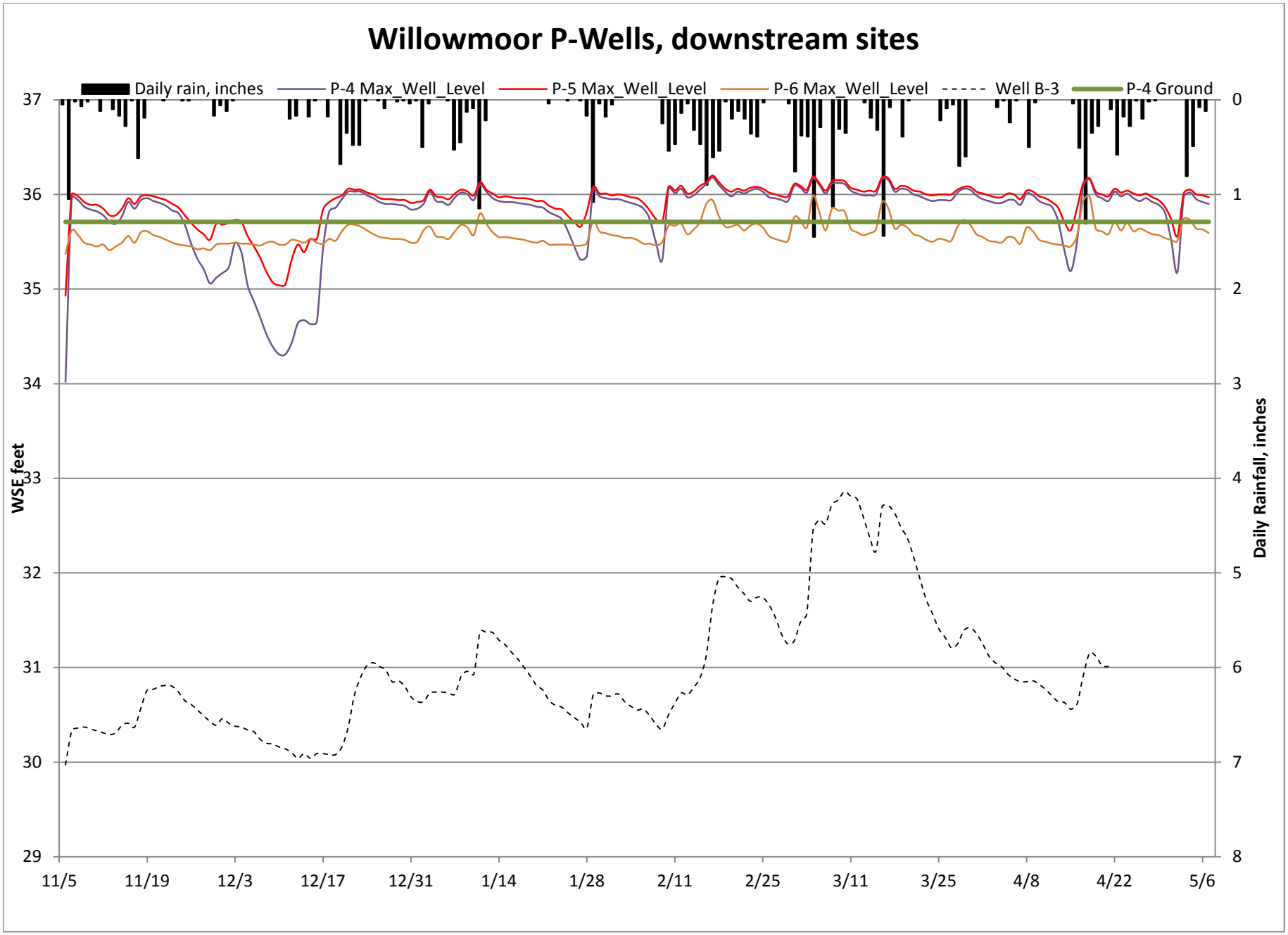
1/14
1/28
2/11
2/25
3/11
3/25
4/8
4/22
5/6


Willowmoor P-Wells, downstream sites
Daily rain, inches
P-4 Max_Well_Level
P-5 Max_Well_Level
P-6 Max_Well_Level
Well B-3
P-4 Ground
WSE feet
Daily Rainfall, inches
37
36
35
34
33
32
31
30
29
0
1
2
3
4
5
6
7
8
11/5
11/19
12/3
12/17
12/31
1/14
1/28
2/11
2/25
3/11
3/25
4/8
4/22
5/6

Appendix C – Hydraulic Modeling Technical Memo, King County 2014

King County

Memo

Date:	January 24, 2013
To:	Craig Garric, EIII, PM
Cc:	Willowmoor Team
From:	
Project No./Name:	1112037/WLFL5 WILLOWMOOR FLDPLAIN REST
Subject:	Willowmoor Hydraulics Memo

Introduction:

This technical memo covers the calibration of the hydraulic model used in the evaluation of the Willowmoor Project existing conditions and alternatives. Hydraulic modeling for the Willowmoor project utilized an existing HEC-RAS model for the Sammamish River as its starting point. In 2009 King County contracted with Northwest Hydraulics (NHC) to conduct a flood study for the Sammamish River (from Lake Sammamish to Lake Washington), and part of that effort was creating a calibrated HEC-RAS model for the river (NHC 2010). While only the river was calibrated, the model did include Lake Sammamish that was modeled as a storage area to function as the upstream boundary condition. This was done to address timing issues with respect to flood peaks, i.e. peak lake discharge is not coincident with peak tributary discharges on Bear/Evans, Little Bear, North and Swamp Creeks.

Additional data were available since completion of the flood study. These data include more recent survey data of the transition zone with additional cross-section locations added, and four pressure transducers deployed through the transition zone section of the Sammamish River down to the Bear/Evans Creek confluence with the main stem Sammamish River [see Figure 1]. The data from the pressure transducers were converted into time varying water depths with data collection starting in 2011. Survey of the transducer locations allowed the depths to be converted into elevations creating water surface profiles through the transition zone. These water surface profiles were used to calibrate the model to existing conditions.

Hydraulic Model Calibration:

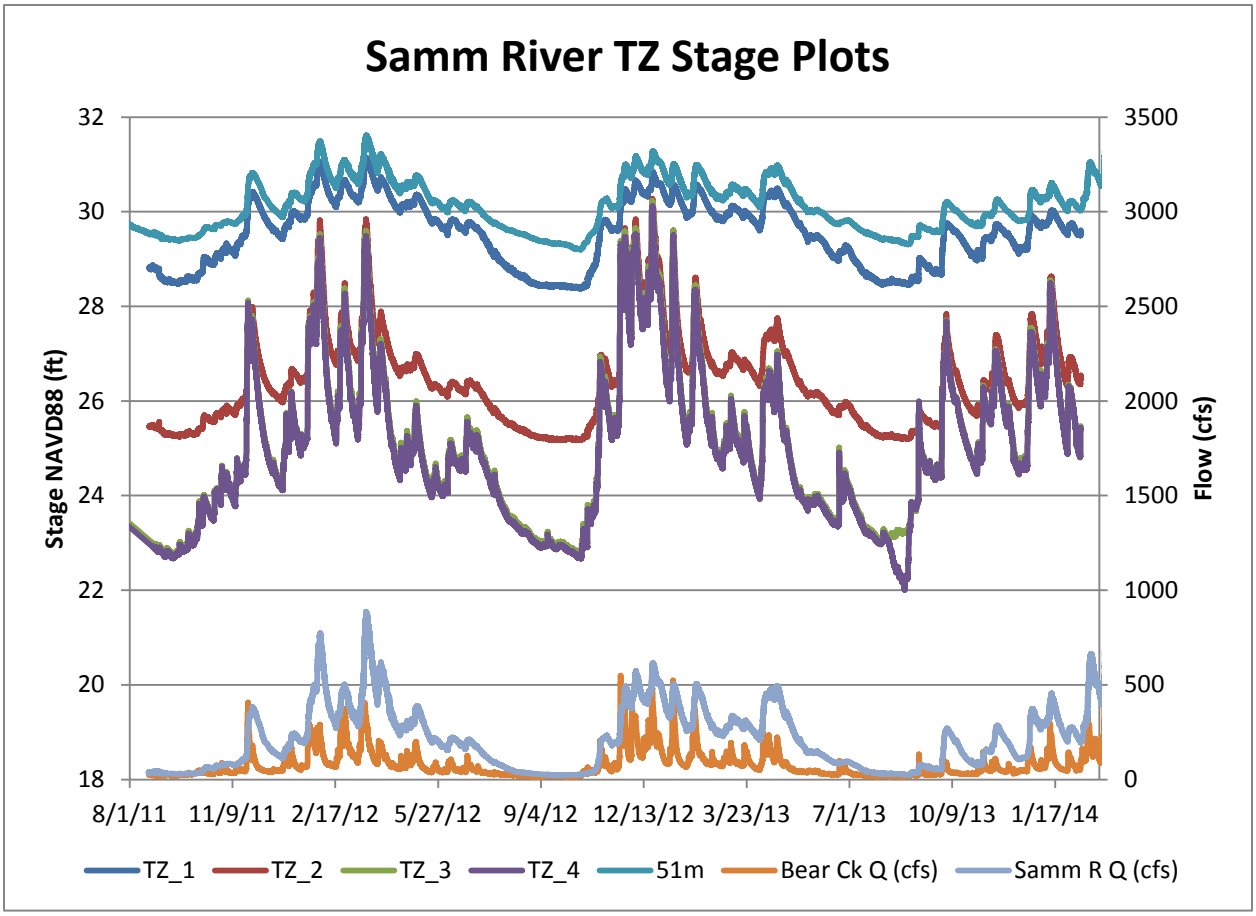
The most recent maintenance action prior to model development in the transition zone of the Sammamish River was conducted in the summer of 2013. The calibration period was set to be August 2013 through March 2014 to capture post maintenance conditions. This calibrated model also resulted in the “Existing Conditions” scenario used to evaluate alternatives against. The model was calibrated in an unsteady flow simulation, that is, flows into the lake and from Bear Creek varied through time. Simulated water levels at the lake, weir, and at the locations of the four pressure transducers were compared to the measured water levels, and model parameters were changed in order to better match the simulated values with the measured ones. The parameter with the most influence on simulated water surfaces is Manning’s n, a roughness coefficient representing the ease of which water can move over the riverbed. Rougher surfaces result in slower and deeper water than smoother surfaces. A further adjustment to Manning’s n was

the inclusion of seasonality – the time of the year with fully grown vegetation is specified to have a higher roughness than the time of year when most vegetation is dead or senescent.

Figure 1: Hydraulic Model Cross-Sections and Locations of Gages.

The data used in model calibration are shown in Figure 2. The top five lines track observed stage (NAVD88; left axis) over time from the Weir (gage 51m) through the four transition zone data loggers. The bottom two lines track flow (cfs, right axis) for the Sammamish River (also at 51m) and Bear Creek. Figure 2 shows the hydraulic behavior necessary to capture in the calibrated model. In periods of low flow, the stages at the locations of the pressure transducers (TZ_1 through TZ_4) are separated in elevation – with the exception of TZ_3 and TZ_4 both at the mouth of Bear Creek (note the spurious data from TZ_4 in Sept. 2013) – with substantial drop between locations. This reflects the change in bottom elevation of the channel through the transition zone. At higher flows the differences in stages among the locations of the transducers drops markedly. This is especially apparent when Bear Creek flows are large when the stages at TZ_2, TZ_3, and TZ_4 plot on top of each other. Towards the end of December 2012, after a period of high flows in Bear Creek and from the lake, the total drop in water surface from the weir to Bear Creek is approximately six inches. This reflects the backwater condition created by high Bear Creek flows. The unsteady model was set up to capture this range of stages.

Figure 2. Sammamish River Transition Zone Stage Plots.



Model output locations were set up at the same locations of observed stage. Manning's n values were adjusted to capture the physical condition of the transition zone after the summer maintenance actions in 2013.

Calibration runs covered time prior to the date of the most recent maintenance; although, the calibration was limited to the post maintenance condition. This was done for two reasons: to facilitate creation of the "Existing Conditions" scenario, and to inform creation of project alternatives. Once calibrated, differences between observed and modeled stages prior to the most recent maintenance action are largely due to the actual physical conditions of the transition zone not being accurately simulated in the model. This can be seen by comparing the calibrated stages (late summer 2013 on) to earlier stages for pressure transducer locations TZ_1, and TZ_2 in Figures 3 and 4. At the TZ_2 location midway down the transition zone, modeled stages are higher indicating more flow through maintained transition zone than actually occurred in the record. This is reflected in the peak lake level stages that occurred in the winter of 2012 [Figure 5].

Figure 3. Modeled and Observed Stage at TZ_1.

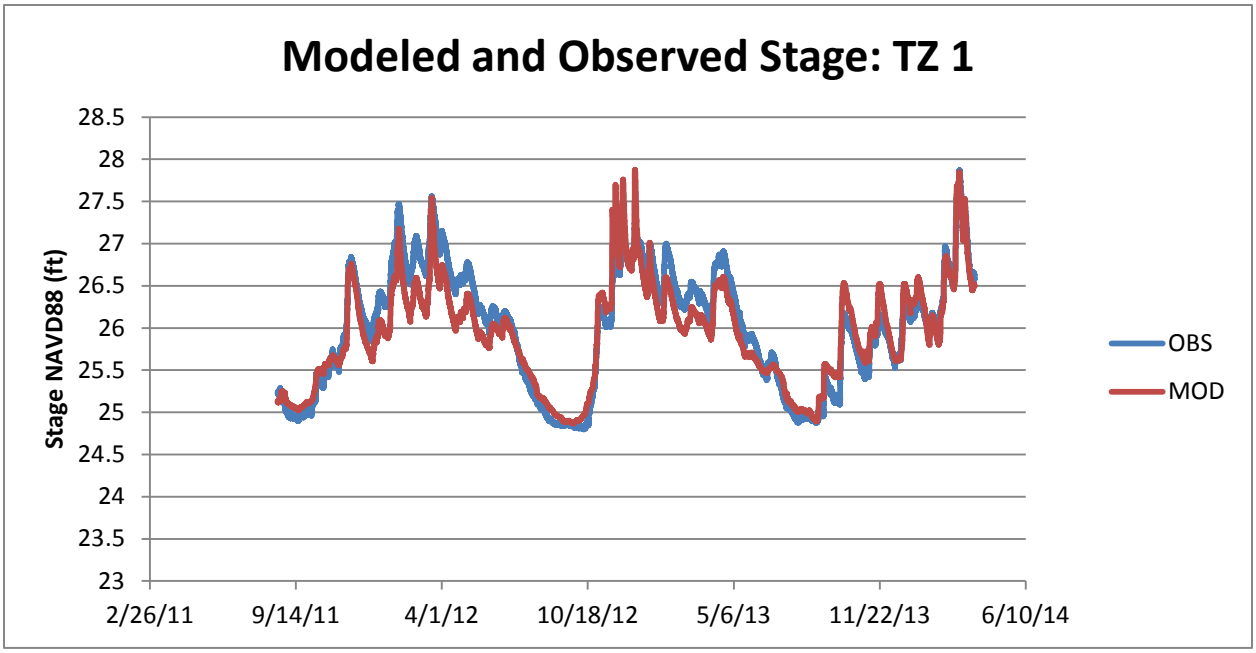
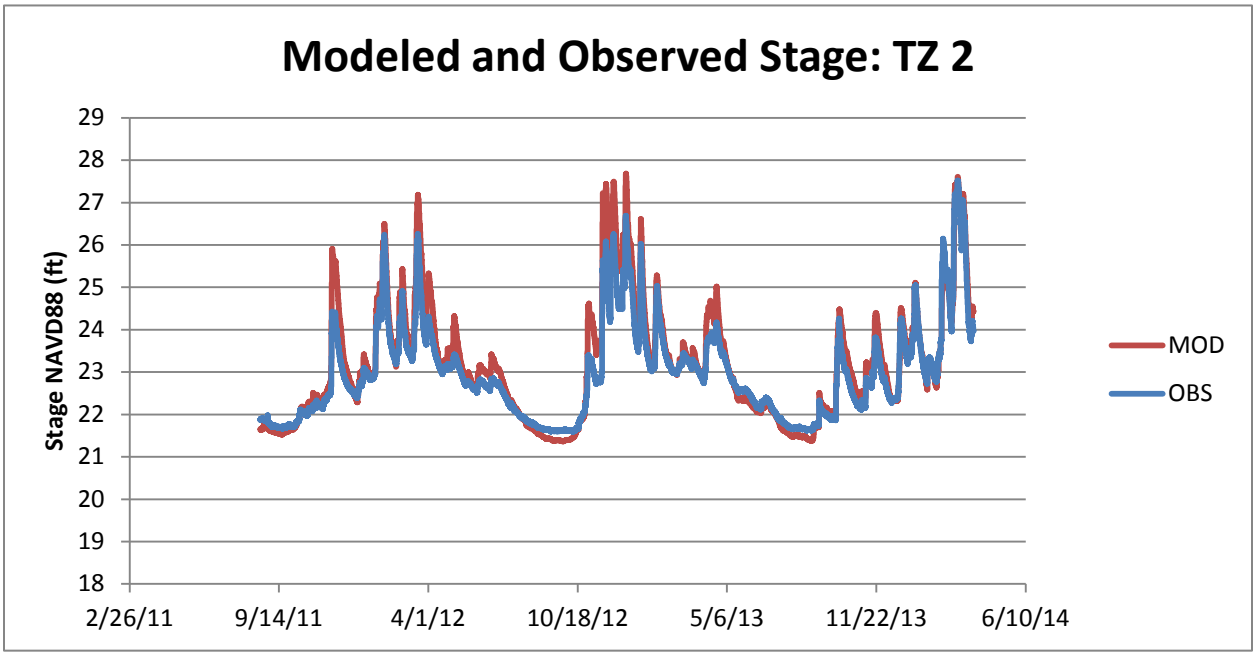


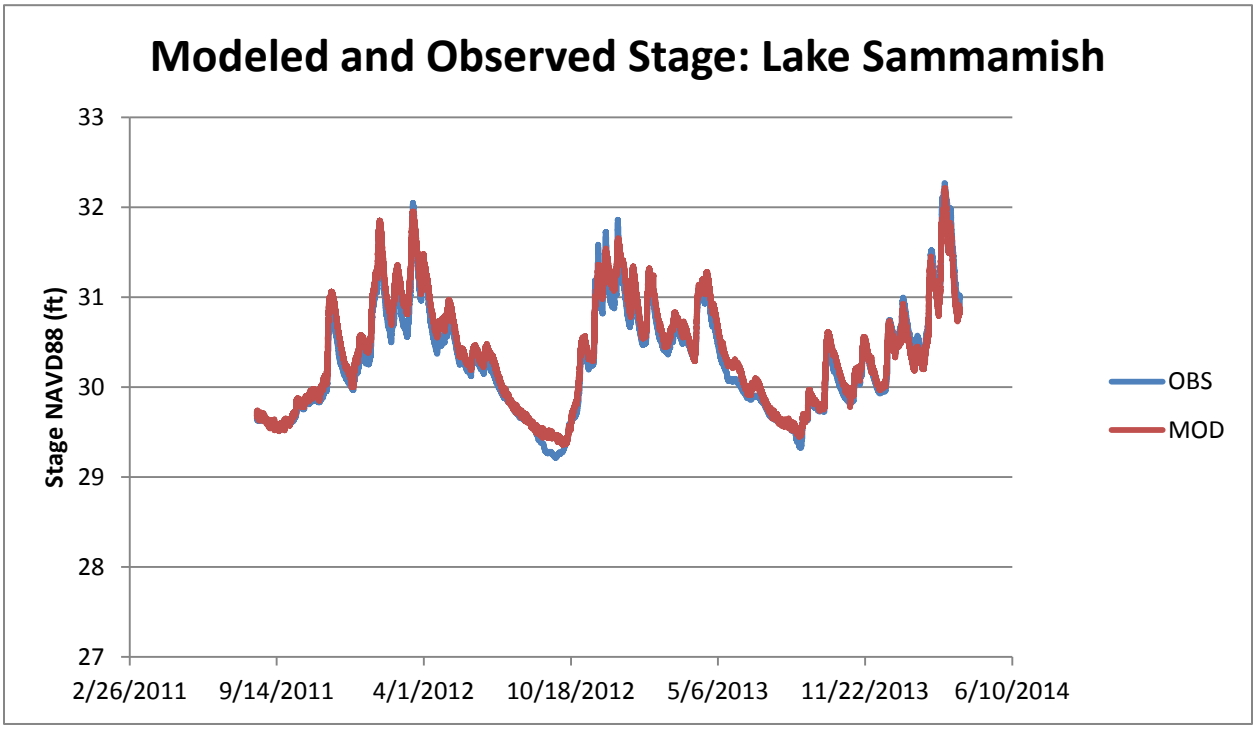
Figure 4. Modeled and Observed Stage at TZ_2.



Modeled stages were well within +/-12 inches of observed – considered the threshold for a good calibration [US Army Corps of Engineers, 2010] and were often within +/-6 inches of observed. These thresholds come from the inherent uncertainty in flow measurements and the stage-discharge relationship for a gage location. Once calibration is complete, the assessment of alternative performance is done relative to the calibrated model, which in this case

also serves as the no action (Maintenance) condition of the transition zone. At that point any difference in the hydraulic performance of the alternatives is due to the changes in model configuration for those alternatives.

Figure 5. Modeled and Observed Stage, Lake Sammamish.



Hydraulic Simulation of Alternatives:

Each alternative was designed to meet objectives under several goals, but only hydraulic objectives are discussed here. Alternatives were assessed using the calibrated model in two phases: the initial round of conceptual alternatives and a subsequent round of integrated alternatives incorporating feedback from the SAC. Each alternative was created by modifying the existing conditions model. This entailed changing the channel geometry, adding complexity in the form of lateral structures and split flow channels where appropriate. Lateral structures were used to simulate both hydraulic structures (the weir inlet to the proposed side channel in Concept 4) and to simulate areas where portions of the main flow would spread over the river bank into a separate channel (Concepts 3 and 2). Split flow channels were used in the side channel concept (4) and in Concepts 2 and 3 to capture overbank flows and backwater conditions. Manning's n values were also changed to reflect post construction conditions and roughness of the maintained channel in all alternatives.

Performance of Alternatives:

Alternatives were analyzed relative to the performance criteria established under Goal #1 in the Goals and Objectives Table over the time period of available measured data at both Bear Creek and the Weir (2001-2014). It is important to note that the Existing Conditions run (Alternative 1. Maintenance) is not the same as historic conditions but rather

simulates how a fully maintained transition zone would have performed. For specific metrics, see the table of goals, objectives, and metrics in the main report. What follows here is a summary of each alternative's hydraulic performance.

Alternative 1, Maintenance: This alternative meets all the downstream hydraulic criteria, but does not reduce lake levels upstream of the project, nor does it reduce the frequency and duration of high winter and spring lake levels relative to current conditions (i.e. itself). This alternative, like all others, does demonstrate improvement over historic conditions [see Figures 3-5].

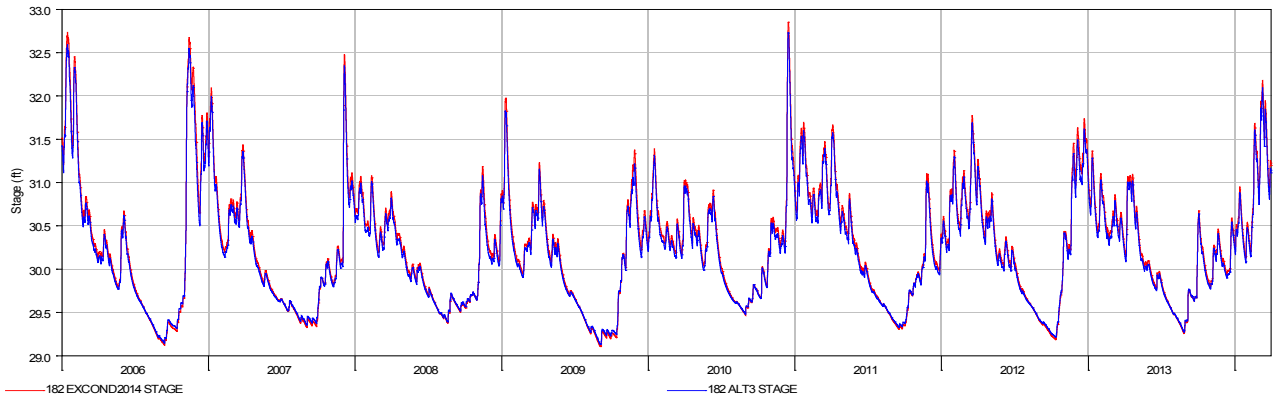
Concept Alternative 2, Single Meander: The model was changed to reflect the longer winding path of the main stem channel through the meander. Cross sections through the meander were developed such that lower flows are completely contained in the main channel. Higher flows were simulated as overbank flows through the use of a lateral structure on the right bank. Overbank flows are collected in a separate channel, which joins the main channel at the end of the meander. At low flows the separate channel functions as a backwater pool. This alternative meets all upstream and downstream hydraulic criteria. While meeting the criteria, the magnitudes of improvement were modest. See Figure 6 for a comparison of Lake Levels between Alternative 2 and Existing Conditions.

Figure 6. Existing Conditions (red) vs. Alternative 2 (blue).

Concept Alternative 3, Hyporheic Channels: The model was changed to reflect the longer winding path of the main stem channel through the meander as in Concept Alternative 2. The wetland complex was simulated as a storage area allowing water levels to fluctuate more like a pond, which was the expectation for the multiple low gradient back channels. The connection from the main channel to the wetland complex was simulated using a lateral structure to functionally simulate the porous gravel weir. Overbank flows on the left bank are collected in the storage area. In order to simulate the porous nature of the gravel weir, eight small pipes were included in the weir at elevations well below the weir invert. These allowed a constant background flow to pass through the weir year round. The HEC-RAS modeling software doesn't not allow for explicitly "leaky" structures, which is why this approach was taken.

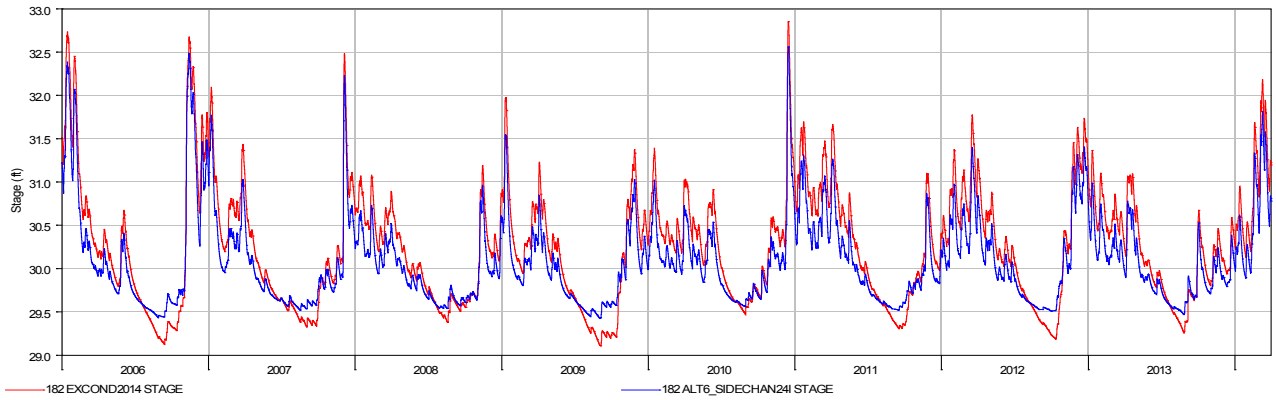
This alternative meets all upstream and downstream hydraulic criteria. This alternative showed greater improvements upstream due to the increased capacity to pass higher flows through the transition zone. Lower lake levels were very similar to Existing Conditions. See Figure 7 for a comparison of Lake Levels between Concept Alternative 3 and Existing Conditions.

Figure 7. Existing Conditions (red) vs. Alternative 3 (blue).



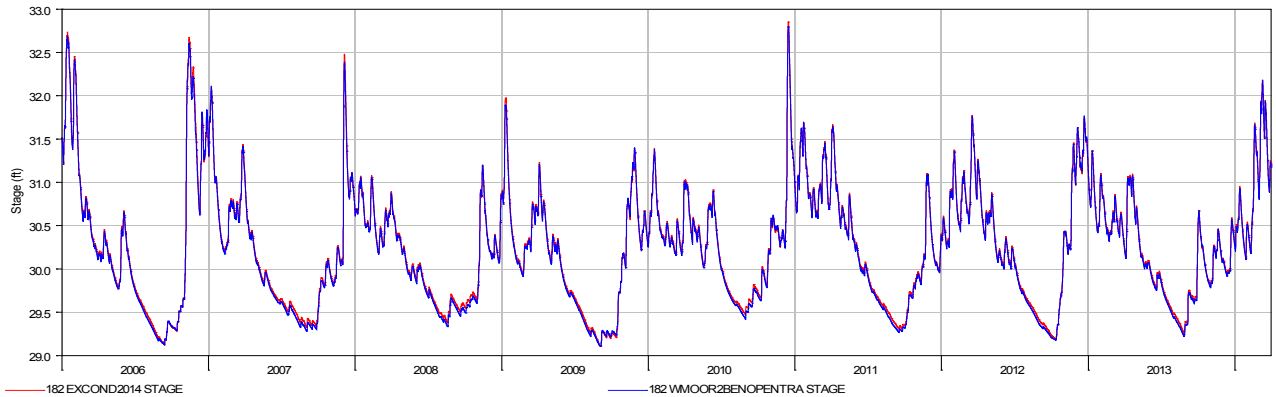
Concept Alternative 4, Split Channel: The model was changed by adding a small channel on the west side of the main channel. This split flow channel begins upstream of the weir and enters the main stem channel at the bottom of the transition zone. Immediately downstream of the entrance to the side channel is a weir with crest and invert elevations set to maintain a year round flow. This alternative meets all upstream and downstream hydraulic criteria save for minimum summer flows; although, further refinements to the side channel weir are likely to result in meeting this criterion should it become the preferred alternative. This alternative showed the greatest improvements upstream due to the side channel maintaining a flow year round lowering the initial lake level during flood events. See Figure 8 for a comparison of Lake Levels between Concept Alternative 4 and Existing Conditions.

Figure 8. Existing Conditions (red) vs. Alternative 4 (blue).



Concept Alternative 5, Enhanced Existing Channel: The model was changed through the transition zone only. A prismatic channel was specified with outer side slopes set to act as benches with shallow inundation at times of the year important for fish habitat. Roughness due to the presence of willows was removed. This alternative meets all upstream hydraulic criteria except for reducing average base winter lake level, which remains the same. This alternative meets all downstream hydraulic criteria. While meeting the criteria except the one, the magnitudes of improvements were modest. See Figure 9 for a comparison of Lake Levels between Concept Alternative 5 and Existing Conditions.

Figure 9. Existing Conditions (red) vs. Alternative 5 (blue).



Summary and Discussion of Alternatives:

While only the differences in lake level are shown in Figures 6-9, figures would be similar for flows, depths over and through the weir, depths in riffles and pools, etc. Other metrics, such as maintaining downstream Sammamish River flood levels at or below the current 100-year flood level, are pass/fail criteria already summarized in the main body of this report. Quantitative results were tabulated for the second round of alternatives presented to the SAC; that is, Alternatives 4 and 5 along with Existing Conditions. What follows here are quantitative results for the following objectives: 1) reduce average number of days per year of lake level exceedances (for EL 27, 28, and 29 NGVD29); 2) reduce average base winter lake level; and, 3) minimum summer lake levels. As in the discussion above, the period of record used to calculate performance criteria is the period of observed data for both Bear Creek and the Sammamish River (2001-2013). Table 1 summarizes the average number of days of lake level exceedance for Existing Conditions.

Table 1. Average Number of Days per Year of Lake Level Exceedance.

	Average Annual Days of Exceedance		
Lake Level (NGVD29)	Existing Conditions	Alternative 4	Alternative 5
29	1	0	1
28	12	6	11
27	97	47	94

Alternative 4 shows the greatest improvement across all lake levels while Alternative 5 shows improvement only for lake levels of 28 and 29 feet NGVD29. This is intuitive, as Alternative 5 represents the least amount of change to the transition zone over existing conditions. It should be noted that the Existing Conditions is an improvement over historic conditions (observed data) from 2001-2013.

Average winter lake levels for Existing Conditions, Alternative 4, and Alternative 5 are 30.7, 30.4, and 30.7 feet (NGVD29) respectively. Alternative 4 shows improvement while Alternative 5 does not. Again, it bears mentioning that Existing Conditions is an improvement over historic conditions for this objective.

With respect to maintaining minimum summer lake levels of 25.4 feet (NGVD29), the results for Existing Conditions, Alternative 4, and Alternative 5 are 25.4, 25.8, and 25.4 feet (NGVD) respectively. The magnitude of changes follows the pattern seen in other objectives for the alternatives considered.

Hydraulically, the two objectives carried forward through the SAC process meet - or in the case of minimum summer discharges for Alternative 4 are expected to meet with further refinements - the hydraulic criteria established for the Willowmoor Project. The magnitude of improvements for each Alternative reflects amount of proposed changes to the transition zone. The more extensive changes associated with have larger effects on performance criteria than the more limited changes to the transition zone proposed in Alternative 5.

References:

Northwest Hydraulic Consultants, (2010) Floodplain Mapping Study for the Sammamish River. Prepared for King County.

US Army Corps of Engineers (2010) HEC-RAS River Analysis System User's Manual, Davis CA.

Appendix D – Willowmoor Phase II Hydrology Report, NHC 2014

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nhc
northwest hydraulic consultants

17 December 2014

To: **Craig Garric**
King County River and Floodplain Management Section

cc: **John Engel, Kate Akyuz**
King County River and Floodplain Management Section

From: **Patty Dillon. P.E.**

Re: **Willowmoor Hydrology**
Model Calibration and Future Hydrology

King County's (County's) Willowmoor Floodplain Restoration Project (Project) is a multi-objective flood control and habitat restoration project for the Sammamish River Transition Zone (TZ), which extends from the Lake Sammamish outlet weir approximately 1,400 feet downstream through Marymoor Park. In previous work in support of this project, documented in the Phase 1 report (NHC, 2013), NHC characterized the existing hydrologic setting for the Project and provided recommendations for developing design hydrologic conditions for performance assessment of various Project alternatives. This memorandum addresses two of the recommendations presented in the Phase 1 report: 1) updates to existing hydrologic models and 2) development of future conditions scenarios.

1 HYDROLOGIC MODEL UPDATES

NHC reviewed and recalibrated the Issaquah Creek and Bear and Evans Creek HSPF models originally developed by the County as part of its Sammamish-Washington Analysis and Modeling Program (SWAMP) assessment. The calibration effort included review of precipitation data and multipliers and adjustment of HSPF land surface response parameters to better match observed data. Following a preliminary review of available land cover data, it was determined that the effort required to update land use for the Sammamish River basin models was beyond the scope of this project.

1.1 Bear Creek

The previous versions of the Bear and Evans Creek models consistently under-simulated peak flows and volumes at the mouth of Bear Creek (King County 02A). NHC first inspected the input precipitation datasets by comparing cumulative precipitation plots at nearby gages. In this type of comparison, we expect to see shifts in the relationships of the curves due to differences in spatial distribution of rainfall during storm events. However, significant shifts in the relative positions of the curves and especially long flat (dry) periods at one station where others see rainfall can indicate problems with the data. Previously unidentified gaps were discovered in records for King County precipitation stations 02v, 18u, and 18v (all located in the Redmond Ridge area). A six-month gap in the 02v record (March-September

2013) was filled using the 18v2 record. There were also multiple gaps in the 18v record between 2006 and 2010, so this period was replaced with hourly totals from the Trilogy_met record disaggregated to 15-minute totals based on the distribution from 02v. In response to these data issues, the 18u, 18v, and 18v2 gages were consolidated into a single record; only 18v2 is currently active. Improvements to the precipitation inputs substantially improved simulation accuracy relative to observed flows.

The Bear and Evans Creek models have a total of eight precipitation zones that use different rain gages and/or precipitation multipliers (Figure 1). NHC reviewed rainfall multipliers based on mean annual precipitation (from PRISM mapping) at gage locations and over model subbasins. A slightly reduced multiplier was applied to the lower west-central portion of the Evans Creek basin (MetZone E2).

The Bear and Evans Creek models were calibrated in concert to come up with a single set of runoff parameters that adequately simulated flows at both the Bear Creek (02A) and Evans Creek (King County 18A) gages. For Evans Creek, the calibration emphasis was primarily on runoff volumes, compared to volume and storm simulation for Bear Creek. NHC first reverted to generalized regional parameters adapted from work by the USGS (Dinicola, 1990), then subsequently adjusted key pervious surface runoff parameters to better match the overall hydrograph and improve simulation of large storm events. For Evans and Bear creeks, NHC primarily adjusted groundwater and interflow parameters to improve simulation of seasonal runoff volumes and hydrograph recessions. Table 1 and Table 2 summarize monthly runoff characteristics for Bear Creek and Evans Creek, respectively, for water years 2002-2013; depending on the date range selected for analysis, model performance will appear slightly better or worse, within a few percent.

Table 1 - Simulated vs. observed monthly flows for Bear Creek (KC 02A, WY 2002-2013)

Period	Mean Flow (cfs)		
	02A	HSPF	% Diff
October	41.0	34.5	-19%
November	111	95	-17%
December	142	135	-5%
January	154	150	-3%
February	107	118	+10%
March	109	119	+8%
April	91	100	+10%
May	55.6	61.7	+10%
June	45.4	46.6	+3%
July	24.0	26.1	+8%
August	19.5	19.8	+2%
September	24.6	21.0	-17%
Annual	77.5	78.0	+1%

Simulated flows corresponding to gaps in observed record eliminated from calculations.

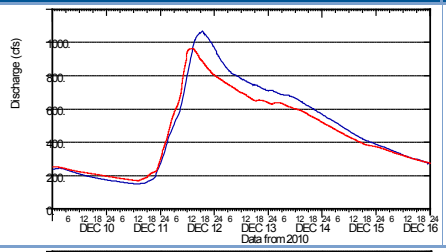
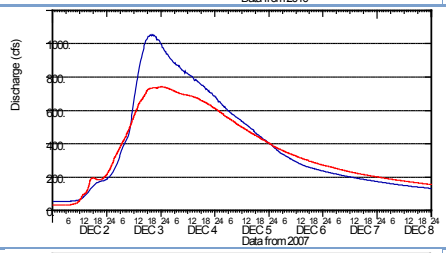
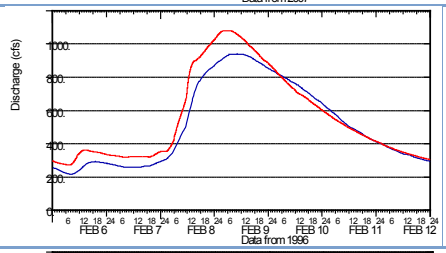
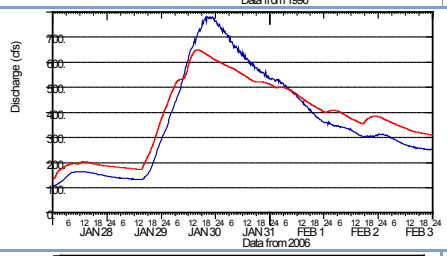
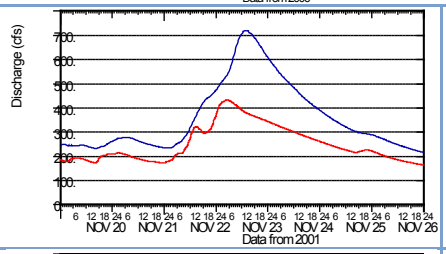
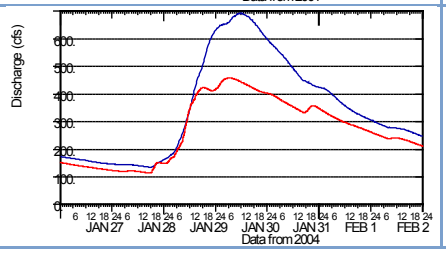
Table 2 - Simulated vs. observed monthly flows for Evans Creek (KC 18A, WY 2002-2013)

Period	Mean Flow (cfs)		
	18A	HSPF	% Diff
October	11.4	9.4	-21%
November	28.5	26.0	-10%
December	36.4	34.8	-5%
January	42.4	41.3	-3%
February	31.1	32.2	+3%
March	28.7	32.5	+12%
April	25.2	28.8	+13%
May	15.4	18.0	+14%
June	12.5	13.8	+9%
July	6.2	7.4	+17%
August	4.2	5.6	+25%
September	6.2	6.0	-5%
Annual	20.6	21.2	+3%

Simulated flows corresponding to gaps in observed record eliminated from calculations.

Event simulation is substantially improved over the previous modeling. Although peaks for larger events still tend to be low, simulation of moderate events is greatly improved over the previous model. Moreover, the number of events exceeding 300 cfs, which is an approximate threshold for backwater influence on the TZ, is consistent between simulated and observed records. Table 3 compares event hydrographs, peaks, and volumes for six of the largest events on Bear Creek in the past 20 years. Four of these events are shown in the calibration plots in the Phase 1 report (NHC, 2013), and February 1996 and December 2010—two of the highest observed Bear Creek flows over this period—were added. The plots in Table 3 show observed hydrographs in blue and simulated in red.

Table 3 - Large Event Comparison for Bear Creek HSPF Simulation

Event Dates	7-Day Hydrograph Comparison	Peak Flow (cfs)	7-Day Volume (kAF)
10-16 Dec 2010		Observed: 1,068 Simulated: 963 % Difference: -9.8	Observed: 6.7 Simulated: 6.4 % Difference: -5.0
2-8 Dec 2007		Observed: 1,055 Simulated: 741 % Difference: -30	Observed: 5.5 Simulated: 5.1 % Difference: -7.2
6-12 Feb 1996		Observed: 941 Simulated: 1,080 % Difference: +15	Observed: 7.2 Simulated: 7.8 % Difference: +8.7
28 Jan-3 Feb 2006		Observed: 780 Simulated: 648 % Difference: -17	Observed: 5.1 Simulated: 5.4 % Difference: +4.2
20-26 Nov 2001		Observed: 718 Simulated: 434 % Difference: -40	Observed: 5.0 Simulated: 3.5 % Difference: -30
27 Jan-2 Feb 2004		Observed: 693 Simulated: 459 % Difference: -34	Observed: 4.9 Simulated: 3.8 % Difference: -23

Note: cfs = cubic feet per second, kAF = 1000 acre-feet. Blue hydrograph trace is observed; red is simulated.

1.2 Issaquah Creek

The previous version of the Issaquah Creek model consistently over-simulated winter flow volumes and small to moderate event runoff peaks at the mouth of Issaquah Creek (USGS 12121600). Also, simulated hydrograph shapes were much different—generally spikier—than observed, indicating that the model was not accurately representing the character of the basin runoff response. NHC calibrated the Issaquah Creek model to the USGS gage at the mouth. King County's North Fork Issaquah Creek gage (46A) was also used as a reference for subbasin flow volume and hydrograph timing.

As with Bear Creek, the initial step in calibration was to review rainfall data and distribution. The Issaquah Creek model has five precipitation zones that use different rain gages and/or precipitation multipliers (Figure 2). NHC reviewed rainfall distribution based on mean annual precipitation (from PRISM mapping) at gage locations and over model subbasins, compared rainfall hyetographs and flow hydrographs for different gages and areas of the basin, and compared gaged rainfall to PRISM estimates. A number of rainfall adjustments were explored during calibration, including adjusting multipliers and shifting subbasins to different zones. In the final calibration, NHC reduced multipliers for MetZones 3, 4, and 5 compared to the previous model. Precipitation for MetZone 2 was switched to a combination of two rain gages based on comparison to flow timing and patterns from the North Fork gage.

In addition to rainfall, the evaporation and deep groundwater fractions were modified to achieve an acceptable annual water balance. Groundwater recession rates were also adjusted to improve summer baseflow simulation. Table 4 summarizes monthly runoff characteristics for Issaquah Creek for water years 2002-2013; depending on the date range selected for analysis, model performance will appear slightly better or worse, within a few percent.

Table 4 - Simulated vs. observed monthly flows for Issaquah Creek (USGS 12121600, WY 2002-2013)

Period	Mean Flow (cfs)		
	12121600	HSPF	% Diff
October	57.7	52.1	-11%
November	175	170	-3%
December	212	219	+3%
January	286	280	-2%
February	170	184	+8%
March	187	216	+13%
April	171	183	+6%
May	106	111	+5%
June	85.0	79.0	-8%
July	39.5	41.5	+5%
August	26.4	29.8	+12%
September	31.7	30.8	-3%
Annual	129	133	+3%

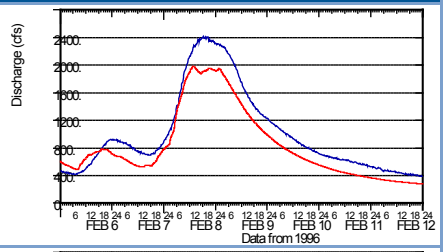
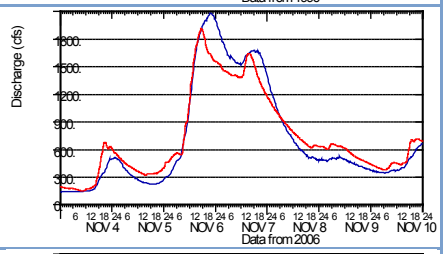
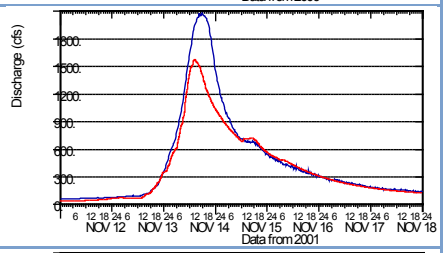
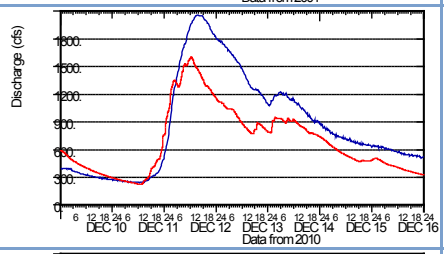
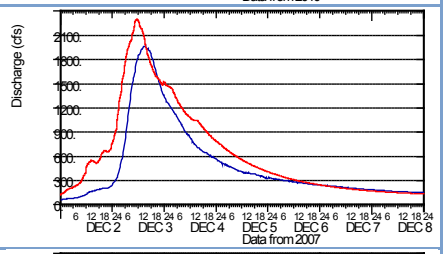
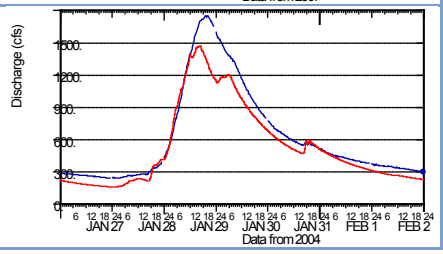
Simulated flows corresponding to gaps in observed record eliminated from calculations.

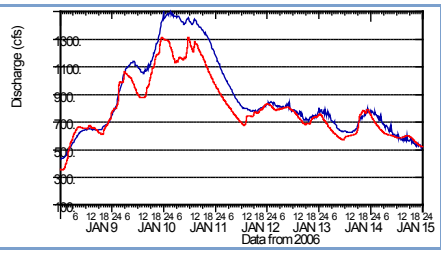
Once a reasonable water balance was achieved, NHC modified infiltration, soil storage, and interflow parameters to calibrate storm runoff, including event peaks, volumes, and hydrograph shapes. For most parameters, the same values were used across all precipitation zones for a common land use/soil type—maintaining consistency with regional parameters where possible. The exception is lower zone soil storage, which was higher in the higher elevation/higher precipitation zones. Bedrock surficial geology, which is not common in the Puget Sound Lowlands, is prevalent in the higher elevation areas of Issaquah Creek. Bedrock parameter values were patterned after till soils, but with lower infiltration and more rapid interflow recession on steep slopes.

The initial hope was to develop a single set of runoff parameters for all of the King County models that would adequately reproduce flows on Bear Creek and Issaquah Creek. As part of the Issaquah Creek calibration process, NHC applied the calibrated parameters from Bear Creek for common land-use/soil-types, but found that the Bear Creek infiltration rates for till soils were too low, producing excessive runoff. Interflow response, which significantly affects hydrograph recessions, also did not match up well.

Event simulation, particularly hydrograph shape, is much improved over the earlier modeling. Although larger events still tend to be low, simulation of small to moderate events is greatly improved over the previous model. Table 5 compares event hydrographs, peaks, and volumes for seven of the largest events on Issaquah Creek in the past 20 years. Five of these events are shown in the calibration plots in the Phase 1 report (NHC, 2013), and February 1996 and December 2010 were added, as with Bear Creek. The plots in Table 5 show observed hydrographs in blue and simulated in red.

Table 5 - Large Event Comparison for Issaquah Creek HSPF Simulation

Event Dates	7-Day Hydrograph Comparison	Peak Flow (cfs)	7-Day Volume (kAF)
6-12 Feb 1996		Observed: 2,420 Simulated: 1,987 % Difference: -18	Observed: 14.0 Simulated: 11.6 % Difference: -17
4-10 Nov 2006		Observed: 2,080 Simulated: 1,915 % Difference: -7.9	Observed: 10.0 Simulated: 10.3 % Difference: +3.0
12-18 Nov 2001		Observed: 2,080 Simulated: 1,573 % Difference: -24	Observed: 6.4 Simulated: 5.5 % Difference: -14
10-16 Dec 2010		Observed: 2,060 Simulated: 1,608 % Difference: -22	Observed: 12.2 Simulated: 9.6 % Difference: -21
2-8 Dec 2007		Observed: 1,970 Simulated: 2,305 % Difference: +17	Observed: 6.9 Simulated: 9.0 % Difference: +31
27 Jan-2 Feb 2004		Observed: 1,750 Simulated: 1,474 % Difference: -16	Observed: 8.7 Simulated: 7.3 % Difference: -15

8-14 Jan 2006		Observed: 1,500 Simulated: 1,316 % Difference: -12	Observed: 11.9 Simulated: 10.8 % Difference: -9.2

Note: cfs = cubic feet per second, kAF = 1000 acre-feet. Blue hydrograph trace is observed; red is simulated.

1.3 Calibration Summary

Simulation accuracy for both Bear Creek and Issaquah Creek is markedly improved over earlier results. Simulated annual volumes are within five percent of observed, and peaks and volumes of the largest storm events are generally within 20 percent of corresponding observed values (and quite a bit better in many events). Overall, both models still have a tendency to undersimulate large storm events. We attempted to address this issue with various calibration adjustments, but these consistently produced worse long-term volume results and often still fell short of storm peaks. For high flow events such as those summarized above, gage flows often have to be extrapolated above the range of measured flows on the rating curve, so there is typically greater uncertainty in highest observed flows. While observed data quality and gage ratings are expected to be generally good in this case, further investigation was beyond the scope of this work. The current calibration, while not outstanding, is reasonable for the intended purpose of comparing differences between modeled scenarios.

The land surface runoff parameters calibrated to Bear/Evans Creek were also applied to the uncalibrated Sammamish River and East and West Lake Sammamish Tributaries models. These areas are more similar in character and physiography to the Bear/Evans basin than to the larger, higher-elevation Issaquah Creek basin. Bedrock areas in the East and West Lake Sammamish Tributaries models use parameters from Issaquah Creek, as there are no bedrock areas in the Evans or Bear Creek models.

2 FUTURE CONDITIONS HYDROLOGY

As discussed in the Phase 1 report (NHC, 2013), uncertainty under potential climate change is one of the key variables in terms of future hydrology and Project performance. While development will continue in parts of the Sammamish River (and especially Lake Sammamish) basin, it is our belief (as documented in the Phase 1 report), that mitigation according to current stormwater management standards will preclude *significant* changes in runoff due to land use change. To assist in the design of a Project that will be robust under future hydrologic conditions, we developed precipitation estimates under future climate conditions, as simulated by a regionally accepted global climate model (GCM), for each of the input precipitation gages for the HSPF models. The models were then rerun with alternative precipitation inputs to produce a plausible future hydrologic conditions scenario. It should be noted that estimation of changes in evaporation associated with higher temperatures was beyond the scope of this work. Evaporation changes would likely have little impact on storm flows (especially large events), but could have more substantial impact on summer flows and lake levels.

The following sections summarize the approach used to develop the future hydrologic conditions scenario. Detailed discussion of methodology and individual gage results are provided in a technical appendix to this memo.

2.1 Summary of Future Precipitation Methodology

The precipitation scenario developed in this analysis is consistent with the projected changes in the Pacific Northwest regional climate simulations produced by Salathé et al. (2014). In these simulations, the global climate model ECHAM5/MPI-OM results were downscaled by regional climate model WRF (ECHAM5-WRF). We found reasonable agreement between the original daily simulated values in ECHAM5-WRF and the gage record values for this watershed, even when comparing the estimated parameters of the extreme-value distributions. Thus, the ECHAM5-WRF simulations could be used for this study without any need for bias correction or statistical downscaling.

For purposes of the analysis, the 18 precipitation gages used in the HSPF modeling were grouped into three geographic regions—Lowland, Sammamish Plateau, and Issaquah Creek. Figure 3 illustrates the approximate "boundaries" of these regions, and gages included in each are summarized in Table 6.

Table 6 - Precipitation Regions for Climate Change Scenario

Region	Mean Flow (cfs)
Lowland	Silver Lake, Alderwood, MARY, BEAR I&I, 27u, 51w, 51u
Sammamish Plateau	18v, 02v, 02w, NOVH, 18y, SAHA, SAMP
Issaquah Creek	14u, 67u, 31z, 63y

All precipitation gages run by King County except Silver Lake and Alderwood (Snohomish County).

To create future precipitation time series, the observed historical time series were first modified to increase the number of precipitation days, based on comparison with GCM results. For each record, precipitation days were added to the end of randomly selected storm events from the observed time series until the number of precipitation days was consistent with the GCM projections. Table 7 summarizes the number of wet days per year (and percent change) for the mid-century period (2040-2069) relative to the historical period (1970-1999) for the ECHAM5-WRF simulations; results are averaged over the gage locations in each region. The percentages in Table 7 represent the percent change in wet days for each region compared to the historical period.

Table 7 - Changes in Mean Number of Wet Days per Year for Mid-Century Period

Lowland	Sammamish Plateau	Issaquah Creek
+1.3 days (0.77%)	+1.4 days (0.86%)	+1.1 days (0.66%)

The daily precipitation totals on the resulting wet days were then adjusted so that the distribution of daily precipitation on wet days would be consistent with the GCM-projected changes. To this end, the

return period of each daily observed precipitation value was estimated, and that value was then replaced by a (higher, in this case) value having the same return period in the future distribution. As described in the technical appendix, statistical distributions were fit to downscaled GCM results for each gage location, then results were averaged over the individual regions to determine average parameters used in creating the frequency distributions.

The changes in daily precipitation intensity projected by ECHAM5-WRF from the historical simulation period (1970-1999) to the mid-21st century period (2040-2069) are small. The most significant changes pertain to the distribution of extremes in the Lowland region of the watershed, with the distribution shifting towards higher values than historical. Sample plots comparing future to observed historical daily precipitation for one rain gage in each region are shown in Figure 4. Projected changes in extremes for the Sammamish Plateau and Issaquah Creek regions of the watershed were similar in sign but smaller.

The daily precipitation record of each meteorological gage was modified in a manner consistent with these projected increases in the more extreme values. Once the future daily time series were developed, the daily values were then disaggregated using the observed pattern of 15-minute rainfall on the corresponding day at each gage. This simple method of disaggregation is adequate in light of the small or moderate projected changes in daily intensity. It does not address changes in storm patterns, which was beyond the scope of this analysis.

2.2 Uncertainty in Future Precipitation Projections

While there is a need to provide quantitative information for design analysis and Project planning, the underlying projections of climate change are subject to large and unquantifiable uncertainty (see e.g. Kundewicz et al., 2013). The main sources of uncertainty are unknown future emissions of greenhouse gases, uncertain response of the global climate system to increases in anthropogenic greenhouse gas concentrations, and incomplete understanding of regional manifestations that will result from global changes (e.g., Hawkins and Sutton, 2010). Additionally, precipitation processes are very complex and difficult to simulate accurately in models.

The downscaling, in space and time, of GCM-projected climate variables, the extrapolation of frequency analyses to extreme return periods, and the disaggregation from future daily precipitation to 15-minute precipitation represent additional sources of uncertainty. The precipitation projections developed in this work should therefore be considered to be plausible representations of the future, given the best current scientific information, but do not represent specific predictions. The actual future realizations of precipitation for the Sammamish River watershed will differ from any of the scenarios developed under this study, and their difference compared to historical precipitation may be greater or smaller than the differences projected in this work.

2.3 Future Flow Scenarios

The future precipitation scenarios were applied as input to the calibrated HSPF models to generate a future inflow scenario. As with precipitation, flow changes associated with the simulated climate change scenario are relatively small. Mean annual flows increase by two to four percent, while maximum flows increase on the order of five to ten percent. Figure 5 and Table 8 compare existing and future flow frequency curves for Issaquah Creek, Bear Creek, and the East and West Lake Sammamish Tributaries. In

general, we see larger increases for more extreme events, which is also consistent with the precipitation changes.

Table 8 - Current versus Future Flow Frequency for Selected Basins

Basin/Model	2-Year Flow			10-Year Flow			100-Year Flow		
	Exist (cfs)	Future (cfs)	% Diff	Exist (cfs)	Future (cfs)	% Diff	Exist (cfs)	Future (cfs)	% Diff
Issaquah Creek	1,450	1,470	+1.3	2,300	2,400	+4.2	3,110	3,370	+8.5
East Lk Samm Tribs	600	640	+6.5	1,150	1,230	+6.8	2,390	2,530	+6.1
West Lk Samm Tribs	1,140	1,190	+4.6	2,150	2,250	+4.6	4,170	4,310	+3.3
Bear Creek	610	640	+5.3	1,080	1,140	+5.6	1,710	1,810	+5.7

Flow quantiles determined from Log Pearson 3 distribution fit by method of moments.

It is anticipated that the climate change hydrology scenario will be applied to the HEC-RAS models representing selected Project alternatives in future work. Effects on Project performance relative to flooding and lake level objectives will be determined from the hydraulic model results.

3 REFERENCES

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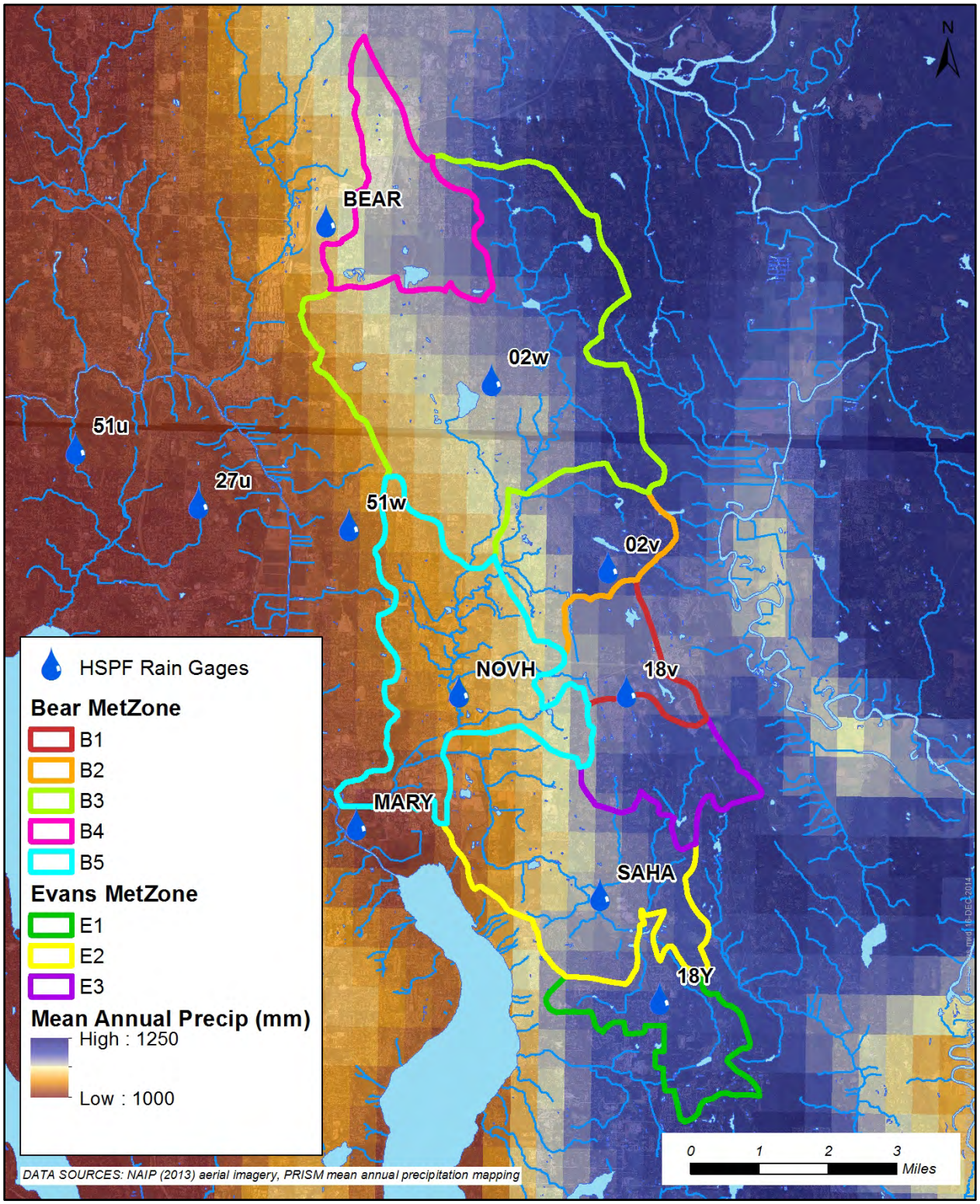


Figure 1. Bear/Evans Creek HSPF Model Precipitation Zones

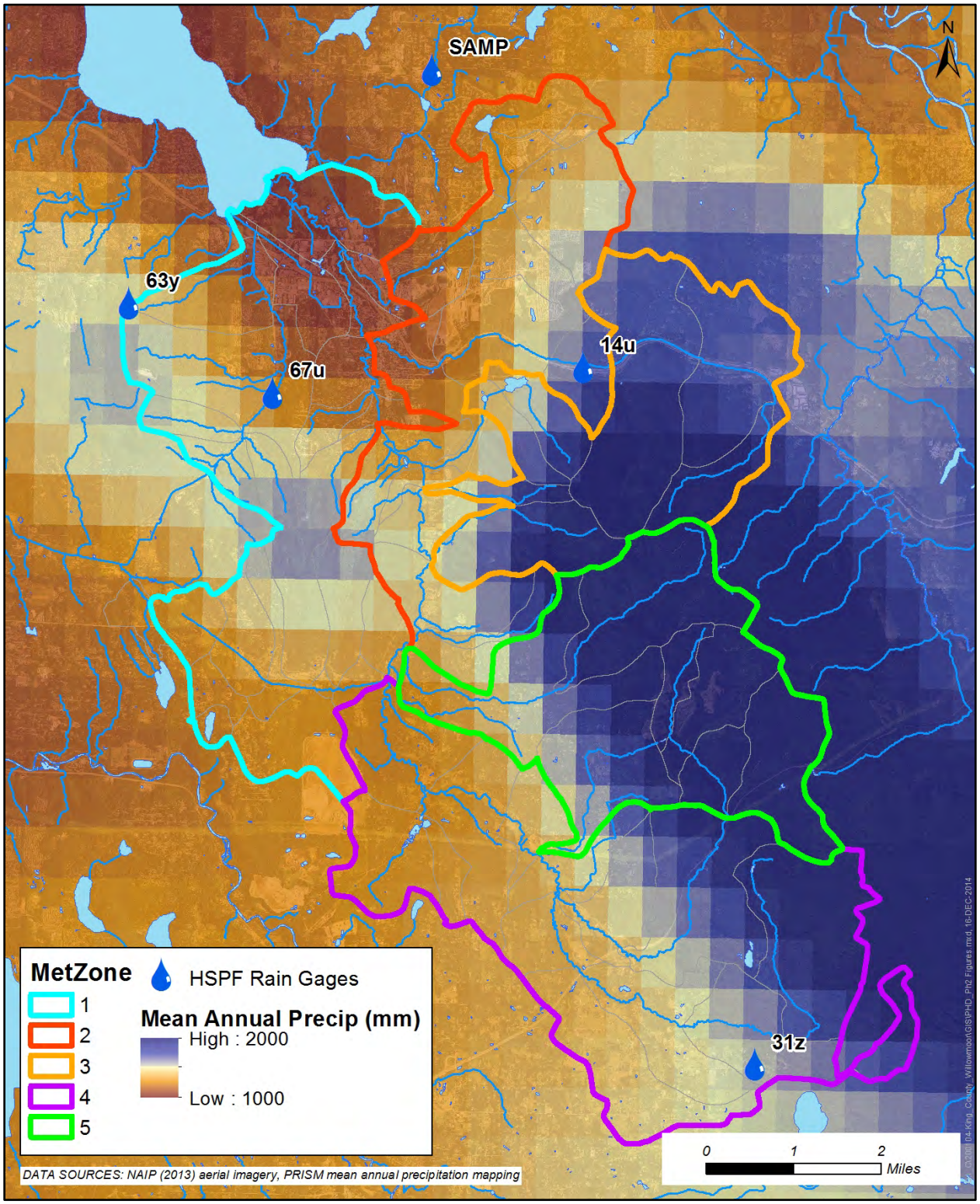


Figure 2. Issaquah Creek HSPF Model Precipitation Zones

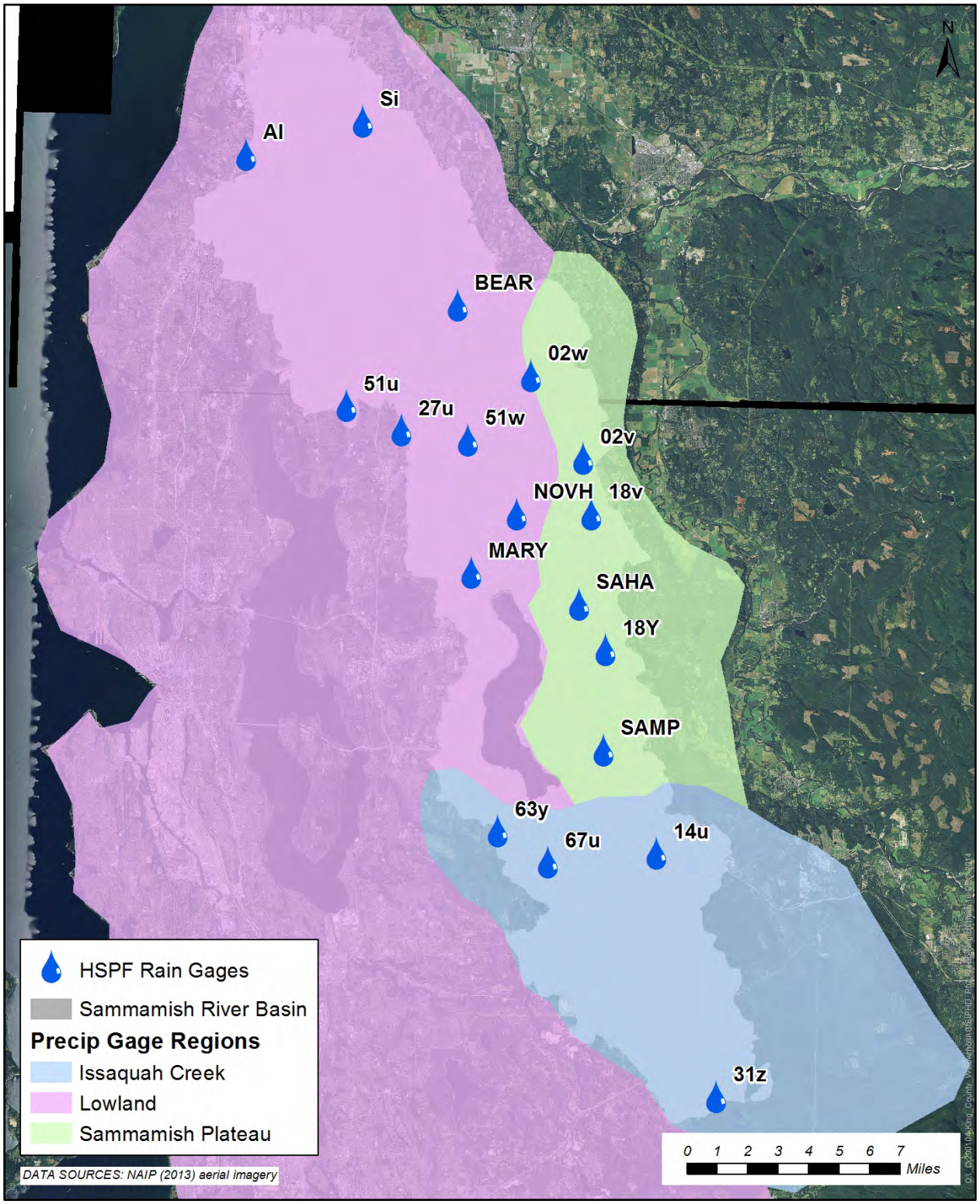
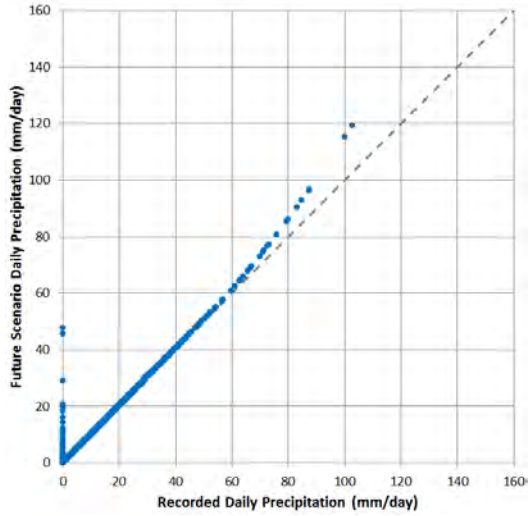
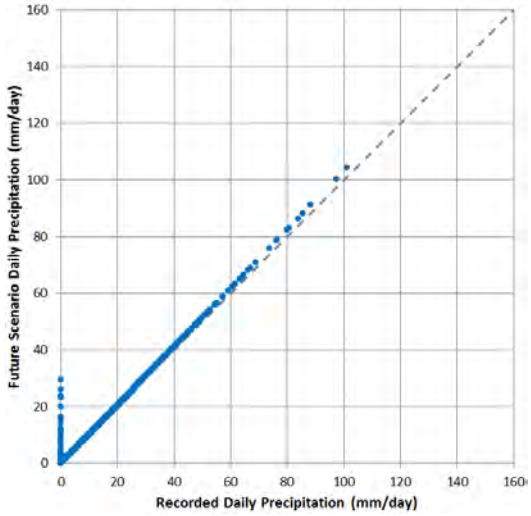


Figure 3. Precipitation Gage Regions for Climate Change Analysis

Lowland Region
Example gage:
BEAR



Sammamish Plateau Region
Example gage:
18y



Issaquah Creek Region
Example gage:
67u

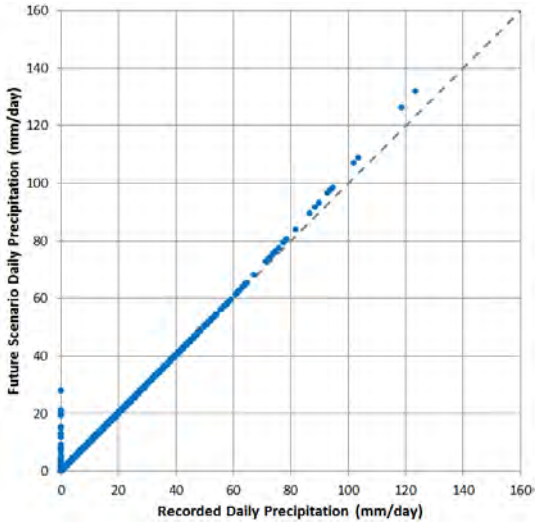


Figure 4. Sample plots of observed daily precipitation values (x axis) and modified values for future climate scenario (y axis). Values above the identity line indicate increases in precipitation.

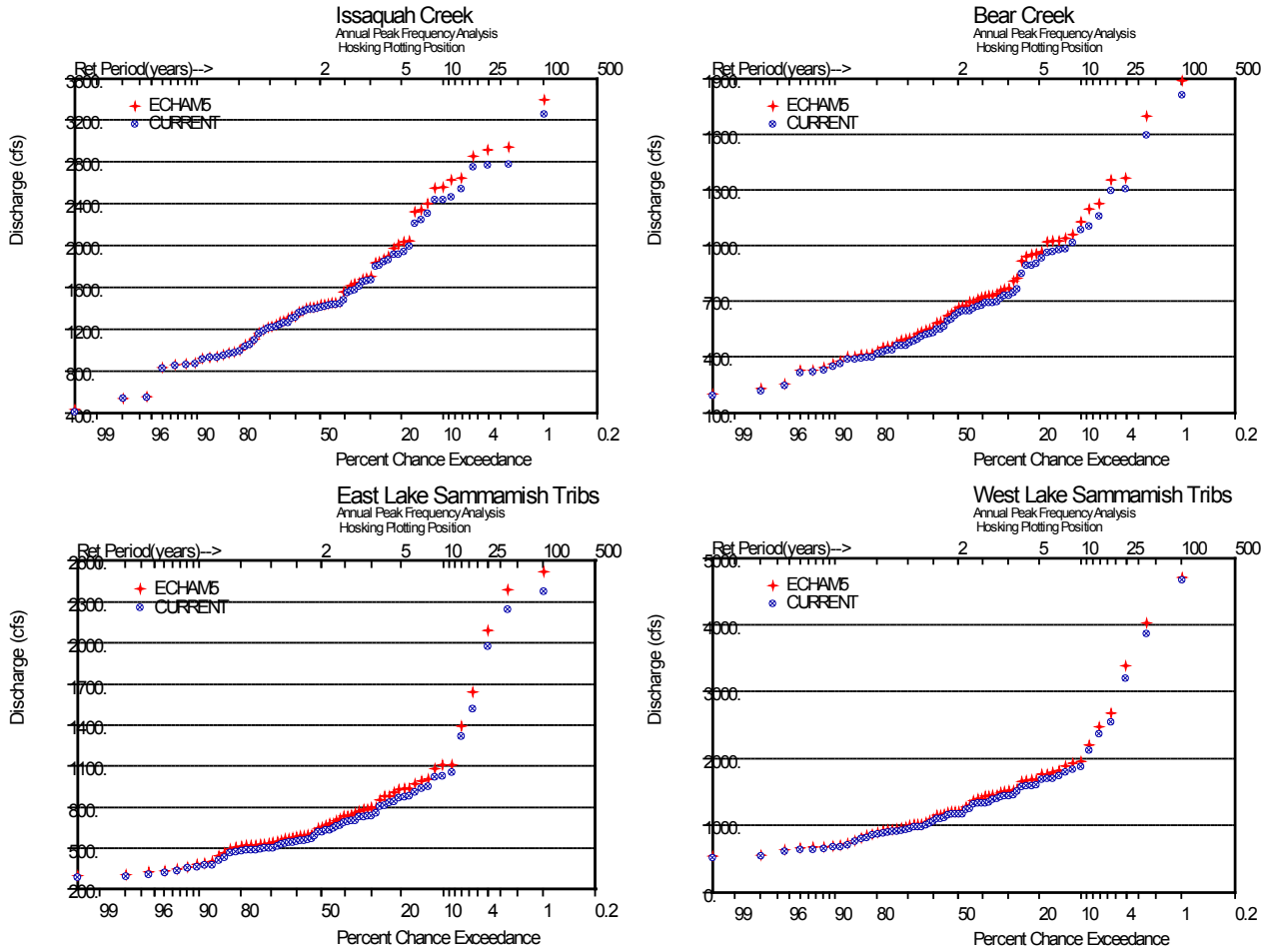


Figure 5. Sample frequency plots comparing current and future conditions for Issaquah Creek, Bear Creek, East Lake Sammamish Tributaries, and West Lake Sammamish Tributaries

Technical Appendix

Mid-21st century scenarios of 15-minute precipitation for the Sammamish River watershed

1 SUMMARY

This document describes the development of synthetic series of 15-minute precipitation representing a scenario of potential climatic conditions for the mid-21st century for the Lake Sammamish watershed. Each time series represents of 18 precipitation gages. The purpose of these 18 time series is to be used as input to a hydrologic model that simulates runoff for use in analysis of runoff conditions in the watershed, including inflows to Lake Sammamish and the Sammamish River. This will allow assessing the robustness of the project's performance under changing hydrologic conditions.

The precipitation scenario developed in this analysis is consistent with the projected changes in the climate simulations produced by Salathé et al. (2014). In these simulations, the global climate model ECHAM5/MPI-OM results were downscaled by regional climate model WRF. We will use the acronym ECHAM5-WRF to refer these simulations. We found reasonable agreement between the original daily simulated values in ECHAM5-WRF and the gage record values for this watershed, even when comparing the estimated parameters of the extreme-value distributions. We used the ECHAM5-WRF simulations in this study without any need for bias correction or statistical downscaling.

The changes in daily precipitation intensity projected by ECHAM5-WRF from the historical simulation period (1970-1999) to the mid-21st century period (2040-2069) are small. The most significant changes pertain to the distribution of extremes in the Lowland region of the watershed, with the distribution shifting towards higher values than historical. Projected changes in extremes for the Sammamish Plateau and Issaquah Creek regions of the watershed were similar in sign but smaller. We modified the daily precipitation record of each meteorological gage in a manner consistent with these projected increases in the more extreme values. The daily values were then disaggregated using the observed pattern of 15-minute rainfall on the corresponding day at the gage. This simple method of disaggregation is adequate in light of the small or moderate projected changes in daily intensity.

2 THE ECHAM5-WRF PROJECTIONS

2.1 The climate models

Salathé et al. (2014) used the WRF regional climate model to derive further spatial and temporal detail (i.e., to "downscale") over the Pacific Northwest region, from the original run of the ECHAM5/MPI-OM global climate model. The main objective of Salathé and colleagues was to improve representation of precipitation extremes over the region. WRF, which stands for Weather Research and Forecasting (http://www.wrf-model.org; Leung et al., 2006), is a state-of-the-art numerical weather prediction model that is used for both climate research (e.g., Dulière et al., 2013) and operational forecasting (Mass et al., 2003). Salathé and colleagues used the WRF parameterization for the Pacific Northwest region described in Zhang et al. (2009), with 12 km grid spacing.

WRF was run for a period of 100 years (1970-2069) at 12 km grid resolution using boundary conditions from a coarser-scale global climate simulation by ECHAM5/MPI-OM, which was part of the Third Climate Model Intercomparison Project (CMIP3) (Covey et al., 2003) that formed the basis for the Fourth Assessment report of the IPCC in 2007. ECHAM5/MPI-OM is a coupled atmosphere-ocean model. Its atmospheric component (ECHAM5) was developed at the European Centre for Medium-Range Weather Forecasts and the Max Planck institute for Meteorology (Roeckner et al., 1999; 2003), and its ocean

component (MPI-OM) was developed at the Max Planck Institute for Meteorology (Marsland et al., 2003).

For simplicity, we will henceforth refer to the coupled model simply as ECHAM5. Salathé et al. (2014) report a favorable evaluation of ECHAM5 performance in hindcasts (i.e., in its simulations of 20th century climate) over the Pacific Northwest. For the historical period, 1970-1999, ECHAM5 used constant levels of atmospheric greenhouse gases and aerosol concentrations and of solar radiation intensity. For the 21st century (2000-2069), the ECHAM5 simulations used the IPCC scenario of future greenhouse gas emissions known as A1B. The A1B scenario is a medium-high scenario of emissions that assumes "business as usual" in the first half of the 21st century (i.e., very limited mitigation of emissions), followed by a period of greater mitigation in the second half of the 21st century as climate change impacts intensify.

The period of interest to this study is 2040-2069. Because of the delayed effect of emissions on climate, projections for this mid-21st century period depend only moderately on the choice of greenhouse gas emissions scenario. It is only in the late-21st century period that differences in projected climate show considerable dependence on the future emissions scenario.

2.2 Climate hindcasts and projections

For ECHAM5-WRF historical period simulations ("hindcasts"), we found reasonable agreement with the gage records on the distribution of daily precipitation. Even more important, we also found reasonable agreement between modeled and observed values of the estimated parameters of the extreme-value distributions. These results are encouraging. We used the ECHAM5-WRF future simulations (projections) without submitting them to any bias correction or statistical downscaling, i.e., we used the "uncorrected" simulation results.

We deliberately chose the uncorrected output, to avoid modifications of the original signal of changes in the extreme values. The process of statistical downscaling, by any of the current methods, invariably involves more or less arbitrary decisions on how to downscale future simulated values that are higher than any of the historical observations. Additionally, quantile mapping uses quantiles estimated empirically from the simulations, which are very imprecise for the highest values. The only post-simulation processing the ECHAM5-WRF simulations had gone through was aggregation from 6-hour to daily time resolution and disaggregation from 12-km to 6-km grid cells using the SYMAP algorithm (which can be succinctly described as an inverse square weighting of the surrounding 4 neighbor cells).

The issue of spatial scale is important to consider. The downscaled simulations of the GCMs are grid cell values, not point values. The precipitation gage values may be conceptualized as point values. Grid cells are defined by geographical coordinates, which in the present case have a spacing of 3.75 arc minutes (1/16°) along parallels (longitude) and meridians (latitude). At the latitude of Lake Sammamish, grid cells have a surface area of roughly 37 km^2.

In the present case, each gage's daily precipitation values were obtained by adding the original 15-minute record from midnight to the subsequent midnight, and the smallest non-zero daily value is 0.01 in/day (corresponding to 0.254 mm/day). In the case of the daily ECHAM5-WRF data, the smallest non-zero daily value downloaded is 0.1 mm/day. This very small value inflates the number of GCM wet days,

which then leads to low values of computed mean daily precipitation intensity, but this is inconsequential to this project because, as we will see later, we will be comparing like to like, i.e., future versus historical ECHAM5-WRF run results.

The comparison shown in Figure A-1 is interpreted in light of the above considerations. Mean annual precipitation over grid cells corresponding to the gage locations (1,479 mm/year, in the average of grid cell simulations of the ECHAM5-WRF runs for the historical period 1971-2000) is 29% higher than the average value for the meteorological stations (1,146 mm/year for water years 1948-2013). Note that the specific time period of simulations chosen for this comparison is not meaningful because in climate simulations there is no direct correspondence between dates of simulation and actual dates. Simulations can only be expected to agree with observations in a statistical sense, for example, by exhibiting similar mean and variability over a period of several years, for comparable levels of greenhouse gas concentrations. Of course, even in a statistical sense there is often considerable difference between simulations and observations, termed the “model bias”, which is the main reason that bias correction and statistical downscaling are usually required before using simulated data. Accounting for differences in spatial scale (a grid cell versus a gage that measures at a point) is another reason why statistical downscaling is usually needed. In the case of the ECHAM5-WRF simulations for the Sammamish watershed, this difference can be considered small, and is not a reason for concern in this study.

Figure A-2 shows the observed and GCM-simulated historical distributions of daily precipitation, showing good overall agreement. The upper portions of these distributions, not discernible from Figure A-2, will be addressed in a later section.

The changes in daily precipitation intensity projected by ECHAM5-WRF from the historical simulation period (1970-1999) to the mid-21st century period (2040-2069) are small. Only small differences are projected in mean annual precipitation (Figure A-3). The most significant changes pertain to the distribution of extremes in the Lowland region of the watershed, with the distribution shifting towards higher values than historical. These changes in extremes will be addressed in a later section.

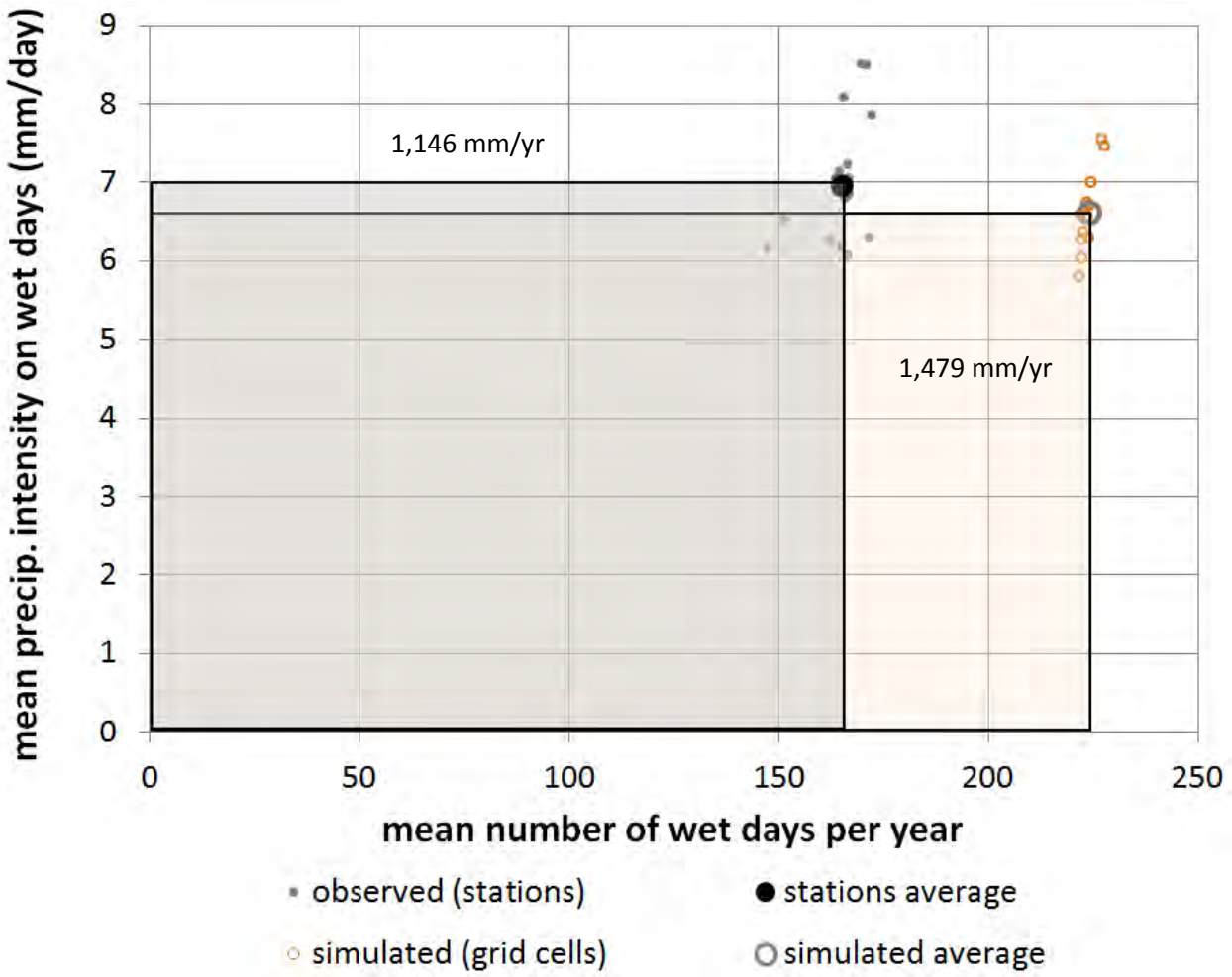


Figure A-1. Comparison of two statistics between the ECHAM5-WRF historical runs (hindcasts) and the 19 local precipitation gage records that are used in the hydrologic models.

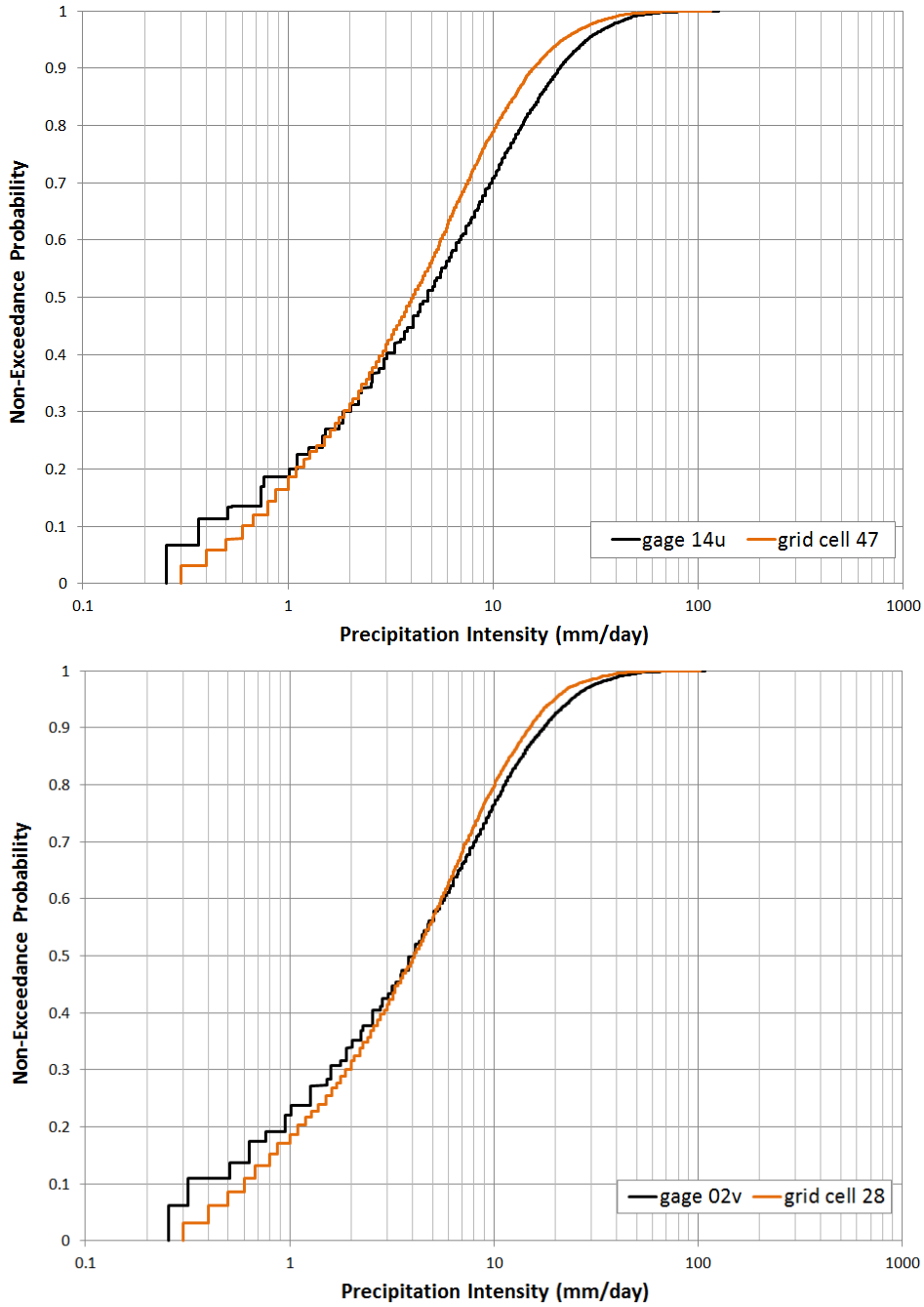


Figure A-2. Distributions of the observed time series (WY 1948-2013) and historical simulated (ECHAM5-WRF) (1970-1999) of daily precipitation for the location of two example gages. Empirical plotting positions are used (1/(n+1)). Drizzle days were removed from the ECHAM5-WRF simulations prior to preparing these figures, i.e., all values smaller than 0.254 mm/day (corresponding to 0.1 inches, the lowest value recorded by the meteorological stations) were converted to zeroes (dry days). <u>Top panel:</u> Gage 14u and grid cell 47, located in the Issaquah Creek region of the watershed. <u>Bottom panel:</u> Gage 02v and grid cell 28, located in the Sammamish Plateau region of the watershed.

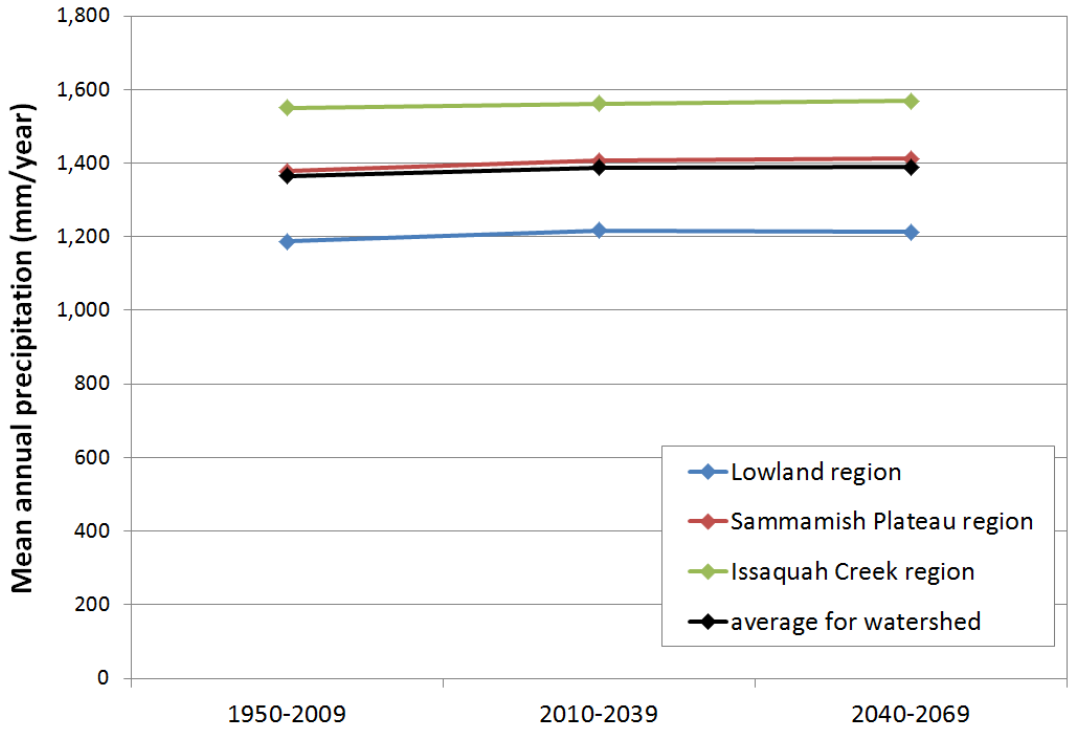


Figure A-3. Changes in mean annual precipitation projected by ECHAM5-WRF for the watershed (black line) and for each sub-region. The average for each multi-year period is displayed.

3 CREATING A MID-21ST CENTURY 15-MINUTE PRECIPITATION TIME SERIES

3.1 Methodology description

The diagram in Figure A-4 summarizes the approach used to create the synthetic future time series of 15-minute precipitation. Given that the hydrologic model is set up and calibrated for the gage record, and this record has 15-minute resolution, our methodology uses the observed time series as the basis for creating the future time series. This ensures that the future time series, and their associated hydrologic model results, are directly comparable to the observed time series and their hydrologic model results and preserves variability between the gages that is lost at the grid-scale.

Step 1 of the methodology ensures that the future precipitation time series are consistent with the ECHAM5-WRF-simulated increase in mean number of wet days per year. Step 2 ensures consistency with the ECHAM5-WRF-simulated increase in the upper end (extreme values) of the daily precipitation intensity distribution.

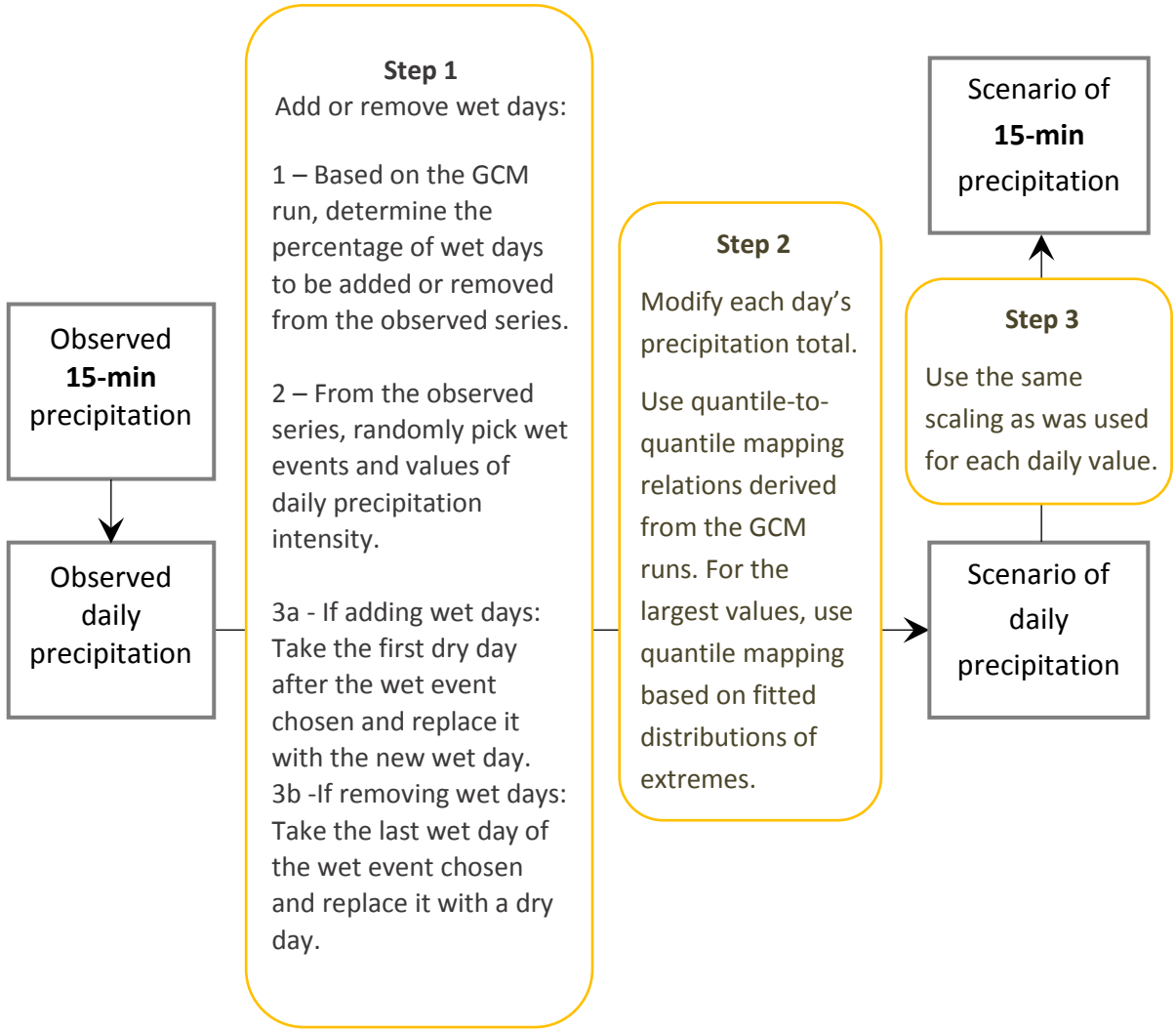


Figure A-4. Methodology for generating a synthetic time series of future hourly precipitation by modification of an observed 15-minute record.

3.1.1 Step 1: Add wet days to the observed precipitation time series

The increases in mean number of wet days per year sampled by the ECHAM-WRF model runs are given in Table A-1. These values are derived from the sample results reported in Table A-2. Although small, the changes in Table A-1 may have significant impact on the calculated return periods of daily precipitation intensity.

Table A-1. Changes in the mean number of wet days per year for the mid-century period (2040-2069) relative to the historical period (1970-1999) in the ECHAM5-WRF simulations

Change in Wet Days by Region		
Lowland	Sammamish Plateau	Issaquah Creek
+1.3 days (0.773%)	+1.4 days (0.855%)	+1.1 days (0.664%)

Addition of wet days was performed by randomly picking a corresponding number of precipitation *events* from the 66-year gage record, and for each chosen event replacing the first dry day after the event with a wet day. A precipitation event is defined as any group of consecutive wet days. An isolated wet day is also a precipitation event. The choice of the last day of the event is somewhat arbitrary but carries little consequence.

3.1.2 Step 2: Modify each day's precipitation total (and scale the 15-minute values accordingly)

The values of daily precipitation simulated by ECHAM5-WRF for the mid-21st century period, 2040-2069, have a different statistical distribution than those simulated for the historical period, 1970-1999. Differences are small, however, except those at the upper end of the distribution which are larger. The latter may be significant to peak runoff generation.

The extreme daily values were treated differently than the others. The non-extreme daily values were simply multiplied by a scaling factor, chosen so that the changes in mean annual precipitation match the percent changes projected by ECHAM5-WRF for 2040-2069. The scaling factor was very small in all cases, representing increases by less than 2%.

Extreme values were modified according to the projected changes in the distribution of extremes. First, it was necessary to define a threshold value to identify extremes. Following the commonly used methodology described in Coles (2001), we found the threshold value $u = 22\ mm/day$ to apply well to the ECHAM5-WRF simulated historical and simulated future time series, and also to the records of all gages. An extreme value distribution was then fit to each dataset, as described next.

Considering the most intense precipitation days, i.e., any daily precipitation value x (where $x > u$), which in the historical period had non-exceedance probability $F_s^h(x)$ will in the future period have a different non-exceedance probability, $F_s^f(x)$. Subscript *s* stands for GCM-simulated distribution, and superscripts *h* and *f* stand for "historical period" and "future period". Because both of our scenarios entail future intensification of precipitation, we can expect to have a decline over time in the probability of any given value x not being exceeded, i.e.:

Equation 1

$$F_s^f(x) < F_s^h(x)$$

The probability of non-exceedance of high precipitation values can be estimated by fitting an extreme value distribution to the time series. This is often done using the series of annual maxima, which in this case would be the 66 values that represent the wettest day in each of the 66 water years. Alternatively, it can be done using all the observed values above a chosen high threshold (several of which values may fall in the same year). We chose the latter method, known as "peaks over threshold" (POT) analysis, as it makes use of a larger number of data points, reducing the uncertainty in parameter estimation.

To choose an appropriate threshold value u, and to fit the Generalized Pareto distribution to the exceedance values above u, we followed the methodology described in Coles (2001), using maximum likelihood for parameter estimation (Coles, 2001, Eqn. 4.10 and following ones).The CDF of the Generalized Pareto distribution is given by the following general expression, when $\xi \neq 0$ (a different expression applies for $\xi = 0$, but is not given here):

Equation 2

$$p(x_i \leq x | x_i > u) = 1 - \left(1 + \xi \cdot \left(\frac{x-u}{\sigma}\right)\right)^{-\frac{1}{\xi}}$$
$$for\ x, x_i > u$$

In this equation, x is the daily precipitation total; u is the high threshold value; $p(x_i \leq x | x_i > u)$ is the non-exceedance probability of x, conditioned on x_i surpassing the threshold u; and σ and ξ are the distribution's parameters (designated the "scale" and "shape" parameters, respectively).

Equation 2 gives the non-exceedance probability conditional on x exceeding u. To obtain the unconditional non-exceedance probability of x, $F(x)$, we must account for the non-exceedance probability of the threshold u, $F(u)$, as follows:

Equation 3

$$F(x) = p(x_i \leq x | x_i > u) \cdot \big(1 - F(u)\big) + F(u)$$
$$for\ x, x_i > u$$

Combining Equation 2 and Equation 3, we obtain:

Equation 4

$$F(x) = \left\{1 - \left(1 + \xi \cdot \left(\frac{x-u}{\sigma}\right)\right)^{-\frac{1}{\xi}}\right\} \cdot \big(1 - F(u)\big) + F(u)$$
$$for\ x > u$$

The value of $F(u)$ can be estimated empirically using the rank-based expression that we used for all non-extreme values of x, i.e., for all $x < u$:

Equation 5

$$F(x) = \frac{r(x)}{n+1}$$

$$for\ x \leq u$$

In Equation 5, $r(x)$ represents the rank of x (when all values in the series are ranked from smallest to largest). Many other options could be used instead of Equation 5, but the specific choice is of little practical consequence to this study.

Solving Equation 4 for x, we obtain Equation 6:

Equation 6

$$x = \frac{\sigma}{\xi} \cdot \left[\left(1 - \frac{F(x) - F(u)}{1 - F(u)} \right)^{-\xi} - 1 \right] + u$$
$$for\ x > u$$

In our application of the POT analysis, we avoided counting more than one extreme day belonging to the same storm. To do this, whenever we found two above-threshold days that were less than 3 days apart, we considered only the one with the highest value of the two, excluding the other one from our analysis.

Table A-2 gives the estimated parameter values for the general Equation 2, for both the daily observed series and the simulated ECHAM5-WRF daily series for the mid-century time horizon. The estimates for both parameters are higher for mid-century than for the historical period simulated by ECHAM5-WRF. The estimated parameters for each ECHAM5-WRF-simulated time series show reasonable agreement with the observed series, a reassuring result. The parameter variability seen from gage to gage, and from grid cell to grid cell for a fixed time horizon, is considered small, reflecting relative spatial homogeneity with respect to extremes.

Table A-2. Parameter estimates for the generalized Pareto distribution (GPD) using the POT method and maximum likelihood, for the observations, and for the downscaled simulated precipitation by ECHAM5-WRF.

	Gage or RCM Pixel		Average annual number of wet days, n_w	Average annual number of independent events having one or more exceedances over u = 22 mm/day	$\widehat{F}(u)$	$\widehat{\sigma}$	$\widehat{\xi}$
	Gage Observations (WY 1948-2013)						
Lowland		Average values →	**160.4**	**415**	**0.955053**	**8.87**	**0.093**
	Si	**(47.8768°N -122.2018°E)**	151.3	414	0.953949	8.00	0.044
	Al	**(47.8601°N -122.2837°E)**	147.3	333	0.962400	7.77	0.049
	MARY	**(47.6635°N -122.1201°E)**	166.5	406	0.957950	8.87	0.129
	BEAR I&I	**(47.7904°N -122.1329°E)**	164.0	515	0.943459	9.83	0.111
	27u	**(47.7306°N -122.1712°E)**	162.4	417	0.954948	8.82	0.120
	51w	**(47.7265°N -122.1241°E)**	166.5	407	0.957234	9.08	0.098
	51u	**(47.7417°N -122.2098°E)**	164.9	416	0.955431	9.35	0.101
Sammamish Plateau		Average values →	**164.9**	**532**	**0.941199**	**10.05**	**0.094**
	18v	**(47.6924°N -122.0366°E)**	166.4	579	0.936180	10.42	0.091
	02v	**(47.7186°N -122.0429°E)**	163.7	562	0.937240	9.99	0.110
	02w	**(47.7576°N -122.0803°E)**	166.8	518	0.943667	10.16	0.093
	NOVH	**(47.6918°N -122.0889°E)**	165.0	460	0.949940	9.51	0.085
	18y	**(47.6279°N -122.0249°E)**	165.9	512	0.944099	10.04	0.090
	SAHA	**(47.6495°N -122.0440°E)**	164.2	565	0.936871	9.94	0.115
	SAMP	**(47.5805°N -122.0253°E)**	162.4	527	0.940397	10.32	0.072
Issaquah Ck		Average values →	**169.8**	**760**	**0.914282**	**12.29**	**0.073**
	14u	**(47.5317°N -121.9872°E)**	169.8	805	0.907371	12.57	0.068
	67u	**(47.5267°N -122.0630°E)**	172.4	717	0.921441	12.01	0.065
	31z	**(47.4168°N -121.9428°E)**	171.1	794	0.911208	12.62	0.071
	63y	**(47.5411°N -122.0984°E)**	165.6	724	0.917109	11.95	0.086
	ECHAM5-WRF (1970-1999)						
Lowland		Average values →	**221.4**	**163**	**0.974010**	**8.94**	**0.058**
	Cell #12	**(47.8437°N -122.2812°E)**	220.2	135	0.979029	8.53	0.043
	Cell #13	**(47.8437°N -122.2187°E)**	222.5	149	0.976714	8.35	0.040
	Cell #14	**(47.8437°N -122.1562°E)**	224.3	172	0.973368	7.80	0.055
	Cell #18	**(47.7812°N -122.2812°E)**	219.3	158	0.975394	7.95	0.137
	Cell #19	**(47.7812°N -122.2187°E)**	221.2	162	0.974403	8.55	0.077
	Cell #20	**(47.7812°N -122.1562°E)**	218.9	171	0.971791	9.40	0.050
	Cell #21	**(47.7812°N -122.0938°E)**	220.1	182	0.970510	9.12	0.032
	Cell #25	**(47.7187°N -122.2187°E)**	221.4	162	0.973891	9.62	0.065
	Cell #26	**(47.7187°N -122.1562°E)**	222.9	163	0.974052	10.23	0.029
	Cell #27	**(47.7187°N -122.0938°E)**	223.0	178	0.970943	9.87	0.048

Sammamish Plateau		Average values →	**222.6**	**224**	**0.964390**	**10.07**	**0.078**
	Cell #22	**(47.7812°N -122.0313°E)**	222.5	223	0.962844	8.53	0.075
	Cell #28	**(47.7187°N -122.0313°E)**	222.7	197	0.967399	9.46	0.063
	Cell #33	**(47.6562°N -122.0938°E)**	221.8	182	0.970537	10.10	0.084
	Cell #34	**(47.6562°N -122.0313°E)**	221.9	211	0.964522	9.82	0.086
	Cell #39	**(47.5937°N -122.0938°E)**	222.4	258	0.961343	10.28	0.098
	Cell #40	**(47.5937°N -122.0313°E)**	224.1	271	0.959697	10.65	0.085

Issaquah Creek		Average values →	**224.9**	**365**	**0.945900**	**12.00**	**0.066**
	Cell #45	**(47.5313°N -122.0938°E)**	222.5	304	0.954464	11.85	0.092
	Cell #46	**(47.5313°N -122.0313°E)**	223.6	320	0.952303	11.62	0.072
	Cell #47	**(47.5313°N -121.9688°E)**	223.8	336	0.949955	11.13	0.093
	Cell #51	**(47.4688°N -122.0938°E)**	224.4	345	0.948767	11.85	0.051
	Cell #52	**(47.4688°N -122.0313°E)**	224.6	372	0.944791	12.22	0.051
	Cell #53	**(47.4688°N -121.9688°E)**	228.0	437	0.936111	12.27	0.070
	Cell #59	**(47.4063°N -121.9688°E)**	227.3	444	0.934907	13.11	0.035
ECHAM5-WRF (2040-2069)							
Lowland		Average values →	**223.2**	**179**	**0.972003**	**7.86**	**0.161**
	Cell #12	**(47.8437°N -122.2812°E)**	222.1	146	0.978244	6.55	0.219
	Cell #13	**(47.8437°N -122.2187°E)**	224.6	158	0.975924	6.97	0.180
	Cell #14	**(47.8437°N -122.1562°E)**	225.7	177	0.972740	6.77	0.194
	Cell #18	**(47.7812°N -122.2812°E)**	221.1	169	0.974413	7.65	0.170
	Cell #19	**(47.7812°N -122.2187°E)**	222.1	179	0.972463	7.44	0.185
	Cell #20	**(47.7812°N -122.1562°E)**	220.2	188	0.969774	8.74	0.126
	Cell #21	**(47.7812°N -122.0938°E)**	222.3	207	0.967708	7.85	0.151
	Cell #25	**(47.7187°N -122.2187°E)**	223.5	177	0.972058	9.09	0.114
	Cell #26	**(47.7187°N -122.1562°E)**	225.0	188	0.970194	8.65	0.145
	Cell #27	**(47.7187°N -122.0938°E)**	224.9	206	0.966509	8.90	0.125

Sammamish Plateau		Average values →	**224.4**	**242**	**0.961582**	**10.19**	**0.082**
	Cell #22	**(47.7812°N -122.0313°E)**	223.7	244	0.959798	9.05	0.076
	Cell #28	**(47.7187°N -122.0313°E)**	224.7	222	0.963622	9.64	0.071
	Cell #33	**(47.6562°N -122.0938°E)**	224.2	194	0.968288	10.59	0.069
	Cell #34	**(47.6562°N -122.0313°E)**	224.1	242	0.959394	9.76	0.098
	Cell #39	**(47.5937°N -122.0938°E)**	224.5	264	0.960813	11.02	0.092
	Cell #40	**(47.5937°N -122.0313°E)**	225.5	287	0.957576	11.07	0.086

Issaquah Creek		Average values →	**226.4**	**359**	**0.947234**	**11.79**	**0.097**
	Cell #45	**(47.5313°N -122.0938°E)**	224.5	295	0.956205	11.73	0.103
	Cell #46	**(47.5313°N -122.0313°E)**	225.1	322	0.952332	11.69	0.110
	Cell #47	**(47.5313°N -121.9688°E)**	225.6	336	0.950355	12.35	0.087
	Cell #51	**(47.4688°N -122.0938°E)**	225.8	325	0.952022	11.03	0.080
	Cell #52	**(47.4688°N -122.0313°E)**	226.3	366	0.946105	11.99	0.097
	Cell #53	**(47.4688°N -121.9688°E)**	229.1	423	0.938455	11.98	0.093
	Cell #59	**(47.4063°N -121.9688°E)**	228.2	444	0.935164	11.78	0.108

Consider that we are performing Step 2 and that we will now perform this step for a high observed daily value, x, where x is above a high threshold u. We want to transform x into a new value (x') for the future time series based on the ECHAM5-WRF model run for 2040-2069. We do this through the following sub-steps:

i. We take the observed daily value x and determine its non-exceedance probability, $F(x)$, using Equation 4, and the parameter values in Table A-2.

ii. We determine what value has this same non-exceedance probability $F(x)$ in the daily distribution corresponding to the ECHAM5-WRF simulations for 2040-2069. Call this value x_{WRF}^{f} (where the superscript *f* stands for "future period").

iii. Determine the original non-exceedance probability of value x_{WRF}^{f}, i.e., in the distribution corresponding to the ECHAM5-WRF simulations for the historical period, 1970-1999. Call this $F_{WRF}^{h}(x_{WRF}^{f})$.

iv. Determine the value x' for which the non-exceedance probability in the distribution of observed daily values equals the probability in (iii). We will have $x' > x$.

v. Replace x with x'.

Projected changes in precipitation extremes for the Sammamish Plateau and Issaquah Creek regions of the watershed are smaller than for the Lowland region, and the center and bottom panels of Figure A-5 show graphically the smaller changes incurred by a similar example value of 100.2 mm/day, for gages located in those sub-regions.

3.1.3 Case Example

Suppose we are modifying the daily record of gage BEAR to represent the ECHAM5-WRF-simulated changes for the mid-century period, 2040-2069. This gage is located in the Lowland region of the watershed. For this example, consider the value 100.2 mm, which was observed on 20 November 1959 at this gage. In ***sub-step (i)***, we take x=100.2 mm and we use Equation 4, and the values in Table A-2 to calculate:

Equation 7

$$F(100.2) = p(x \leq 100.2 | x > 22) \cdot \big(1 - F(22)\big) + F(22)$$
$$= \left\{1 - \left(1 + 0.111 \cdot \left(\frac{100.2 - 22}{9.83}\right)\right)^{-\frac{1}{0.111}}\right\} \cdot (1 - 0.943459) + 0.943459$$
$$=0.999811$$

In ***sub-step (ii)***, we find the value which had this same non-exceedance probability in the future simulations by ECHAM5-WRF for the Lowland region of the watershed. For this, we use Equation 6, set $F(x) = 0.999811$ (from Equation 7 above), and use the parameter values from Table A-2 (Lowland region average values) to calculate x_{WRF}^{f}:

Equation 8

$$x_{WRF}^{f} = \frac{7.86}{0.161} \cdot \left[\left(1 - \frac{0.999811 - 0.972003}{1 - 0.972003}\right)^{-0.161} - 1\right] + 22$$
$$= 82.35 \ mm$$

In ***sub-step (iii)***, we determine the original non-exceedance probability of this value $x_{WRF}^{f} = 82.35$ mm. Again using Equation 4, we obtain:

Equation 9

$$F_{MPI}^{h}(82.35) = \left\{1 - \left(1 + 0.058 \cdot \left(\frac{82.35 - 22}{8.94}\right)\right)^{-\frac{1}{0.058}}\right\} \cdot (1 - 0.974010) + 0.974010$$
$$= 0.999913$$

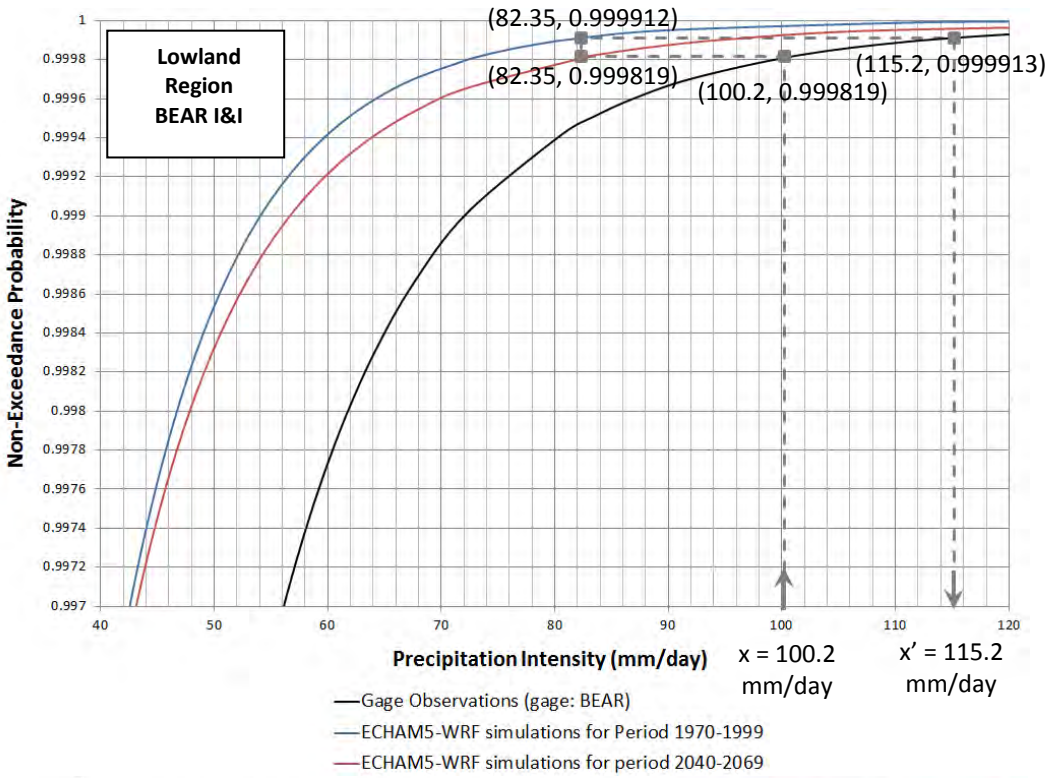
In ***sub-step (iv)***, we determine the value x' for which the non-exceedance probability in the distribution of observed values equals the result of Equation 9, 0.999913. To do this, we apply Equation 6, setting $F(x) = 0.999913$:

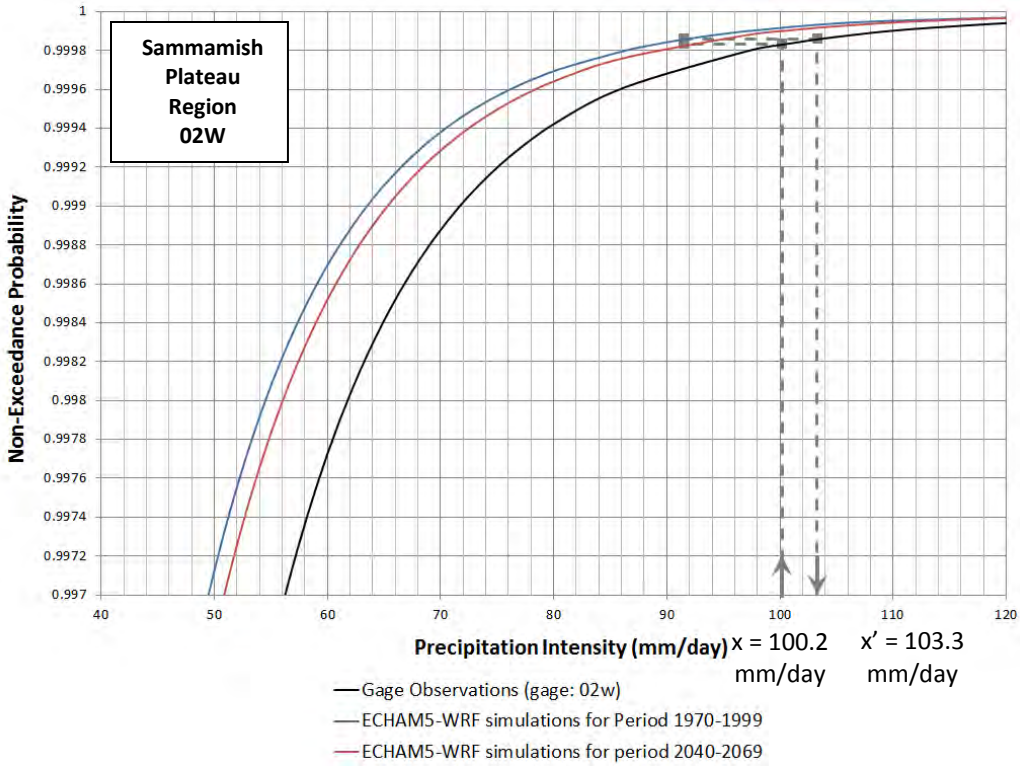
Equation 10

$$x' = \frac{9.83}{0.111} \cdot \left[\left(1 - \frac{0.999913 - 0.943459}{1 - 0.943459}\right)^{-0.111} - 1\right] + 22$$
$$= 115.2 \ mm$$

In ***the final sub-step (v)***, we replace the observed value 100.2 mm with this larger value 115.2 mm.

Figure A-5 (top panel) shows a graphical depiction of the above calculations.


Lowland Region BEAR I&I
(82.35, 0.999912)
(82.35, 0.999819)
(100.2, 0.999819)
(115.2, 0.999913)
Non-Exceedance Probability
Precipitation Intensity (mm/day)
x = 100.2 mm/day
x' = 115.2 mm/day
Gage Observations (gage: BEAR)
ECHAM5-WRF simulations for Period 1970-1999
ECHAM5-WRF simulations for period 2040-2069


Sammamish Plateau Region 02W
Non-Exceedance Probability
Precipitation Intensity (mm/day)
x = 100.2 mm/day
x' = 103.3 mm/day
Gage Observations (gage: 02w)
ECHAM5-WRF simulations for Period 1970-1999
ECHAM5-WRF simulations for period 2040-2069

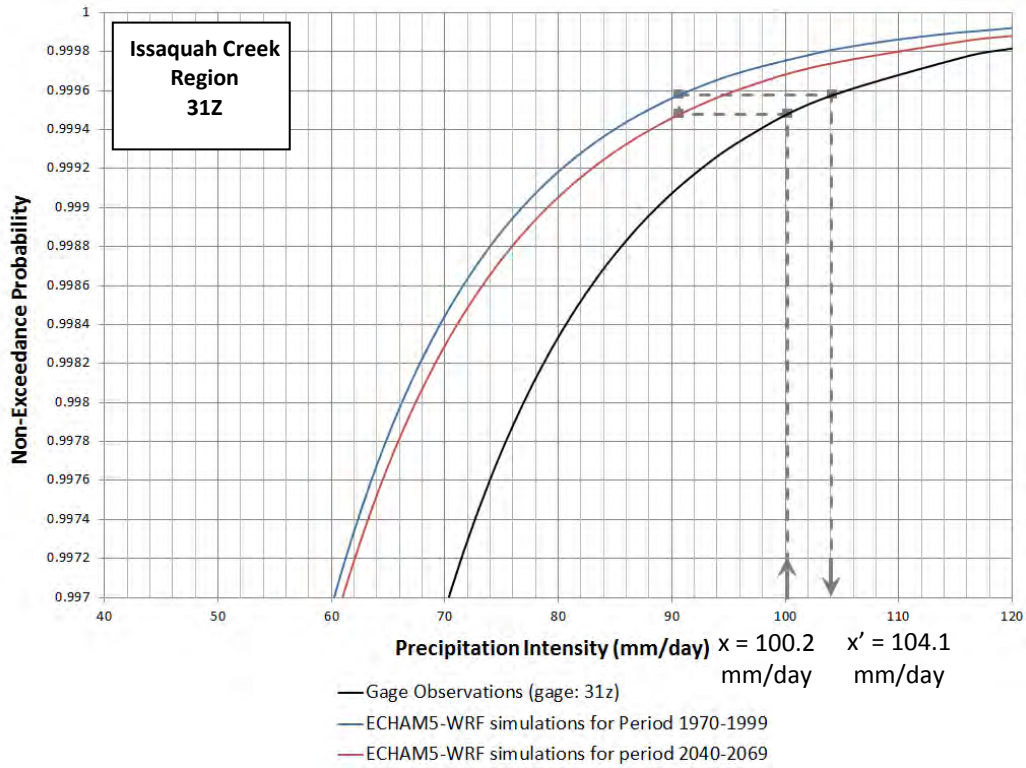


Figure A-5. (top panel) Graphical representation of the calculations in the case example. The lines show the fitted extreme-value distributions. The observed gage value 100.2 mm/day is replaced with value 115.2 mm/day in the future time series that represents the MPI-ESM-LR scenario. The change in the non-exceedance probability in the observations-based distribution (from 0.999819 for 100.2 mm/day to 0.999913 for 115.2 mm/day) is the same as the change from the historical GCM simulation (blue line) to the future GCM simulation (red line). (center panel) Similar, but for an example gage in the Sammamish Plateau region. (bottom panel) Similar, but for an example gage in the Issaquah Creek region.

4 HSPF FUTURE PRECIPITATION TIME SERIES

A future daily precipitation time series was derived from the observed record for each of the 18 gages as described above. This produced 66-year future scenario records (water years 1949-2014) corresponding to the observed records used in the HSPF modeling. Despite the 66-year record length, each future scenario time series represents the climate conditions for a 30-year time horizon (2040-2069). Comparisons of current and future scenario daily precipitation are displayed for all 18 gages (by precipitation region) in Figure A-6 through Figure A-8. In these figures, the observed daily precipitation values are plotted on the x-axis, while the modified future daily values are plotted on the y-axis. The replacement of some dry days (chosen randomly) by wet days is seen in the points that fall directly on the y-axis.

Future scenario daily values were disaggregated to a 15-minute time series using the 15-minute temporal distribution recorded by the gage on that day. This simple method of disaggregation, which

does not account for variability in sub-daily precipitation distribution, is adequate in light of the small or moderate projected changes in daily intensity. However, it does not address potential changes in short-duration precipitation intensities or in storm patterns or timing.

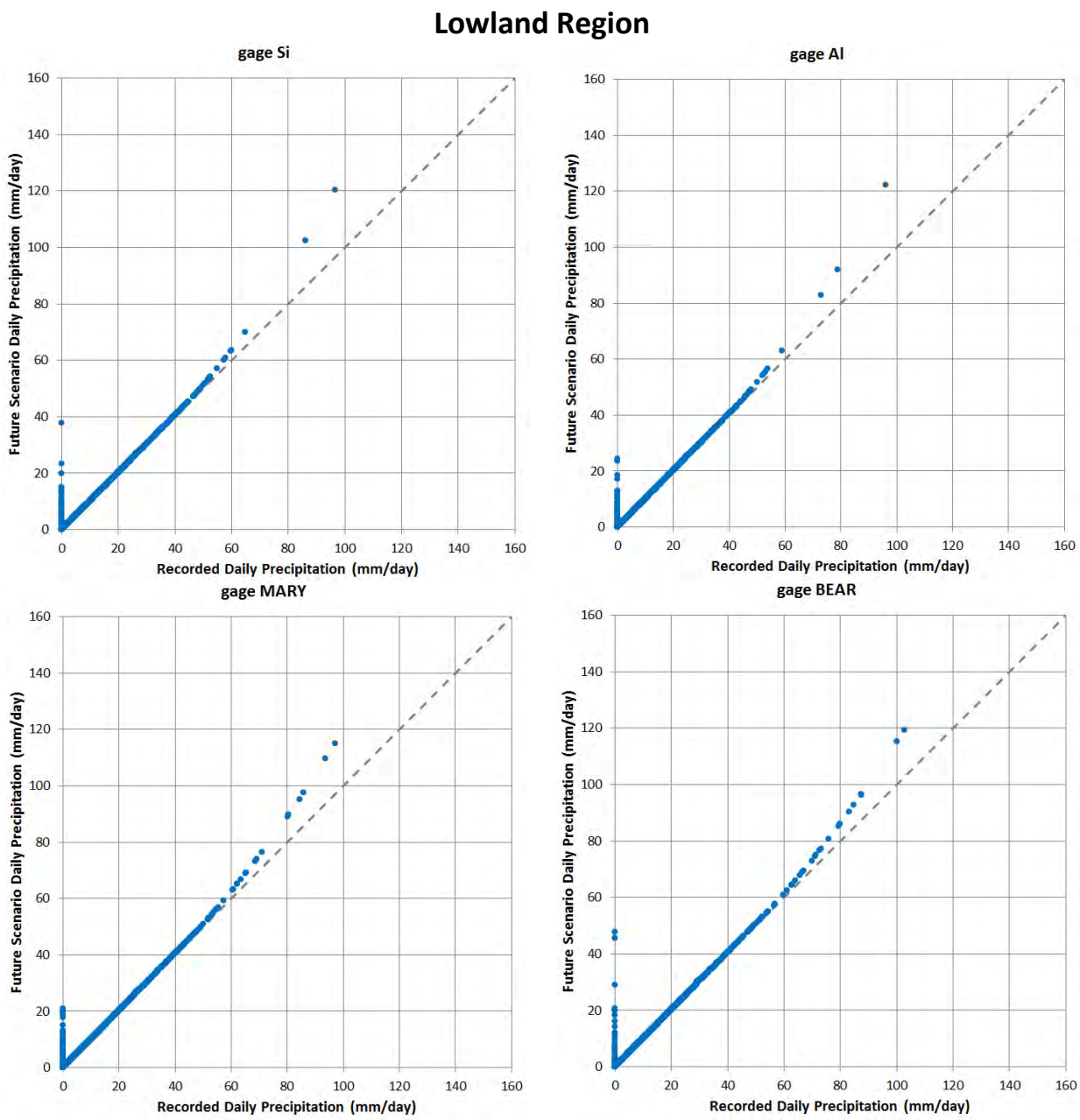
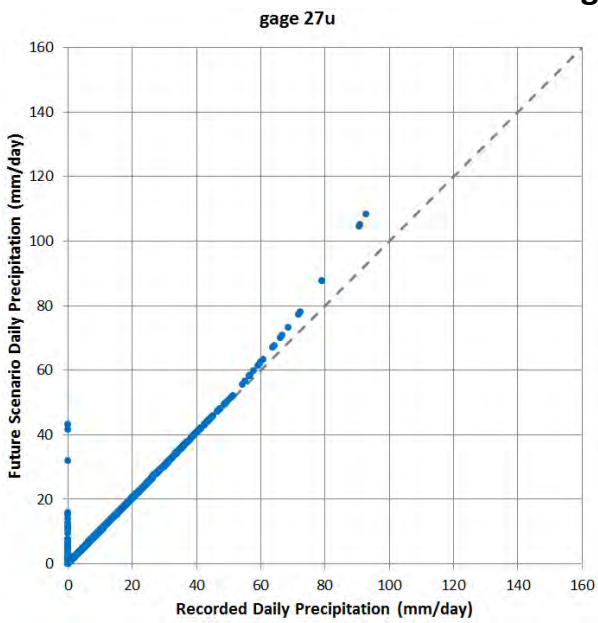
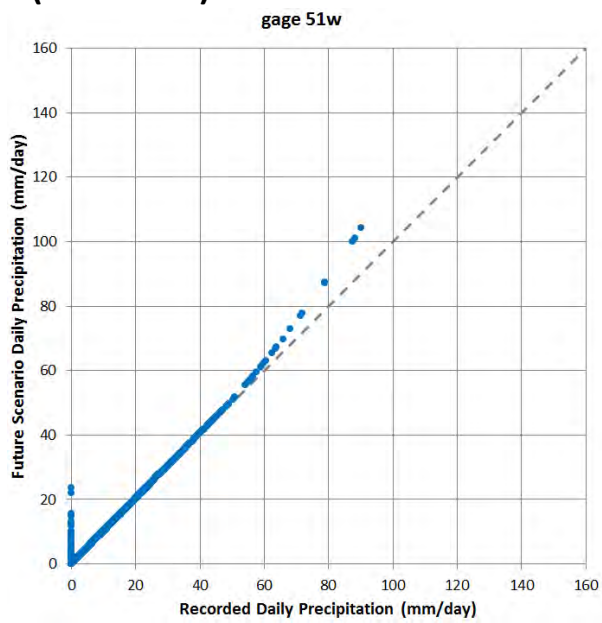
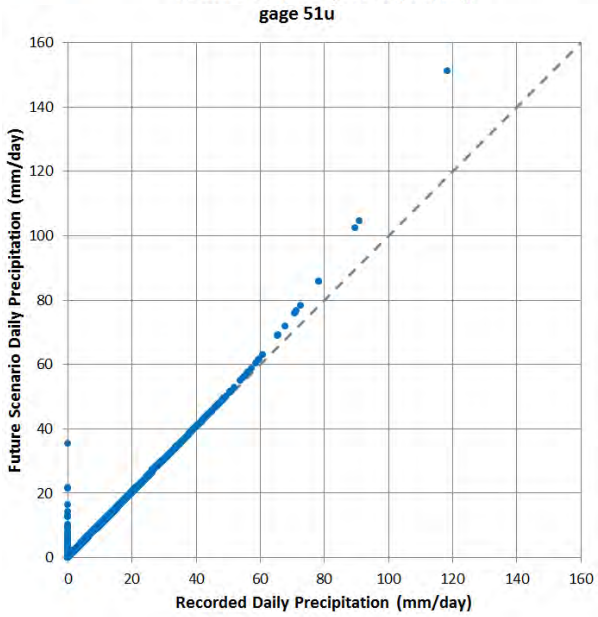


Figure A-6. Daily precipitation values recorded at each gage (x axis) and after modification to represent the future climate scenario (y axis), for the gages located in the Lowland region. ***(Figure continues on the next page.)***

Lowland Region (continued)







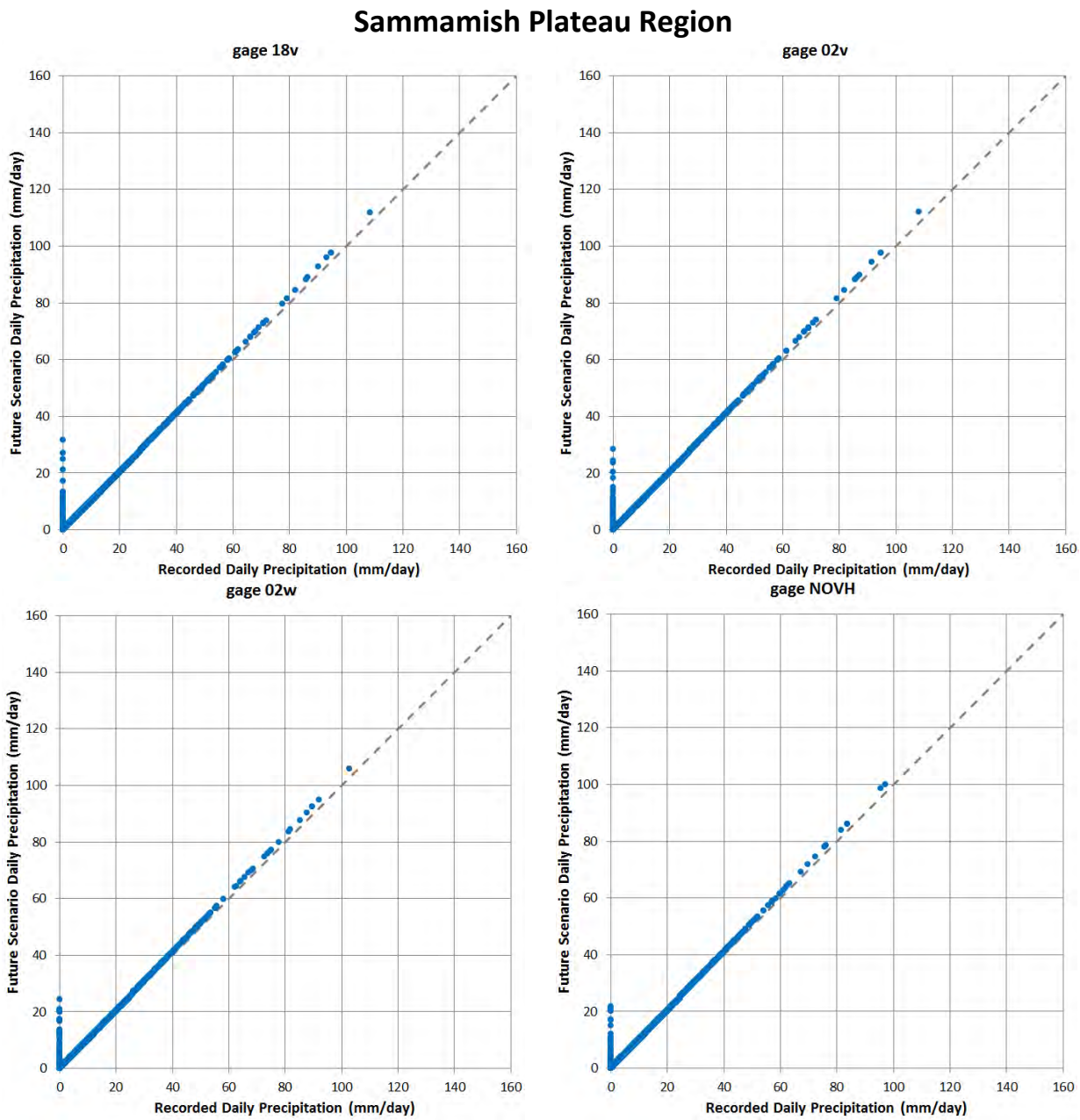
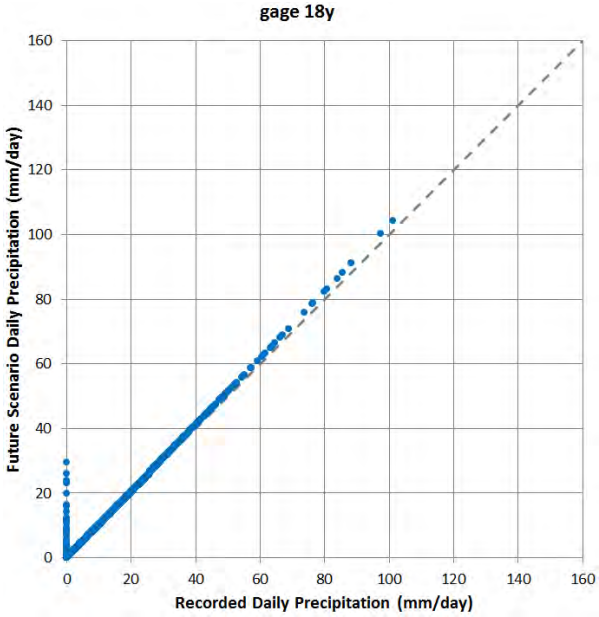
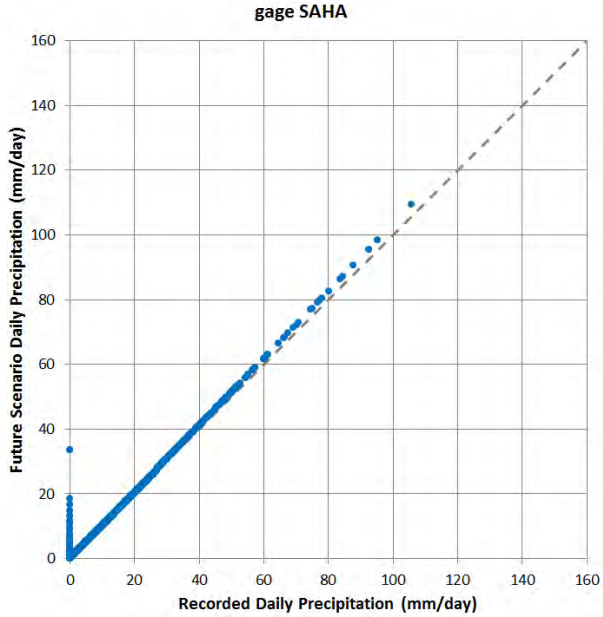
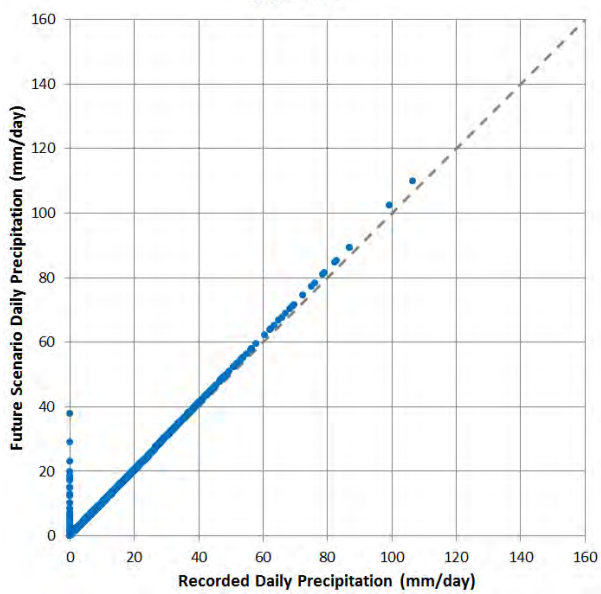


Figure A-7. Daily precipitation values recorded at each gage (x axis) and after modification to represent the future climate scenario (y axis), for the gages located in the Sammamish Plateau region. ***(Figure continues on the next page.)***

Sammamish Plateau Region (continued)







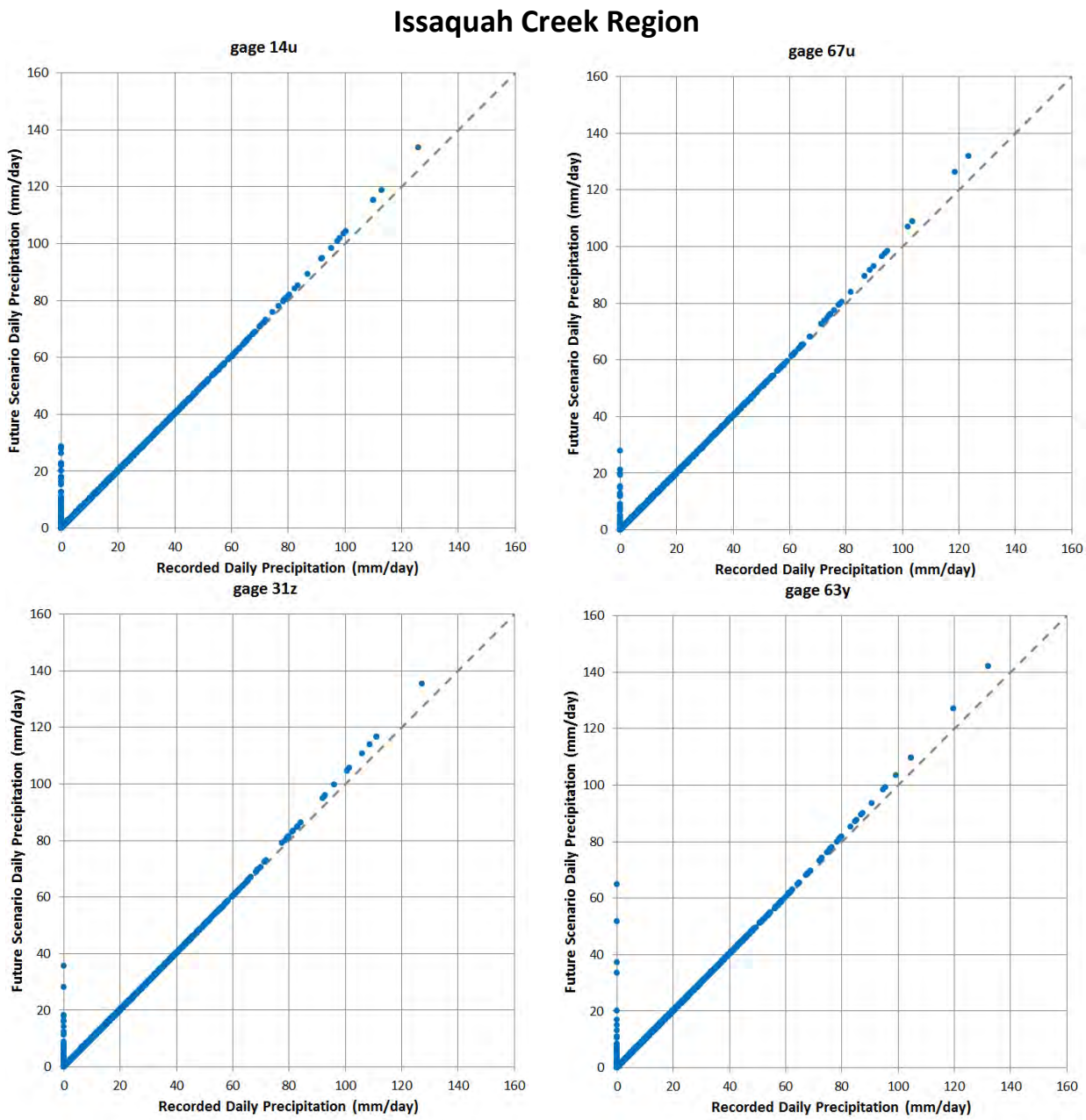


Figure A-8. Daily precipitation values recorded at each gage (x axis) and after modification to represent the future climate scenario (y axis), for the gages located in the Issaquah Creek region.

5 UNCERTAINTY ASSOCIATED WITH CLIMATE MODEL PROJECTIONS AND LIMITATIONS OF THIS STUDY

While there is a need to provide quantitative information for water resources planning and flood protection planning, the underlying projections of climate change and changes in extreme flows are subject to large and unquantifiable uncertainty (e.g. Kundewicz et al., 2013). The main sources of uncertainty are unknown future emissions of greenhouse gases, uncertain response of the global climate system to increases in greenhouse gas concentrations, and incomplete understanding of regional manifestations that will result from global changes (e.g., Hawkins and Sutton 2010). Additionally, precipitation processes are very complex and difficult to simulate accurately in models.

The downscaling, in space and time, of GCM-projected climate variables and the use of extreme value analysis for time series that are only a few decades long, represent additional sources of uncertainty in this analysis. The precipitation projections developed in this work should therefore be considered to be plausible representations of the future, given the best current scientific information, and do not represent specific predictions. The actual future realizations of precipitation in the Lake Sammamish watershed will differ from the scenario developed here, and their difference compared to historical precipitation may be greater or smaller than the differences projected in this work.

6 ACKNOWLEDGEMENT

We thank Alan Hamlet (U. Notre Dame) and Se-Yeun Lee (U. Washington) for making the ECHAM5-WRF simulation results available for this study.

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Appendix E – Cost Estimates for Channel and Cold-Water Concepts and O&M Costs

Channel Concept Cost Estimates

Client: King County - Willowmoor
Project: Transition Zone Modification
Subject: Concept Alternative Cost Estimate Details
Alternative 2 - Main Channel Meander
Date : 27-Apr-15

Item	Description	Quantity	Unit	Unit cost, $		Cost, $
1	**Preparation**					
	Mobilization	1	ls	10%	$	251,820
	Clearing and Grubbing	1	ls	$30,000	$	30,000
				subtotal	$	281,820
2	**Main Channel Site Work**					
	Channel Excavation	70,000	cy	$20	$	1,400,000
	Habitat Wood	50	ea	$1,200	$	60,000
	Boulders	50	ea	$350	$	17,500
	Mechanical Anchors	100	ea	$150	$	15,000
	Streambed Gravels	8,815	tn	$35	$	308,500
	Weir Reconfiguration	1	ls	$30,000	$	30,000
				subtotal	$	1,831,000
4	**Dewatering/Water Isolation**					
	Localized Pumping	5	ls	$20,000	$	100,000
	Temporary Diversion Structure	2	ls	$20,000	$	40,000
	Water isolation at downstream	1	ls	$40,000	$	40,000
	Channel Excavation	20,400	cy	$20	$	408,000
	Streambed Gravels	2,833	tn	$35	$	99,200
				subtotal	$	687,200
5	**Plantings and Revegetation**					
	Site Preparation	1	ls	$155,000	$	155,000
	Plants (Installed)	1	ls	$287,428	$	287,400
	Mulch (Installed)	1	ls	$81,150	$	81,200
	Watering	1	ls	$165,156	$	165,200
	Weeding	1	ls	$133,280	$	133,300
				subtotal	$	822,100
	Total Estimated Direct Costs (Rounded)				$	3,622,000
	Contingency	30.0%			$	1,087,000
	Sales Tax (City of Redmond)	9.5%			$	447,000
	Subtotal				**$**	**5,156,000**
	Engineering (Design and Construction)	15.0%			$	773,000
	Administration	10.0%			$	516,000
	Alternative 2 - Total Estimated Project Costs					**$6,445,000**

Client: King County - Willowmoor
Project: Transition Zone Modification
Subject: Concept Alternative Cost Estimate Details
Alternative 3 - Main Channel Meander with Hyporheic Channel
Date : 27-Apr-15

Item	Description	Quantity	Unit	Unit cost, $		Cost, $
1	**Preparation**					
	Mobilization	1	ls	10%	$	825,730
	Clearing and Grubbing	1	ls	$30,000	$	30,000
				subtotal	$	855,730
2	**Main Channel Site Work**					
	Channel Excavation	70,000	cy	$20	$	1,400,000
	Habitat Wood	50	ea	$1,200	$	60,000
	Boulders	50	ea	$350	$	17,500
	Mechanical Anchors	100	ea	$150	$	15,000
	Streambed Gravels	8,815	tn	$35	$	308,500
	Weir Reconfiguration	1	ls	$30,000	$	30,000
				subtotal	$	1,831,000
3	**Hyporheic Channel Site Work**					
	Channel Excavation	205,000	cy	$20	$	4,100,000
	Streambed Gravels	52,133	tn	$35	$	1,824,700
	Habitat Wood	115	ea	$1,200	$	138,000
	Boulders	115	ea	$350	$	40,300
	Mechanical Anchors	230	ea	$150	$	34,500
	Side Channel control structure	1	ls	$50,000	$	50,000
				subtotal	$	6,187,500
4	**Dewatering/Water Isolation**					
	Localized Pumping	5	ls	$20,000	$	100,000
	Temporary Diversion Structure	2	ls	$20,000	$	40,000
	Water isolation at downstream	1	ls	$40,000	$	40,000
	Channel Excavation	2,690	cy	$20	$	53,800
	Streambed Gravels	142	tn	$35	$	5,000
				subtotal	$	238,800
5	**Plantings and Revegetation**					
	Site Preparation	1	ls	$155,000	$	155,000
	Plants (Installed)	1	ls	$287,428	$	287,400
	Mulch (Installed)	1	ls	$81,150	$	81,200
	Watering	1	ls	$165,156	$	165,200
	Weeding	1	ls	$133,280	$	133,300
				subtotal	$	822,100

Total Estimated Direct Costs (Rounded)		$	9,935,000
Contingency	30.0%	$	2,981,000
Sales Tax (City of Redmond)	9.5%	$	1,227,000
Subtotal		**$**	**14,143,000**
Engineering (Design and Construction)	15.0%	$	2,121,000
Administration	10.0%	$	1,414,000
Alternative 3 - Total Estimated Project Costs			**$17,678,000**

Client: King County - Willowmoor
Project: Transition Zone Modification
Subject: Concept Alternative Cost Estimate Details
Alternative 4 - Main Channel Modification with Side Channel
Date : 27-Apr-15

Item	Description	Quantity	Unit	Unit cost, $		Cost, $
1	**Preparation**					
	Mobilization	1	ls	10%	$	342,740
	Clearing and Grubbing	1	ls	$30,000	$	30,000
				subtotal	$	372,740
2	**Main Channel Site Work**					
	Channel Excavation	30,185	cy	$20	$	603,700
	Habitat Wood	50	ea	$1,200	$	60,000
	Boulders	50	ea	$350	$	17,500
	Mechanical Anchors	100	ea	$150	$	15,000
	Streambed Gravels	8,815	tn	$35	$	308,500
	Weir Reconfiguration	1	ls	$30,000	$	30,000
				subtotal	$	1,034,700
3	**Side Channel Site Work**					
	Channel Excavation	93,900	cy	$20	$	1,878,000
	Streambed Gravels	3,230	tn	$35	$	113,100
	Habitat Wood	115	ea	$1,200	$	138,000
	Boulders	115	ea	$350	$	40,300
	Mechanical Anchors	230	ea	$150	$	34,500
	Side Channel control structure	1	ls	$50,000	$	50,000
				subtotal	$	2,253,900
4	**Dewatering/Water Isolation**					
	Localized Pumping	1	ls	$20,000	$	20,000
	Temporary Diversion Structure	1	ls	$20,000	$	20,000
	Water isolation at downstream	1	ls	$40,000	$	40,000
	Channel Excavation	2,690	cy	$20	$	53,800
	Streambed Gravels	142	tn	$35	$	5,000
				subtotal	$	138,800
5	**Plantings and Revegetation**					
	Site Preparation	1	ls	$155,000	$	155,000
	Plants (Installed)	1	ls	$287,428	$	287,400
	Mulch (Installed)	1	ls	$81,150	$	81,200
	Watering	1	ls	$165,156	$	165,200
	Weeding	1	ls	$133,280	$	133,300
				subtotal	$	822,100

Total Estimated Direct Costs (Rounded)		$	4,622,000
Contingency	30.0%	$	1,387,000
Sales Tax (City of Redmond)	9.5%	$	571,000
Subtotal		**$**	**6,580,000**
Engineering (Design and Construction)	15.0%	$	987,000
Administration	10.0%	$	658,000
Alternative 4 - Total Estimated Project Costs			**$8,225,000**

Client: King County - Willowmoor
Project: Transition Zone Modification
Subject: Concept Alternative Cost Estimate Details
Alternative 5 - Main Channel Modification
Date : 27-Apr-15

Item	Description	Quantity	Unit	Unit cost, $		Cost, $
1	**Preparation**					
	Mobilization	1	ls	10%	$	164,190
	Clearing and Grubbing	1	ls	$30,000	$	30,000
				subtotal	$	194,190
2	**Main Channel Site Work**					
	Channel Excavation	30,185	cy	$20	$	603,700
	Habitat Wood	50	ea	$1,200	$	60,000
	Boulders	50	ea	$350	$	17,500
	Mechanical Anchors	100	ea	$150	$	15,000
	Streambed Gravels	8,815	tn	$35	$	308,500
	Weir Reconfiguration	1	ls	$30,000	$	30,000
				subtotal	$	1,034,700
3	**Dewatering/Water Isolation**					
	Localized Pumping	1	ls	$20,000	$	20,000
	Temporary Diversion Structure at upstream	2	ls	$20,000	$	40,000
	Water isolation at downstream	1	ls	$40,000	$	40,000
	Channel Excavation	20,400	cy	$20	$	408,000
	Streambed Gravels	2,833	tn	$35	$	99,200
				subtotal	$	607,200
4	**Plantings and Revegetation**					
	Site Preparation	1	ls	$100,370	$	100,400
	Plants (Installed)	1	ls	$99,886	$	99,900
	Mulch (Installed)	1	ls	$64,480	$	64,500
	Watering	1	ls	$42,912	$	42,900
	Weeding	1	ls	$56,385	$	56,400
				subtotal	$	364,100
	Total Estimated Direct Costs (Rounded)				$	2,200,000
	Contingency	30.0%			$	660,000
	Sales Tax (City of Redmond)	9.5%			$	272,000
	Subtotal				**$**	**3,132,000**
	Engineering (Design and Construction)	15.0%			$	470,000
	Administration	10.0%			$	313,000
	Alternative 5 - Total Estimated Project Costs					**$3,915,000**

Cold-Water Concept Cost Estimates

T31746 King County - Willowmoor
Task 6 Cold Water Supplementation
Concept Alternative Cost Estimate Details
Concept 1-Hypoliminetic Withdrawal From Lake Sammamish (20 cfs)
Date : 6-Jun-14

Item	Description	Quantity	Unit	Unit cost, $		Cost, $
1	**Mobilization/Demobilization/Testing**					
	Assume 8% of subtotal for items 2-5	1	ls	$242,300	**$**	**242,300**
2	**Sitework**					
	Pump Site					
	Archaeological monitoring (SHPO standards) allowance	1	ls	$10,000	$	10,000
	Erosion control	1	ls	$5,000	$	5,000
	Clear & grub	1	ls	$5,000	$	5,000
	Excavation - Pipelines	640	cy	$15	$	9,600
	Excavation - Pump station	40	cy	$20	$	800
	Turbidity Curtain	200	lf	$15	$	3,000
	Haul waste to disposal	1,300	ton	$10	$	13,000
	Imported fill - Pipeline & Pump Station	1,300	ton	$15	$	19,500
	Trench shoring	1	ls	$5,000	$	5,000
	Dewatering for pipeline and pump station	5	days	$200	$	1,000
	Crushed Surfacing Base Course	100	cy	$30	$	3,000
	Discharge Site At Weir					
	Archaeological monitoring (SHPO standards) allowance	1	ls	$10,000	$	10,000
	Erosion control	1	ls	$2,000	$	2,000
	Clear & grub	1	ls	$2,000	$	2,000
	Excavation - Pipelines	210	cy	$15	$	3,200
	Turbidity Curtain	200	lf	$15	$	3,000
	Haul waste to disposal	400	ton	$10	$	4,000
	Imported fill - Pipeline	400	ton	$20	$	8,000
	Trench shoring	1	ls	$2,000	$	2,000
	Dewatering for pipeline construction	2	days	$200	$	400
	Rip Rap Energy Dissipation	30	ton	$40	$	1,200
	Weir retrofit contingency allowance	1	ls	$5,000	$	5,000
	Subtotal, Sitework				**$**	**115,700**

Item	Description	Quantity	Unit	Unit cost, $		Cost, $
3	**Piping**					
	Intake To Pump Station					
	HDPE Intake MH & Cone Style Fish Screen	1	allow	$50,000	$	50,000
	36" HDPE DIPS DR 21 Intake Pipe	16,000	lf	$141	$	2,256,000
	36" Precast Pipe Anchors	640	ea	$300	$	192,000
	4 - work boats for pipe positioning	1	ls	$10,000	$	10,000
	30" HDPE DIPS DR 21 PS Transition Pipe	150	lf	$105	$	15,800
	30" Valve	1	ea	$25,000	$	25,000
	30" 45 Deg Bend	4	ea	$732	$	2,900
	36x30 Reducer	1	ea	$1,000	$	1,000
	Discharge From Pump Station					
	18" HDPE DIPS DR 21 PS Transition Pipe	150	lf	$42	$	6,300
	18" Valve	1	ea	$20,000	$	20,000
	18" 45 Deg Bend	8	ea	$224	$	1,800
	24x18 Reducer	1	ea	$500	$	500
	24" HDPE DIPS DR 21 Discharge Pipe	2,000	lf	$69	$	138,000
	24" Precast Pipe Anchors	80	ea	$300	$	24,000
	Discharge Site At Weir					
	24" HDPE DIPS DR 21 PS Transition Pipe	150	lf	$69	$	10,400
	24" 45 Deg Bend	5	ea	$371	$	1,900
	Subtotal, Piping				**$**	**2,755,600**
4	**Structural and Architectural**					
	Pump Station					
	Slab on grade (10'x20'x8")	5	cy	$250	$	1,200
	Pump building (timber frame, 8'x16')	128	sf	$200	$	25,600
	Subtotal, Structural and Architectural				**$**	**26,800**
5	**Mechanical**					
	Pump Station					
	Vertical Turbine Pump (single pump, with no backup pum	1	ea	$126,000	$	126,000
	Building space heater and passive ventilation	1	ls	$5,000	$	5,000
	Subtotal, Mechanical				**$**	**131,000**

Item	Description	Quantity	Unit	Unit cost, $		Cost, $
6	**Electrical**					
	Pump Station					
	Pump station power and control panel	1	allow	$100,000	$	100,000
	2-3" PVC direct bury conduit	500	lf	$20	$	10,000
	Power extension to pump station	500	lf	$20	$	10,000
	Meter & shutoff	1	ls	$500	$	500
	Electrical contingency allowance	1	ls	$2,500	$	2,500
	Subtotal, Electrical and Control				**$**	**123,000**
7	**Intrumentation and Control**					
	Included in electrical in section 6				**$**	**-**
	Subtotal, Intrumentation and Control				**$**	**-**
8	**Site Restoration**					
	Pump Station					
	Site landscaping	1	ls	$2,000	$	2,000
	Discharge Below Existing Weir					
	Key Logs	3	ea	$500	$	1,500
	Imported topsoil	100	cy	$15	$	1,500
	Wetland landscaping	1	ls	$2,000	$	2,000
	Subtotal, Site Restoration				**$**	**7,000**
	Total Estimated Direct Costs (Rounded)				$	3,401,000
	General Contractor Overhead and Profit	15.0%			$	510,000
	Subtotal				**$**	**3,911,000**
	Contingency	30.0%			$	1,173,000
	Sales Tax (City of Redmond)	9.5%			$	483,000
	Subtotal					**$5,567,000**
	Engineering (Design and Construction)	15.0%			$	835,000
	Administration	10.0%			$	557,000
	Alternative 1 - Total Estimated Project Costs					**$6,959,000**

Client: T31746 King County - Willowmoor
Project: Task 6 Cold Water Supplementation
Subject: Concept Alternative Cost Estimate Details
Concept 2-Pumped Groundwater to Pools
Date : 6-Jun-14

Item	Description	Quantity	Unit	Unit cost, $		Cost, $
1	**Mobilization/Demobilization/Testing**					
	Assume 8% of subtotal for items 2-5	1	ls	$70,800	**$**	**70,800**
2	**Sitework**					
	Well Site					
	New well	1	ls	$50,000	$	50,000
	Site fencing, landscaping, driveway etc	1	ls	$75,000	$	75,000
	Erosion control	1	ls	$2,000	$	2,000
	Trench shoring	1	ls	$10,000	$	10,000
	Dewatering for pump station wet well	14	days	$500	$	7,000
	Transition Zone Pools					
	Transition Zone Resting Pools - sitework by others during channel reconfiguration project				$	-
					$	**144,000**
3	**Piping**					
	8" HDPE pipe	3,500	lf	$30	$	105,000
	Pipe valves and appertenances	1	ls	$15,000	$	15,000
	Excavation Pipe Trench	4,000	cy	$20	$	80,000
	Pipe Trench Bedding	2,500	cy	$35	$	87,500
	Trench Restoration - Hydroseed	0.75	ac	$5,000	$	3,800
	River outfall locations energy dissipation & pool excavation	1	ls	$50,000	$	50,000
	36" PVC C905 DR 25 Gravity Sewer	0	lf	$250	$	-
	Subtotal, Piping				**$**	**341,300**
4	**Structural and Architectural**					
	Pump Builiding	1	ls	$300,000	$	300,000
	Subtotal, Structural and Architectural				**$**	**300,000**
5	**Mechanical**					
	Pump 25 hp w/ controls, electric hook up, plumb, mech for pump	1	ls	$100,000	$	100,000

Item	Description	Quantity	Unit	Unit cost, $		Cost, $
	Subtotal, Mechanical				**$**	**100,000**
6	**Electrical**					
	Pump station power and control panel	1	allow	$100,000	$	100,000
	Subtotal, Electrical and Control				**$**	**100,000**
7	**Intrumentation and Control**					
	Included in electrical in section 6				**$**	**-**
	Subtotal, Intrumentation and Control				**$**	**-**
8	**Site Restoration**					
	Included in Section 3 pipe and Section 2 well site, above				$	-
	Transition Zone Resting Pools - restoration by others during channel reconfiguration project				$	-
	Subtotal, Site Restoration				**$**	**-**
	Total Estimated Direct Costs (Rounded)				$	1,056,000
	General Contractor Overhead and Profit	15.0%			$	158,000
	Subtotal				**$**	**1,214,000**
	Contingency	30.0%			$	364,000
	Sales Tax (City of Redmond)	9.5%			$	150,000
	Subtotal					**$1,728,000**
	Engineering (Design and Construction)	15.0%			$	259,000
	Administration	10.0%			$	173,000
	Alternative 2 - Total Estimated Project Costs					**$2,160,000**

T31746 King County - Willowmoor
Task 6 Cold Water Supplementation
Concept Alternative Cost Estimate Details
Concept 3-Shallow Groundwater Trench(es) to Pools
Date : 6-Jun-14

Item	Description	Quantity	Unit	Unit cost, $		Cost, $
1	**Mobilization/Demobilization/Testing**					
	Assume 8% of subtotal for items 2-5	1	ls	$26,900	**$**	**26,900**
2	**Sitework**					
	Groundwater Trench(es)					
	Archaeological monitoring (SHPO standards) allowance	1	ls	$20,000	$	20,000
	Erosion control	1	ls	$2,000	$	2,000
	Clear & grub	1	ls	$2,000	$	2,000
	Excavation - Pipelines	4,300	cy	$15	$	64,500
	Haul waste to disposal	8,000	ton	$10	$	80,000
	Imported free draining fill - Pipeline	8,000	ton	$15	$	120,000
	Trench shoring	1	ls	$2,000	$	2,000
	Dewatering during trench work	7	days	$200	$	1,400
	Transition Zone Pools					
	Transition Zone Resting Pools - sitework by others during channel reconfiguration project				$	-
	Subtotal, Sitework				**$**	**291,900**
3	**Piping**					
	Intake System					
	Transiton zone discharge assembly	4	ea	$250	$	1,000
	8" perforated pipe	2,000	lf	$20	$	40,000
	Cleanouts	5	ea	$200	$	1,000
	Tosh Creek intake assembly	1	ea	$2,000	$	2,000
	Subtotal, Piping				**$**	**44,000**

Item	Description	Quantity	Unit	Unit cost, $		Cost, $
4	**Structural and Architectural**					
	Not applicable - no structures				$	-
	Subtotal, Structural and Architectural				**$**	**-**
5	**Mechanical**					
	Not applicable - no mechanical system				$	-
	Subtotal, Mechanical				**$**	**-**
6	**Electrical**					
	Not applicable - no electrical system				$	-
	Subtotal, Electrical and Control				**$**	**-**
7	**Intrumentation and Control**					
	Not applicable - no I&C system				**$**	**-**
	Subtotal, Intrumentation and Control				**$**	**-**
8	**Site Restoration**					
	Surface restoration & landscaping	1	ls	$5,000	$	5,000
	Transition Zone Resting Pools - restoration by others during channel reconfiguration project				$	-
	Subtotal, Site Restoration				**$**	**5,000**
	Total Estimated Direct Costs (Rounded)				$	368,000
	General Contractor Overhead and Profit	15.0%			$	55,200
	Subtotal				**$**	**423,000**
	Contingency	30.0%			$	127,000
	Sales Tax (City of Redmond)	9.5%			$	52,000
	Subtotal					**$602,000**
	Engineering (Design and Construction)	15.0%			$	90,000
	Administration	10.0%			$	60,000
	Alternative 3 - Total Estimated Project Costs					**$752,000**

T31746 King County - Willowmoor
Task 6 Cold Water Supplementation
Concept Alternative Cost Estimate Details
Concept 4-Purchase Potable Water & Pipe To Pools
Date : 6-Jun-14

Item	Description	Quantity	Unit	Unit cost, $	Cost, $
1	**Mobilization/Demobilization/Testing**				
	Assume 8% of subtotal for items 2-5	1	ls	$30,800	**$ 30,800**
2	**Sitework**				
	Water Meter 4"	1	ls	$10,000	$ 10,000
	City of Redmond Connection Fee	1	ls	$155,000	$ 155,000
	Trench shoring	1	ls	$5,000	$ 5,000
	Dewatering for pipeline construction	30	days	$500	$ 15,000
	Transition Zone Pools				
	Transition Zone Resting Pools - sitework by others during channel reconfiguration project				$ -
	Subtotal, Sitework				**$ 185,000**
3	**Piping**				
	4" HDPE	2,000	lf	$15	$ 30,000
	Pipe valves and appertenances	1	ls	$15,000	$ 15,000
	Excavation - Pipe Trench	2,500	cy	$20	$ 50,000
	Backfill Pipe Bedding	1,500	cy	$35	$ 52,500
	Trench Restoration - Hydroseed	0.50	ac	$5,000	$ 2,500
	River outfall locations energy dissipation & pool excavatio	1	ls	$50,000	$ 50,000
	Subtotal, Piping				**$ 200,000**
4	**Structural and Architectural**				
	Not applicable - no structures				$ -
	Subtotal, Structural and Architectural				**$ -**
5	**Mechanical**				
	Not applicable - no mechanical system				$ -
	Subtotal, Mechanical				**$ -**

Item	Description	Quantity	Unit	Unit cost, $	Cost, $
6	**Electrical**				
	Not applicable - no electrical system				$ -
	Subtotal, Electrical and Control				**$ -**
7	**Intrumentation and Control**				
	Not applicable - no I&C system				**$ -**
	Subtotal, Intrumentation and Control				**$ -**
8	**Site Restoration**				
	Included in Section 3 piping				$ -
	Transition Zone Resting Pools - restoration by others during channel reconfiguration project				$ -
	Subtotal, Site Restoration				**$ -**
	Total Estimated Direct Costs (Rounded)				$ 416,000
	General Contractor Overhead and Profit	15.0%			$ 62,400
	Subtotal				**$ 478,000**
	Contingency	30.0%			$ 143,000
	Sales Tax (City of Redmond)	9.5%			$ 59,000
	Subtotal				**$680,000**
	Engineering (Design and Construction)	15.0%			$ 102,000
	Administration	10.0%			$ 68,000
	Alternative 4 - Total Estimated Project Costs				**$850,000**

T31746 King County - Willowmoor
Task 6 Cold Water Supplementation
Concept Alternative Cost Estimate Details
Concept 5-Pump Lake Water To Heat Exchange System
Date : 6-Jun-14

Item	Description	Quantity	Unit	Unit cost, $		Cost, $
1	**Mobilization/Demobilization/Testing**					
	Assume 8% of subtotal for items 2-5	1	ls	$86,100	**$**	**86,100**
2	**Sitework**					
	Pump Site					
	Archaeological monitoring (SHPO standards) allowance	1	ls	$10,000	$	10,000
	Erosion control	1	ls	$5,000	$	5,000
	Clear & grub	1	ls	$5,000	$	5,000
	Trench shoring	1	ls	$5,000	$	5,000
	Excavation - Pipelines	640	cy	$15	$	9,600
	Excavation - Pump station	40	cy	$20	$	800
	Turbidity Curtain	200	lf	$15	$	3,000
	Haul waste to disposal	1,300	ton	$10	$	13,000
	Imported fill - Pipeline & Pump Station	1,300	ton	$15	$	19,500
	Dewatering for pipeline and pump station	5	days	$200	$	1,000
	Crushed Surfacing Base Course	100	cy	$30	$	3,000
	Upland Pipe From Pump Station To Heat Exchange To Transition Zone Discharge					
	Archaeological monitoring (SHPO standards) allowance	1	ls	$10,000	$	10,000
	Erosion control	1	ls	$2,000	$	2,000
	Clear & grub	1	ls	$2,000	$	2,000
	Trench shoring	1	ls	$2,000	$	2,000
	Excavation - Conveyance Pipelines	2,300	cy	$15	$	34,500
	Excavation - Heat Exchange Pipe Trench	3,200	cy	$15	$	48,000
	Haul waste to disposal	10,200	ton	$10	$	102,000
	Imported fill - Pipeline	10,200	ton	$15	$	153,000
	Dewatering for pipeline construction	2	days	$200	$	400
	Transition Zone Pools					
	Transition Zone Resting Pools - sitework by others during channel reconfiguration project				$	-
	Subtotal, Sitework				**$**	**428,800**

3	**Piping**					
	Intake To Pump Station					
	Fish Screen Assembly	1	ls	$2,000	$	2,000
	16" HDPE DIPS DR 21 Intake Assembly	1	ls	$3,000	$	3,000
	16" HDPE DIPS DR 21 Intake Pipe	130	lf	$66	$	8,600
	36" Precast Pipe Anchors	2	ea	$240	$	500
	Work boat for pipe intake positioning	2	day	$200	$	400
	16x12 Reducer	1	ea	$1,575	$	1,600
	12" HDPE DIPS DR 21 PS Transition Pipe	20	lf	$35	$	700
	12" Valve	1	ea	$5,400	$	5,400
	16" 45 Deg Bend	4	ea	$1,575	$	6,300
	Upland Pipe From Pump Station To Heat Exchange To Transition Zone Discharge					
	12" HDPE DIPS DR 21 PS Transition Pipe	20	lf	$35	$	700
	12" Valve	1	ea	$5,400	$	5,400
	16x12 Reducer	1	ea	$1,575	$	1,600
	16" 45 Deg Bend	4	ea	$1,575	$	6,300
	16" HDPE DIPS DR 21 Discharge Pipe	1,100	lf	$66	$	72,600
	Heat Exchange Pipe Transition	2	ea	$5,000	$	10,000
	6" Heat Exchange Pipe	18,000	ea	$15	$	270,000
	Transition Zone Pipe Discharge to Pools					
	16x6 Wye	4	ea	$1,575	$	6,300
	16" Cleanout/Blowoff	1	ea	$1,575	$	1,600
	6" Valve	4	ea	$1,300	$	5,200
	6" Distribution Pipe	600	lf	$15	$	9,000
	Subtotal, Piping				**$**	**415,200**
4	**Structural and Architectural**					
	Pump Station					
	Slab on grade (10'x20'x8")	5	cy	$250	$	1,200
	Pump building (timber frame, 8'x16')	128	sf	$200	$	25,600
	Subtotal, Structural and Architectural				**$**	**26,800**

5	**Mechanical**					
	Pump Station					
	Pump System	1	ea	$200,000	$	200,000
	Building space heater and passive ventilation	1	ls	$5,000	$	5,000
	Subtotal, Mechanical				**$**	**205,000**
6	**Electrical**					
	Pump Station					
	Pump station power and control panel	1	allow	$75,000	$	75,000
	2-3" PVC direct bury conduit	500	lf	$20	$	10,000
	Power extension to pump station	500	lf	$20	$	10,000
	Meter & shutoff	1	ls	$500	$	500
	Electrical contingency allowance	1	ls	$2,500	$	2,500
	Subtotal, Electrical and Control				**$**	**98,000**
7	**Intrumentation and Control**					
	Included in electrical in section 6				**$**	**-**
	Subtotal, Intrumentation and Control				**$**	**-**
8	**Site Restoration**					
	Pump Station					
	Site landscaping	1	ls	$2,000	$	2,000
	Upland Piping					
	Surface restoration & landscaping	1	ls	$10,000	$	10,000
	Discharge Site					
	Transition Zone Resting Pools - restoration by others during channel reconfiguration project				$	-
	Subtotal, Site Restoration				**$**	**12,000**

Total Estimated Direct Costs (Rounded)		$	1,272,000
General Contractor Overhead and Profit	15.0%	$	191,000
Subtotal		**$**	**1,463,000**
Contingency	30.0%	$	439,000
Sales Tax (City of Redmond)	9.5%	$	181,000
Subtotal			**$2,083,000**
Engineering (Design and Construction)	15.0%	$	312,000
Administration	10.0%	$	208,000
Alternative 1 - Total Estimated Project Costs			**$2,603,000**

T31746 King County - Willowmoor
Task 6 Cold Water Supplementation
Concept Alternative Cost Estimate Details
Concept 6-Pump Lake Water To Hyporheic Discharge
Date : 6-Jun-14

Item	Description	Quantity	Unit	Unit cost, $	Cost, $
1	**Mobilization/Demobilization/Testing**				
	Assume 8% of subtotal for items 2-5	1	ls	$62,800	**$ 62,800**
2	**Sitework**				
	Pump Site				
	Archaeological monitoring (SHPO standards) allowance	1	ls	$10,000	$ 10,000
	Erosion control	1	ls	$5,000	$ 5,000
	Clear & grub	1	ls	$5,000	$ 5,000
	Trench shoring	1	ls	$5,000	$ 5,000
	Excavation - Pipelines	640	cy	$15	$ 9,600
	Excavation - Pump station	40	cy	$20	$ 800
	Turbidity Curtain	200	lf	$15	$ 3,000
	Haul waste to disposal	1,300	ton	$10	$ 13,000
	Imported fill - Pipeline & Pump Station	1,300	ton	$15	$ 19,500
	Dewatering for pipeline and pump station	5	days	$200	$ 1,000
	Crushed Surfacing Base Course	100	cy	$30	$ 3,000
	Upland Pipe From Weir To Transition Zone Discharge				
	Archaeological monitoring (SHPO standards) allowance	1	ls	$10,000	$ 10,000
	Erosion control	1	ls	$2,000	$ 2,000
	Clear & grub	1	ls	$2,000	$ 2,000
	Trench shoring	1	ls	$2,000	$ 2,000
	Excavation - Pipelines	1,700	cy	$15	$ 25,500
	Haul waste to disposal	3,100	ton	$10	$ 31,000
	Imported fill - Pipeline	3,100	ton	$20	$ 62,000
	Dewatering for pipeline construction	2	days	$200	$ 400
	Transition Zone Infiltration Trenches & Resting Pools				
	Archaeological monitoring (SHPO standards) allowance	1	ls	$20,000	$ 20,000
	Erosion control	1	ls	$5,000	$ 5,000
	Clear & grub	1	ls	$5,000	$ 5,000
	Excavation shoring	1	ls	$2,000	$ 2,000
	Excavation - Infiltration Trenches	1,600	cy	$20	$ 32,000

	Haul waste to disposal	3,000	ton	$10	$	30,000
	Imported gravel backfill - Infiltration Trenches	3,000	ton	$20	$	60,000
	Transition Zone Resting Pools - sitework by others during channel reconfiguration project				$	-
	Subtotal, Sitework				**$**	**363,800**
3	**Piping**					
	Intake To Pump Station					
	Fish Screen Assembly	1	ls	$2,000	$	2,000
	16" HDPE DIPS DR 21 Intake Assembly	1	ls	$3,000	$	3,000
	16" HDPE DIPS DR 21 Intake Pipe	130	lf	$66	$	8,600
	36" Precast Pipe Anchors	2	ea	$240	$	500
	Work boat for pipe intake positioning	2	day	$200	$	400
	16x12 Reducer	1	ea	$1,575	$	1,600
	12" HDPE DIPS DR 21 PS Transition Pipe	20	lf	$35	$	700
	12" Valve	1	ea	$5,400	$	5,400
	16" 45 Deg Bend	4	ea	$1,575	$	6,300
	Discharge From Pump Station					
	12" HDPE DIPS DR 21 PS Transition Pipe	20	lf	$35	$	700
	12" Valve	1	ea	$5,400	$	5,400
	16x12 Reducer	1	ea	$1,575	$	1,600
	16" 45 Deg Bend	10	ea	$1,575	$	15,800
	16" HDPE DIPS DR 21 Discharge Pipe	2,930	lf	$66	$	193,400
	24" Precast Pipe Anchors	100	ea	$240	$	24,000
	Transition Zone Infiltration Trenches					
	16x6 Wye	4	ea	$1,575	$	6,300
	16" Cleanout/Blowoff	1	ea	$1,575	$	1,600
	6" Valve	4	ea	$1,300	$	5,200
	6" Perforated Distribution Pipe	600	lf	$15	$	9,000
	Subtotal, Piping				**$**	**289,500**
4	**Structural and Architectural**					
	Pump Station					
	Slab on grade (10'x20'x8")	5	cy	$250	$	1,200
	Pump building (timber frame, 8'x16')	128	sf	$200	$	25,600
	Subtotal, Structural and Architectural				**$**	**26,800**

5	**Mechanical**					
	Pump Station					
	Pump System	1	ea	$100,000	$	100,000
	Building space heater and passive ventilation	1	ls	$5,000	$	5,000
	Subtotal, Mechanical				**$**	**105,000**
6	**Electrical**					
	Pump Station					
	Pump station power and control panel	1	allow	$75,000	$	75,000
	2-3" PVC direct bury conduit	500	lf	$20	$	10,000
	Power extension to pump station	500	lf	$20	$	10,000
	Meter & shutoff	1	ls	$500	$	500
	Electrical contingency allowance	1	ls	$2,500	$	2,500
	Subtotal, Electrical and Control				**$**	**98,000**
7	**Intrumentation and Control**					
	Included in electrical in section 6				**$**	**-**
	Subtotal, Intrumentation and Control				**$**	**-**
8	**Site Restoration**					
	Pump Station					
	Site landscaping	1	ls	$2,000	$	2,000
	Upland Piping & Infiltration Trenches					
	Surface restoration & landscaping	1	ls	$5,000	$	5,000
	Discharge Site					
	Transition Zone Resting Pools - restoration by others during channel reconfiguration project				$	-
	Subtotal, Site Restoration				**$**	**7,000**

Total Estimated Direct Costs (Rounded)		$	953,000
General Contractor Overhead and Profit	15.0%	$	143,000
Subtotal		**$**	**1,096,000**
Contingency	30.0%	$	329,000
Sales Tax (City of Redmond)	9.5%	$	135,000
Subtotal			**$1,560,000**
Engineering (Design and Construction)	15.0%	$	234,000
Administration	10.0%	$	156,000
Alternative 1 - Total Estimated Project Costs			**$1,950,000**

T31746 King County - Willowmoor
Task 6 Cold Water Supplementation
Concept Alternative Cost Estimate Details
Concept 7 - Riffle-Pool Complex with Hyporheic Zone Transition Zone
Date : 22-Aug-14

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Item	Description	Quantity	Unit	Unit cost, $		Cost, $
1	**Mobilization/Demobilization/Testing**					
	Assume 8% of subtotal for items 2-5	1	ls	$155,200	**$**	**155,200**
2	**Sitework**					
	Transition Zone Riffle-Pool Construction					
	Archaeological monitoring (SHPO standards) allowance	1	ls	$20,000	$	20,000
	Erosion control & turbidity curtains	1	ls	$10,000	$	10,000
	Clear & grub	6.5	ac	$6,800	$	44,200
	Salvage Topsoil in existing Transition Zone	6,000	cy	$12	$	72,000
	Wet excavation in existing Transition Zone	31,900	cy	$25	$	797,500
	Haul waste to disposal	1,900	ton	$10	$	19,000
	Impermeable fill zone downstream of pools	1,000	cy	$20	$	20,000
	Light rip rap protection of impervious zone	1,000	tn	$40	$	40,000
	Course gravel fill in reconstructed Transition Zone	57,300	tn	$16	$	916,800
	Transition Zone Resting Pools - sitework by others during channel reconfiguration project				$	-
	Subtotal, Sitework				**$**	**1,939,500**
3	**Piping**					
	not applicable				$	-
	Subtotal, Piping				**$**	**-**
4	**Structural and Architectural**					
	not applicable				$	-
	Subtotal, Structural and Architectural				**$**	**-**
5	**Mechanical**					
	not applicable				$	-
	Subtotal, Structural and Architectural				**$**	**-**

6	**Electrical**					
	not applicable				$	-
	Subtotal, Structural and Architectural				**$**	**-**
7	**Intrumentation and Control**					
	not applicable				$	-
	Subtotal, Structural and Architectural				**$**	**-**
8	**Site Restoration**					
	Transition Zone Riffle-Pool Construction					
	Fine grading and slope dressing	1	ls	$25,000	$	25,000
	Transition Zone Resting Pools - restoration by others during channel reconfiguration project				$	-
	Subtotal, Structural and Architectural				**$**	**25,000**

Total Estimated Direct Costs (Rounded)		$	2,120,000
General Contractor Overhead and Profit	15.0%	$	318,000
Subtotal		**$**	**2,438,000**
Contingency	30.0%	$	731,000
Sales Tax (City of Redmond)	9.5%	$	301,000
Subtotal			**$3,470,000**
Engineering (Design and Construction)	15.0%	$	521,000
Administration	10.0%	$	347,000
Alternative 7 - Total Estimated Project Costs			**$4,338,000**

T31746 King County - Willowmoor
Task 6 Cold Water Supplementation
Concept Alternative Cost Estimate Details

Concept 8 - Hypoliminetic Cooling of Lake Sammamish Surface Water (20 cfs)

Date : **22-Aug-14**

Item	Description	Quantity	Unit	Unit cost, $		Cost, $
1	**Mobilization/Demobilization/Testing**					
	Assume 8% of subtotal for items 2-5	1	ls	$259,600	**$**	**259,600**
2	**Sitework**					
	Pump Site					
	Archaeological monitoring (SHPO standards) allowance	1	ls	$10,000	$	10,000
	Erosion control	1	ls	$5,000	$	5,000
	Clear & grub	1	ls	$5,000	$	5,000
	Excavation - Pipelines	640	cy	$15	$	9,600
	Excavation - Pump station	40	cy	$20	$	800
	Turbidity Curtain	200	lf	$15	$	3,000
	Haul waste to disposal	1,300	ton	$10	$	13,000
	Imported fill - Pipeline & Pump Station	1,300	ton	$15	$	19,500
	Trench shoring	1	ls	$5,000	$	5,000
	Dewatering for pipeline and pump station	5	days	$200	$	1,000
	Crushed Surfacing Base Course	100	cy	$30	$	3,000
	Discharge Site At Weir					
	Archaeological monitoring (SHPO standards) allowance	1	ls	$10,000	$	10,000
	Erosion control	1	ls	$2,000	$	2,000
	Clear & grub	1	ls	$2,000	$	2,000
	Excavation - Pipelines	210	cy	$15	$	3,200
	Turbidity Curtain	200	lf	$15	$	3,000
	Haul waste to disposal	400	ton	$10	$	4,000
	Imported fill - Pipeline	400	ton	$20	$	8,000
	Trench shoring	1	ls	$2,000	$	2,000
	Dewatering for pipeline construction	2	days	$200	$	400
	Rip Rap Energy Dissipation	30	ton	$40	$	1,200
	Weir retrofit contingency allowance	1	ls	$5,000	$	5,000
	Subtotal, Sitework				**$**	**115,700**

3	**Piping**					
	Intake To Pump Station					
	Cylinder Style Fish Screen	1	allow	$50,000	$	50,000
	36" HDPE Intake to Heat Exchange System	100	lf	$141	$	14,100
	24" Alum Heat Exhange Pipe with Fittings	1,000	lf	$240	$	240,200
	36" HDPE DIPS DR 21 Intake Pipe	16,000	lf	$141	$	2,256,000
	36" Precast Pipe Anchors	640	ea	$300	$	192,000
	Large work boat for fish screen & heat exchange	1	allow	$12,000	$	12,000
	4 - small work boats for pipe positioning	1	ls	$10,000	$	10,000
	30" HDPE DIPS DR 21 PS Transition Pipe	150	lf	$105	$	15,800
	30" Valve	1	ea	$25,000	$	25,000
	30" 45 Deg Bend	4	ea	$732	$	2,900
	36x30 Reducer	1	ea	$1,000	$	1,000
	Discharge From Pump Station					
	18" HDPE DIPS DR 21 PS Transition Pipe	150	lf	$42	$	6,300
	18" Valve	1	ea	$20,000	$	20,000
	18" 45 Deg Bend	8	ea	$224	$	1,800
	24x18 Reducer	1	ea	$500	$	500
	24" HDPE DIPS DR 21 Discharge Pipe	2,000	lf	$69	$	138,000
	24" Precast Pipe Anchors	80	ea	$300	$	24,000
	Discharge Site At Weir					
	24" HDPE DIPS DR 21 PS Transition Pipe	150	lf	$69	$	10,400
	24" 45 Deg Bend	5	ea	$371	$	1,900
	Subtotal, Piping				**$**	**2,971,900**
4	**Structural and Architectural**					
	Pump Station					
	Slab on grade (10'x20'x8")	5	cy	$250	$	1,200
	Pump building (timber frame, 8'x16')	128	sf	$200	$	25,600
	Subtotal, Structural and Architectural				**$**	**26,800**
5	**Mechanical**					
	Pump Station					
	Vertical Turbine Pump (single pump, with no backup pum	1	ea	$126,000	$	126,000
	Building space heater and passive ventilation	1	ls	$5,000	$	5,000
	Subtotal, Mechanical				**$**	**131,000**

6	**Electrical**					
	Pump Station					
	Pump station power and control panel	1	allow	$100,000	$	100,000
	2-3" PVC direct bury conduit	500	lf	$20	$	10,000
	Power extension to pump station	500	lf	$20	$	10,000
	Meter & shutoff	1	ls	$500	$	500
	Electrical contingency allowance	1	ls	$2,500	$	2,500
	Subtotal, Electrical and Control				**$**	**123,000**
7	**Intrumentation and Control**					
	Included in electrical in section 6				**$**	**-**
	Subtotal, Intrumentation and Control				**$**	**-**
8	**Site Restoration**					
	Pump Station					
	Site landscaping	1	ls	$2,000	$	2,000
	Discharge Below Existing Weir					
	Key Logs	3	ea	$500	$	1,500
	Imported topsoil	100	cy	$15	$	1,500
	Wetland landscaping	1	ls	$2,000	$	2,000
	Subtotal, Site Restoration				**$**	**7,000**

Total Estimated Direct Costs (Rounded)		$	3,635,000
General Contractor Overhead and Profit	15.0%	$	545,000
Subtotal		**$**	**4,180,000**
Contingency	30.0%	$	1,254,000
Sales Tax (City of Redmond)	9.5%	$	516,000
Subtotal			**$5,950,000**
Engineering (Design and Construction)	15.0%	$	893,000
Administration	10.0%	$	595,000
Alternative 8 - Total Estimated Project Costs			**$7,438,000**

T32971 King County - Willowmoor
Task 420 Alternative 4 (Previously Concept 2) - Pump Groundwater to Side Channel
Subject: Concept Alternative Cost Estimate Details
Alternative 4 - Pump Groundwater to Side Channel
Date : 25-Nov-14

TETRA TECH

Item	Description	Quantity	Unit	Unit cost, $		Cost, $
1	**Mobilization/Demobilization/Testing**					
	Assume 8% of subtotal for items 2-5	1	ls	$50,000	**$**	**50,000**
2	**Sitework**					
	Well Site					
	Archaeological monitoring (SHPO standards) allowance	1	ls	$10,000	$	10,000
	Erosion control	1	ls	$5,000	$	5,000
	Clear & grub	1	ls	$5,000	$	5,000
	Trench shoring	1	ls	$1,000	$	1,000
	Construction entrance & well site access driveway	100	cy	$30	$	3,000
	Excavation - Electrical Conduits	640	cy	$15	$	10,000
	Haul waste to disposal	1,200	ton	$10	$	12,000
	Imported concrete fill - Electrical Conduits	640	ton	$111	$	71,000
	New well	1	ls	$30,000	$	30,000
	Discharge Pipeline					
	Archaeological monitoring (SHPO standards) allowance	1	ls	$10,000	$	10,000
	Trench shoring	1	ls	$5,000	$	5,000
	Excavation - Discharge Pipeline	5,680	cy	$15	$	85,000
	Haul waste to disposal	10,500	ton	$10	$	105,000
	Imported fill - Discharge Pipeline	5,680	ton	$15	$	85,000
	Side Channel Discharge					
	Side Channel Discharge - sitework by others during channel reconfiguration project				$	-
					$	**437,000**
3	**Piping**					
	10" HDPE pipe	3,500	lf	$33	$	115,500
	Pipe valves and appertenances	1	ea	$1,325	$	2,000
	Fittings	4	ea	$300	$	1,200
	Subtotal, Piping				**$**	**118,700**

Item	Description	Quantity	Unit	Unit cost, $	Cost, $
4	**Structural and Architectural**				
	Well House				
	Slab on grade (10'x20'x8")	5	cy	$420	$ 3,000
	Pump building (timber frame, 8'x16')	128	sf	$200	$ 26,000
	Subtotal, Structural and Architectural				**$ 29,000**
5	**Mechanical**				
	Pump 25 hp w/ controls, electric hook up, plumb, & mech	1	ls	$40,000	$ 40,000
	Subtotal, Mechanical				**$ 40,000**
6	**Electrical**				
	Wood electrical service pole at W Lake Sammish Pkwy	1	ea	$2,000	$ 2,000
	Trench 3 phase service connection from W Lk Sammamish Pkwy	300	lf	$17	$ 6,000
	Pump station power and control panel	1	allow	$75,000	$ 75,000
	Electrical contingency allowance	1	ls	$5,000	$ 5,000
	Subtotal, Electrical and Control				**$ 88,000**
7	**Intrumentation and Control**				
	Included in electrical in section 6				**$ -**
	Subtotal, Intrumentation and Control				**$ -**
8	**Site Restoration**				
	Well Site				
	Site landscaping	1	ls	$2,000	$ 2,000
	Upland Piping				
	Surface restoration & landscaping	200	msf	$67	$ 13,400
	Discharge Site				
	Transition Zone Resting Pools - restoration by others during channel reconfiguration project				$ -
	Subtotal, Site Restoration				**$ 15,400**
	Total Estimated Direct Costs (Rounded)				$ 778,000
	General Contractor Overhead and Profit	15.0%			$ 117,000
	Subtotal				**$ 895,000**
	Contingency	30.0%			$ 269,000
	Sales Tax (City of Redmond)	9.5%			$ 111,000
	Subtotal				**$1,275,000**
	Engineering (Design and Construction)	15.0%			$ 191,000
	Administration	10.0%			$ 128,000
	Alternative 2 - Total Estimated Project Costs				**$1,594,000**

T32971 King County - Willowmoor
Task 420 Alternative 5 (Refined Concept 5) - Heat Exchange Water Cooling
Concept Alternative Cost Estimate Details
Alternative 5 - Pump River Water To Heat Exchange System
Date : **24-Nov-14**

Item	Description	Quantity	Unit	Unit cost, $		Cost, $
1	**Mobilization/Demobilization/Testing**					
	Assume 8% of subtotal for items 2-5	1	ls	$141,600	**$**	**141,600**
2	**Sitework**					
	Pump Site					
	Archaeological monitoring (SHPO standards) allowance	1	ls	$10,000	$	10,000
	Erosion control	1	ls	$5,000	$	5,000
	Clear & grub	1	ls	$5,000	$	5,000
	Trench shoring	1	ls	$5,000	$	5,000
	Excavation - Pipelines	1,280	cy	$15	$	19,200
	Excavation - Pump station	40	cy	$20	$	800
	Turbidity Curtain	200	lf	$15	$	3,000
	Haul waste to disposal	2,400	ton	$10	$	24,000
	Imported fill - Pipeline & Pump Station	2,400	ton	$15	$	36,000
	Dewatering for pipeline and pump station	5	days	$200	$	1,000
	Crushed Surfacing Base Course	100	cy	$30	$	3,000
	Upland Pipe From Pump Station To Heat Exchange To Transition Zone Discharge					
	Archaeological monitoring (SHPO standards) allowance	1	ls	$10,000	$	10,000
	Erosion control	1	ls	$2,000	$	2,000
	Clear & grub	1	ls	$2,000	$	2,000
	Trench shoring	1	ls	$2,000	$	2,000
	Excavation - Conveyance & Discharge Pipelines	1,400	cy	$15	$	21,000
	Excavation - Heat Exchange Pipe Trench	6,400	cy	$15	$	96,000
	Excavation - Infiltration Pipelines	1,500	cy	$15	$	22,500
	Haul waste to disposal	17,200	ton	$10	$	172,000
	Imported free draining fill - Pipeline & Heat Exchange	17,200	ton	$15	$	258,000
	Dewatering for pipeline construction	15	days	$200	$	3,000
	Transition Zone Resting Pools					
	Transition Zone Resting Pools - sitework by others during channel reconfiguration work				$	-
	Subtotal, Sitework				**$**	**700,500**

3	**Piping**					
	Intake To Pump Station					
	Fish Screen Assembly	1	allow	$5,000	$	5,000
	16" HDPE DIPS DR 21 Intake Assembly	1	ls	$3,000	$	3,000
	16" HDPE DIPS DR 21 Intake Pipe	280	lf	$69	$	19,300
	36" Precast Pipe Anchors	3	ea	$240	$	700
	Work boat for pipe intake positioning	3	day	$200	$	600
	16x12 Reducer	1	ea	$1,600	$	1,600
	12" HDPE DIPS DR 21 PS Transition Pipe	20	lf	$37	$	700
	12" Valve	1	ea	$5,400	$	5,400
	16" 45 Deg Bend	4	ea	$1,600	$	6,400
	Upland Pipe From Pump Station To Heat Exchange To Transition Zone					
	12" HDPE DIPS DR 21 PS Transition Pipe	20	lf	$37	$	700
	12" Valve	1	ea	$1,950	$	2,000
	16x12 Reducer	1	ea	$1,600	$	1,600
	16" HDPE DIPS DR 21 Discharge Pipe	400	lf	$69	$	27,600
	16" 45 Deg Bend	4	ea	$1,600	$	6,400
	16" Wye	1	ea	$1,950	$	2,000
	Heat Exchange Pipe Transition	4	ea	$5,000	$	20,000
	6" Aluminum Heat Exchange Pipe	36,000	lf	$18	$	648,000
	Transition Zone Pipe Discharge to Pools					
	16" HDPE DIPS DR 21 Discharge Pipe	250	lf	$69	$	17,300
	16" Discharge Tee Energy Dissipator	2	ea	$1,950	$	3,900
	6" Valve	4	ea	$1,300	$	5,200
	8" Perforated Aluminum Infiltration Pipe	700	lf	$14	$	9,800
	Subtotal, Piping				**$**	**787,200**
4	**Structural and Architectural**					
	Pump Station					
	Slab on grade (10'x20'x8")	5	cy	$420	$	2,100
	Pump building (timber frame, 8'x16')	128	sf	$200	$	25,600
	Subtotal, Structural and Architectural				**$**	**27,700**
5	**Mechanical**					
	Pump Station					
	Pump System	1	ea	$250,000	$	250,000
	Building space heater and passive ventilation	1	ls	$5,000	$	5,000
	Subtotal, Mechanical				**$**	**255,000**

6	**Electrical**					
	Pump Station					
	Pump station power and control panel	1	allow	$75,000	$	75,000
	2-3" PVC direct bury conduit	500	lf	$20	$	10,000
	Power extension to pump station	500	lf	$20	$	10,000
	Meter & shutoff	1	ls	$500	$	500
	Electrical contingency allowance	1	ls	$2,500	$	2,500
	Subtotal, Electrical and Control				**$**	**98,000**
7	**Intrumentation and Control**					
	Included in electrical in section 6				**$**	**-**
	Subtotal, Intrumentation and Control				**$**	**-**
8	**Site Restoration**					
	Pump Station					
	Site landscaping	1	ls	$2,000	$	2,000
	Upland Piping					
	Surface restoration & landscaping	460	msf	$67	$	30,800
	Discharge Site					
	Transition Zone Resting Pools - restoration by others during channel reconfiguration project				$	-
	Subtotal, Site Restoration				**$**	**32,800**

Total Estimated Direct Costs (Rounded)		$	2,043,000
General Contractor Overhead and Profit	15.0%	$	306,000
Subtotal		**$**	**2,349,000**
Contingency	30.0%	$	705,000
Sales Tax (City of Redmond)	9.5%	$	290,000
Subtotal			**$3,344,000**
Engineering (Design and Construction)	15.0%	$	502,000
Administration	10.0%	$	334,000
Alternative 1 - Total Estimated Project Costs			**$4,180,000**

O&M Cost Estimates

Willowmoor No Action Alternative O&M Costs
Date: Updated April 2015
Federal FY14 Interest Rate

TETRA TECH

Feature	No.	Item	Unit	Unit Cost	No Action Qty	Cost	Notes
O&M		Planning/Permitting	LS	$ 40,000	1.0	$ 40,000	Permit applications, agency coordination, assume every 5 years (HPA, etc. valid for 5 yea
		Mowing/Raking Both Banks	LS	$ 20,000	1.0	$ 20,000	Mowing and raking to remove debris, 7 acres, leaving a 10 foot willow buffer both sides of low-flow channel; likely trimming of willow buffer annually and thinning every other year
		Remove Sediment	LS	$ 10,000	1.0	$ 10,000	Remove accumulated sediment on the channel bed, assume every 25 years
		Mitigation -- Planting	LS	$ 40,000	1.0	$ 40,000	Mitigation required for every permit renewal, assume 1 acre and monitoring
		Annual Inspection	LS	$ 3,000	1.0	$ 3,000	
		NPV O&M Cost				**$972,719**	Over a 50 year project life
		Discounted O&M Costs			Year	Cost	
		Interest Rate (Federal FY14)		**3.500%**	1	$ 103,000	Planning, permitting, mowing/raking, and mitigation
		Project life		50	2	$ 23,000	Mowing/raking
					3	$ 23,000	Mowing/raking
					4	$ 23,000	Mowing/raking
					5	$ 103,000	Planning, permitting, mowing/raking, and mitigation
					6	$ 23,000	Mowing/raking
					7	$ 23,000	Mowing/raking
					8	$ 23,000	Mowing/raking
					9	$ 23,000	Mowing/raking
					10	$ 103,000	Planning, permitting, mowing/raking, and mitigation
					11	$ 23,000	Mowing/raking
					12	$ 23,000	Mowing/raking
					13	$ 23,000	Mowing/raking
					14	$ 23,000	Mowing/raking
					15	$ 103,000	Planning, permitting, mowing/raking, and mitigation
					16	$ 23,000	Mowing/raking
					17	$ 23,000	Mowing/raking
					18	$ 23,000	Mowing/raking
					19	$ 23,000	Mowing/raking
					20	$ 103,000	Planning, permitting, mowing/raking, and mitigation
					21	$ 23,000	Mowing/raking
					22	$ 23,000	Mowing/raking
					23	$ 23,000	Mowing/raking
					24	$ 23,000	Mowing/raking

Willowmoor No Action Alternative O&M Costs
Date: Updated April 2015
Federal FY14 Interest Rate

TETRA TECH

	No Action			
	25	$	113,000	Planning, permitting, mowing/raking, remove sediment and mitigation
	26	$	23,000	Mowing/raking
	27	$	23,000	Mowing/raking
	28	$	23,000	Mowing/raking
	29	$	23,000	Mowing/raking
	30	$	103,000	Planning, permitting, mowing/raking, and mitigation
	31	$	23,000	Mowing/raking
	32	$	23,000	Mowing/raking
	33	$	23,000	Mowing/raking
	34	$	23,000	Mowing/raking
	35	$	103,000	Planning, permitting, mowing/raking, and mitigation
	36	$	23,000	Mowing/raking
	37	$	23,000	Mowing/raking
	38	$	23,000	Mowing/raking
	39	$	23,000	Mowing/raking
	40	$	103,000	Planning, permitting, mowing/raking, and mitigation
	41	$	23,000	Mowing/raking
	42	$	23,000	Mowing/raking
	43	$	23,000	Mowing/raking
	44	$	23,000	Mowing/raking
	45	$	103,000	Planning, permitting, mowing/raking, and mitigation
	46	$	23,000	Mowing/raking
	47	$	23,000	Mowing/raking
	48	$	23,000	Mowing/raking
	49	$	23,000	Mowing/raking
	50	$	113,000	Planning, permitting, mowing/raking, remove sediment and mitigation
	Sum	$	2,050,000	
	NPV		$972,719	
	AVG	$	41,000	

Willowmoor Channel Concept O&M Costs
Date: April 2015
Federal FY14 Interest Rate

Feature	No.	Item	Unit	Unit Cost	Concept 2, Single Meander Qty	Concept 2, Single Meander Cost	Concept 3, Single Meander w/ Hyporheic Channels Qty	Concept 3, Single Meander w/ Hyporheic Channels Cost	Concept 4, Split Flow Channel Qty	Concept 4, Split Flow Channel Cost	Concept 5, Widened Main Channel Qty	Concept 5, Widened Main Channel Cost	Notes
O&M		Annual Inspection	LS	$3,000.00	1.0	$ 3,000	1.0	$ 3,000	1.0	$ 3,000	1.0	$ 3,000	Assume one to two days for 2 people, every year, each at $150 per hour. Inspection and documentation.
		Repair/replace Large Wood	Each	$ 2,500	25	$ 62,500	83	$ 206,250	83	$ 206,250	25	$ 62,500	Unit cost assumes new LWD, anchors ~ $2000 + 20% for mobilization = $2500. Assume 50% replacement in 50 years.
		Replace Streambed Gravels	Ton	$ 44	2330	$ 102,502	12218	$ 537,592	2437	$ 107,237	2330	$ 102,502	Unit cost assumes gravel cost + 25% for mobilization. Assume 20% replacement in 50 years.
		Clean Hyporheic Intake	LS	$ 20,000	0.0	$ -	1.0	$ 20,000	0.0	$ -	0.0	$ -	Every 10 years
		Removal of Invasive Species	LS	$20,000.00	1.0	$ 20,000	1.0	$ 20,000	1.0	$ 20,000	1.0	$ 20,000	Invasives Species Control; first 10 years only
		Vegetation Trimming	LS	$10,000.00	1.0	$ 10,000	2.0	$ 20,000	2.0	$ 20,000	1.0	$ 10,000	Trimming estimated to be required every 5 years; Concepts 3 and 4 more expensive due to secondary channel(s)
		Mowing/Raking Banks	LS	$ 15,000	1.0	$ 15,000	1.0	$ 15,000	0.0	$ -	0.0	$ -	Mowing/raking required every 2 years for concepts 2 and 3 that only slightly increase conveyance and maintain much of existing TZ
			LS		0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	
		NPV O&M Cost				**$523,151**		**$849,128**		**$456,831**		**$350,260**	Over a 50 year project life

Discounted O&M Costs		Year	Cost	Year	Cost	Year	Cost	Year	Cost
Interest Rate (Federal FY14)	**3.500%**	1	$ 23,000	1	$ 23,000	1	$ 23,000	1	$ 23,000
Project life	50	2	$ 38,000	2	$ 38,000	2	$ 23,000	2	$ 23,000
		3	$ 23,000	3	$ 23,000	3	$ 23,000	3	$ 23,000
		4	$ 38,000	4	$ 38,000	4	$ 23,000	4	$ 23,000
		5	$ 33,000	5	$ 43,000	5	$ 43,000	5	$ 33,000
		6	$ 38,000	6	$ 38,000	6	$ 23,000	6	$ 23,000
		7	$ 23,000	7	$ 23,000	7	$ 23,000	7	$ 23,000
		8	$ 38,000	8	$ 38,000	8	$ 23,000	8	$ 23,000
		9	$ 23,000	9	$ 23,000	9	$ 23,000	9	$ 23,000
		10	$ 48,000	10	$ 78,000	10	$ 43,000	10	$ 33,000
		11	$ 3,000	11	$ 3,000	11	$ 3,000	11	$ 3,000
		12	$ 18,000	12	$ 18,000	12	$ 3,000	12	$ 3,000
		13	$ 3,000	13	$ 3,000	13	$ 3,000	13	$ 3,000
		14	$ 18,000	14	$ 18,000	14	$ 3,000	14	$ 3,000
		15	$ 13,000	15	$ 23,000	15	$ 23,000	15	$ 13,000
		16	$ 18,000	16	$ 18,000	16	$ 3,000	16	$ 3,000
		17	$ 3,000	17	$ 3,000	17	$ 3,000	17	$ 3,000
		18	$ 18,000	18	$ 18,000	18	$ 3,000	18	$ 3,000
		19	$ 3,000	19	$ 3,000	19	$ 3,000	19	$ 3,000
		20	$ 28,000	20	$ 58,000	20	$ 23,000	20	$ 13,000
		21	$ 3,000	21	$ 3,000	21	$ 3,000	21	$ 3,000
		22	$ 18,000	22	$ 18,000	22	$ 3,000	22	$ 3,000
		23	$ 3,000	23	$ 3,000	23	$ 3,000	23	$ 3,000
		24	$ 18,000	24	$ 18,000	24	$ 3,000	24	$ 3,000
		25	$ 178,002	25	$ 766,842	25	$ 336,487	25	$ 178,002
		26	$ 18,000	26	$ 18,000	26	$ 3,000	26	$ 3,000
		27	$ 3,000	27	$ 3,000	27	$ 3,000	27	$ 3,000
		28	$ 18,000	28	$ 18,000	28	$ 3,000	28	$ 3,000
		29	$ 3,000	29	$ 3,000	29	$ 3,000	29	$ 3,000
		30	$ 28,000	30	$ 58,000	30	$ 23,000	30	$ 13,000
		31	$ 3,000	31	$ 3,000	31	$ 3,000	31	$ 3,000
		32	$ 18,000	32	$ 18,000	32	$ 3,000	32	$ 3,000
		33	$ 3,000	33	$ 3,000	33	$ 3,000	33	$ 3,000
		34	$ 18,000	34	$ 18,000	34	$ 3,000	34	$ 3,000
		35	$ 13,000	35	$ 23,000	35	$ 23,000	35	$ 13,000
		36	$ 18,000	36	$ 18,000	36	$ 3,000	36	$ 3,000
		37	$ 3,000	37	$ 3,000	37	$ 3,000	37	$ 3,000
		38	$ 18,000	38	$ 18,000	38	$ 3,000	38	$ 3,000
		39	$ 3,000	39	$ 3,000	39	$ 3,000	39	$ 3,000
		40	$ 28,000	40	$ 58,000	40	$ 23,000	40	$ 13,000
		41	$ 3,000	41	$ 3,000	41	$ 3,000	41	$ 3,000
		42	$ 18,000	42	$ 18,000	42	$ 3,000	42	$ 3,000
		43	$ 3,000	43	$ 3,000	43	$ 3,000	43	$ 3,000
		44	$ 18,000	44	$ 18,000	44	$ 3,000	44	$ 3,000
		45	$ 13,000	45	$ 23,000	45	$ 23,000	45	$ 13,000
		46	$ 18,000	46	$ 18,000	46	$ 3,000	46	$ 3,000
		47	$ 3,000	47	$ 3,000	47	$ 3,000	47	$ 3,000
		48	$ 18,000	48	$ 18,000	48	$ 3,000	48	$ 3,000
		49	$ 3,000	49	$ 3,000	49	$ 3,000	49	$ 3,000
		50	$ 28,000	50	$ 43,000	50	$ 23,000	50	$ 13,000
		Sum	$ 990,002	Sum	$ 1,753,842	Sum	$ 863,487	Sum	$ 615,002
		NPV	$523,151	NPV	$849,128	NPV	$456,831	NPV	$350,260
		AVG	$ 19,800	AVG	$ 35,077	AVG	$ 17,270	AVG	$ 12,300

Willowmoor Cold Water Supplementation Concept Alternative O&M Costs
Date: June 2014
Federal FY14 Interest Rate

TETRA TECH

Feature	No.	Item	Unit	Unit Cost	Hypoliminetic Withdrawal from Lake Sammamish Qty	Cost	S Groundwater Pump to Side Channel Qty	Cost	Shallow Groundwater Trenches to Pools Qty	Cost	Purchase Potable Water to Pipe to Pools Qty	Cost	Pump to 2-5 cfs Heat Exchangers to Pools Qty	Cost	Pump Lake Water to Hyporheic Discharge at Pools Qty	Cost	Riffle Pool and Hyporheic Transition Zone Qty	Cost	Hypolimnetic Cooling of Lake Surface Water Qty	Cost
O&M		Pump Usage Cost - Electricity	LS	$ 1	1.0	$ 6,300	1.0	$ 3,200	0.0	$ -	0.0	$ -	1.0	$ 16,800	1.0	$ 900	0.0	$ -	1.0	$ 6,300
		Potable Water Usage Costs	LS	$ 190,000	0.0	$ -	0.0	$ -	0.0	$ -	1.0	$ 190,000	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
		Annual On/Off	LS	$ 1,000	1.0	$ 1,000	1.0	$ 1,000	0.0	$ -	0.0	$ -	1.0	$ 1,000	1.0	$ 1,000	0.0	$ -	1.0	$ 1,000
		Lake Intake Inspection	LS	$ 5,000	1.0	$ 5,000	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	1.0	$ 5,000
		River Intake Inspection	LS	$ 2,000	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	1.0	$ 2,000	1.0	$ 2,000	0.0	$ -	0.0	$ -
		Pump & Pipe Maintenance	LS	$ 1,000	1.0	$ 1,000	1.0	$ 1,000	0.0	$ -	0.0	$ -	1.0	$ 1,000	1.0	$ 1,000	0.0	$ -	1.0	$ 1,000
		Perf Pipe Inspection & Cleaning	LS	$ 1,000	0.0	$ -	0.0	$ -	1.0	$ 1,000	0.0	$ -	0.0	$ -	1.0	$ 1,000	0.0	$ -	0.0	$ -
		Heat exchange inspection and cleaning	LS	$ 1,000	0.0	$ -	0.0	$ -	1.0	$ 1,000	0.0	$ -	1.0	$ 1,000	0.0	$ -	0.0	$ -	0.0	$ -
		Transition zone maintenance	LS	$ 5,000	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	1.0	$ 5,000	0.0	$ -
		NPV O&M Cost				**$197,470**		**$102,888**		**$23,456**		**$4,456,567**		**$435,006**		**$62,062**		**$117,278**		**$197,470**

Discounted O&M Costs		Year	Cost	Year	Cost	Year	Cost	Year	Cost	Year	Cost	Year	Cost	Year	Cost	Year	Cost
Interest Rate (Federal FY14)	**3.500%**	1	$ 7,300	1	$ 4,200	1	$ 1,000	1	$ 190,000	1	$ 17,800	1	$ 1,900	1	$ 5,000	1	$ 7,300
Project life	50	2	$ 7,300	2	$ 4,200	2	$ 1,000	2	$ 190,000	2	$ 17,800	2	$ 1,900	2	$ 5,000	2	$ 7,300
		3	$ 7,300	3	$ 4,200	3	$ 1,000	3	$ 190,000	3	$ 17,800	3	$ 1,900	3	$ 5,000	3	$ 7,300
		4	$ 7,300	4	$ 4,200	4	$ 1,000	4	$ 190,000	4	$ 17,800	4	$ 1,900	4	$ 5,000	4	$ 7,300
		5	$ 13,300	5	$ 5,200	5	$ 1,000	5	$ 190,000	5	$ 21,800	5	$ 5,900	5	$ 5,000	5	$ 13,300
		6	$ 7,300	6	$ 4,200	6	$ 1,000	6	$ 190,000	6	$ 17,800	6	$ 1,900	6	$ 5,000	6	$ 7,300
		7	$ 7,300	7	$ 4,200	7	$ 1,000	7	$ 190,000	7	$ 17,800	7	$ 1,900	7	$ 5,000	7	$ 7,300
		8	$ 7,300	8	$ 4,200	8	$ 1,000	8	$ 190,000	8	$ 17,800	8	$ 1,900	8	$ 5,000	8	$ 7,300
		9	$ 7,300	9	$ 4,200	9	$ 1,000	9	$ 190,000	9	$ 17,800	9	$ 1,900	9	$ 5,000	9	$ 7,300
		10	$ 13,300	10	$ 5,200	10	$ 1,000	10	$ 190,000	10	$ 21,800	10	$ 5,900	10	$ 5,000	10	$ 13,300
		11	$ 7,300	11	$ 4,200	11	$ 1,000	11	$ 190,000	11	$ 17,800	11	$ 1,900	11	$ 5,000	11	$ 7,300
		12	$ 7,300	12	$ 4,200	12	$ 1,000	12	$ 190,000	12	$ 17,800	12	$ 1,900	12	$ 5,000	12	$ 7,300
		13	$ 7,300	13	$ 4,200	13	$ 1,000	13	$ 190,000	13	$ 17,800	13	$ 1,900	13	$ 5,000	13	$ 7,300
		14	$ 7,300	14	$ 4,200	14	$ 1,000	14	$ 190,000	14	$ 17,800	14	$ 1,900	14	$ 5,000	14	$ 7,300
		15	$ 13,300	15	$ 5,200	15	$ 1,000	15	$ 190,000	15	$ 21,800	15	$ 5,900	15	$ 5,000	15	$ 13,300
		16	$ 7,300	16	$ 4,200	16	$ 1,000	16	$ 190,000	16	$ 17,800	16	$ 1,900	16	$ 5,000	16	$ 7,300
		17	$ 7,300	17	$ 4,200	17	$ 1,000	17	$ 190,000	17	$ 17,800	17	$ 1,900	17	$ 5,000	17	$ 7,300
		18	$ 7,300	18	$ 4,200	18	$ 1,000	18	$ 190,000	18	$ 17,800	18	$ 1,900	18	$ 5,000	18	$ 7,300
		19	$ 7,300	19	$ 4,200	19	$ 1,000	19	$ 190,000	19	$ 17,800	19	$ 1,900	19	$ 5,000	19	$ 7,300
		20	$ 13,300	20	$ 5,200	20	$ 1,000	20	$ 190,000	20	$ 21,800	20	$ 5,900	20	$ 5,000	20	$ 13,300
		21	$ 7,300	21	$ 4,200	21	$ 1,000	21	$ 190,000	21	$ 17,800	21	$ 1,900	21	$ 5,000	21	$ 7,300
		22	$ 7,300	22	$ 4,200	22	$ 1,000	22	$ 190,000	22	$ 17,800	22	$ 1,900	22	$ 5,000	22	$ 7,300
		23	$ 7,300	23	$ 4,200	23	$ 1,000	23	$ 190,000	23	$ 17,800	23	$ 1,900	23	$ 5,000	23	$ 7,300
		24	$ 7,300	24	$ 4,200	24	$ 1,000	24	$ 190,000	24	$ 17,800	24	$ 1,900	24	$ 5,000	24	$ 7,300
		25	$ 13,300	25	$ 5,200	25	$ 1,000	25	$ 190,000	25	$ 21,800	25	$ 5,900	25	$ 5,000	25	$ 13,300
		26	$ 7,300	26	$ 4,200	26	$ 1,000	26	$ 190,000	26	$ 17,800	26	$ 1,900	26	$ 5,000	26	$ 7,300
		27	$ 7,300	27	$ 4,200	27	$ 1,000	27	$ 190,000	27	$ 17,800	27	$ 1,900	27	$ 5,000	27	$ 7,300
		28	$ 7,300	28	$ 4,200	28	$ 1,000	28	$ 190,000	28	$ 17,800	28	$ 1,900	28	$ 5,000	28	$ 7,300
		29	$ 7,300	29	$ 4,200	29	$ 1,000	29	$ 190,000	29	$ 17,800	29	$ 1,900	29	$ 5,000	29	$ 7,300
		30	$ 13,300	30	$ 5,200	30	$ 1,000	30	$ 190,000	30	$ 21,800	30	$ 5,900	30	$ 5,000	30	$ 13,300
		31	$ 7,300	31	$ 4,200	31	$ 1,000	31	$ 190,000	31	$ 17,800	31	$ 1,900	31	$ 5,000	31	$ 7,300
		32	$ 7,300	32	$ 4,200	32	$ 1,000	32	$ 190,000	32	$ 17,800	32	$ 1,900	32	$ 5,000	32	$ 7,300
		33	$ 7,300	33	$ 4,200	33	$ 1,000	33	$ 190,000	33	$ 17,800	33	$ 1,900	33	$ 5,000	33	$ 7,300
		34	$ 7,300	34	$ 4,200	34	$ 1,000	34	$ 190,000	34	$ 17,800	34	$ 1,900	34	$ 5,000	34	$ 7,300
		35	$ 13,300	35	$ 5,200	35	$ 1,000	35	$ 190,000	35	$ 21,800	35	$ 5,900	35	$ 5,000	35	$ 13,300
		36	$ 7,300	36	$ 4,200	36	$ 1,000	36	$ 190,000	36	$ 17,800	36	$ 1,900	36	$ 5,000	36	$ 7,300
		37	$ 7,300	37	$ 4,200	37	$ 1,000	37	$ 190,000	37	$ 17,800	37	$ 1,900	37	$ 5,000	37	$ 7,300
		38	$ 7,300	38	$ 4,200	38	$ 1,000	38	$ 190,000	38	$ 17,800	38	$ 1,900	38	$ 5,000	38	$ 7,300
		39	$ 7,300	39	$ 4,200	39	$ 1,000	39	$ 190,000	39	$ 17,800	39	$ 1,900	39	$ 5,000	39	$ 7,300
		40	$ 13,300	40	$ 5,200	40	$ 1,000	40	$ 190,000	40	$ 21,800	40	$ 5,900	40	$ 5,000	40	$ 13,300
		41	$ 7,300	41	$ 4,200	41	$ 1,000	41	$ 190,000	41	$ 17,800	41	$ 1,900	41	$ 5,000	41	$ 7,300
		42	$ 7,300	42	$ 4,200	42	$ 1,000	42	$ 190,000	42	$ 17,800	42	$ 1,900	42	$ 5,000	42	$ 7,300
		43	$ 7,300	43	$ 4,200	43	$ 1,000	43	$ 190,000	43	$ 17,800	43	$ 1,900	43	$ 5,000	43	$ 7,300
		44	$ 7,300	44	$ 4,200	44	$ 1,000	44	$ 190,000	44	$ 17,800	44	$ 1,900	44	$ 5,000	44	$ 7,300
		45	$ 13,300	45	$ 5,200	45	$ 1,000	45	$ 190,000	45	$ 21,800	45	$ 5,900	45	$ 5,000	45	$ 13,300
		46	$ 7,300	46	$ 4,200	46	$ 1,000	46	$ 190,000	46	$ 17,800	46	$ 1,900	46	$ 5,000	46	$ 7,300
		47	$ 7,300	47	$ 4,200	47	$ 1,000	47	$ 190,000	47	$ 17,800	47	$ 1,900	47	$ 5,000	47	$ 7,300
		48	$ 7,300	48	$ 4,200	48	$ 1,000	48	$ 190,000	48	$ 17,800	48	$ 1,900	48	$ 5,000	48	$ 7,300
		49	$ 7,300	49	$ 4,200	49	$ 1,000	49	$ 190,000	49	$ 17,800	49	$ 1,900	49	$ 5,000	49	$ 7,300
		50	$ 13,300	50	$ 5,200	50	$ 1,000	50	$ 190,000	50	$ 21,800	50	$ 5,900	50	$ 5,000	50	$ 13,300
		Sum	$ 425,000	Sum	$ 220,000	Sum	$ 50,000	Sum	$ 9,500,000	Sum	$ 930,000	Sum	$ 135,000	Sum	$ 250,000	Sum	$ 425,000
		NPV	$197,470	NPV	$102,888	NPV	$23,456	NPV	$4,456,567	NPV	$435,006	NPV	$62,062	NPV	$117,278	NPV	$197,470
		AVG	$ 8,500	AVG	$ 4,400	AVG	$ 1,000	AVG	$ 190,000	AVG	$ 18,600	AVG	$ 2,700	AVG	$ 5,000	AVG	$ 8,500

Appendix F – Lake Sammamish Nutrient and Stability Modeling, King County 2014

Estimating the Effects of a Hypothetical Hypolimnetic Withdrawal from Lake Sammamish on Sammamish River Nutrient Loading

January 2015

King County

Department of Natural Resources and Parks
Water and Land Resources Division
Science and Technical Support Section
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Alternate Formats Available

DRAFT - Estimating the Effects of a Hypothetical Hypolimnetic Withdrawal From Lake Sammamish on Sammamish River Nutrient Loading

Prepared for:

King County Flood District

Submitted by:

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Department of Natural Resources and Parks

King County
Department of
Natural Resources and Parks
Water and Land Resources Division

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EXECUTIVE SUMMARY

This report describes the results of an evaluation of the potential effect of summer replacement (July 15 to September 15) of a portion of Lake Sammamish outlet flow to the Sammamish River with cool hypolimnetic water from the lake. The focus of the evaluation is on potential changes in nutrient loading to the river due to potentially higher (or lower) hypolimnetic nutrient concentrations relative to existing outlet concentrations during the proposed hypolimnetic withdrawal pumping period. Two hypolimnetic withdrawal scenarios are evaluated:

- **10 cfs Hypolimnetic Withdrawal** - Replace 10 cfs of flow to river at weir boundary with lake hypolimnetic water from the 15 m depth for the period July 15 – September 15.
- **20 cfs Hypolimnetic Withdrawal** - Replace 20 cfs of flow to river at weir boundary with lake hypolimnetic water from the 15 m depth for the period July 15 – September 15.

The evaluation was based on a comparison to Sammamish River nutrient loading estimated as part of the development of a water quality model of the Sammamish. Comparisons were based on the results for the period 1995-2002 and analyses of lake nutrient profiling data collected over the same period that were conducted for this report.

Loading of dissolved phosphorus (the most biologically available form of this nutrient) is estimated to decrease rather than increase as a result of replacing a portion of Lake Sammamish surface outlet flow to the Sammamish River with cool hypolimnetic water. Total phosphorus loading is also estimated to decrease slightly.

Total nitrogen loading is estimated to increase from 10 to 20 percent and dissolved inorganic nitrogen loading is estimated to increase from 60 to 120 percent depending on the magnitude of the hypolimnetic withdrawal (10 or 20 cfs).

In general, existing inter-annual variability in nutrient loading from the lake to the Sammamish River appears to be larger than the magnitude of estimate changes (increasing or decreasing) resulting from the hypolimnetic withdrawal scenarios.

Determining the potential effect of an increase in nitrogen loading on the aquatic condition of the Sammamish River is beyond the scope of the work conducted for this report, but in general, freshwater systems in this region are generally considered to be phosphorus limited. Changes in soluble forms of nutrients would be expected to have the greatest impact on aquatic productivity.

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1.0. INTRODUCTION

Listing of Puget Sound Chinook under the federal Endangered Species Act (ESA) has triggered an intensive effort to identify causes of salmon population declines and measures that can be taken to maintain or improve existing conditions. The King County Flood Control District is investigating options to improve summer temperature conditions in the upper Sammamish River that would potentially benefit adult Chinook migrating through the river to spawn in the Big Bear Creek basin, tributaries to Lake Sammamish (including Issaquah Creek) or return to the hatchery on Issaquah Creek.

Summer temperature conditions in the upper Sammamish River consistently exceed the applicable state standard of 16 ^{o}C[1] as well as temperature thresholds considered to be potentially lethal to salmonids (e.g, 21 ^{o}C). Extremely high river temperatures in 1998 were believed to have contributed to Chinook pre-spawn mortality observed in the river that year (Fresh et al. 1999, Martz et al. 1999). It has also been suggested that the generally higher pre-spawn mortality rate of Chinook observed in Bear and Issaquah creeks relative to pre-spawn mortality in the Cedar River between 2002 and 2005 may be due in part to the relatively high temperatures experienced by fish migrating through the river (Berge et al. 2006). Fresh et al. (1999) suggested that the upper reach of the Sammamish River (perhaps exacerbated by high temperatures in the Ship Canal) represented a significant impediment to the passage of adult Chinook destined to spawn in the Issaquah Creek basin affecting the long-term viability of the population.

This report describes the results of an evaluation of the potential effect of summer replacement (July 15 to September 15) of a portion of Lake Sammamish outlet flow to the Sammamish River with cool hypolimnetic water from the lake. The focus of the evaluation is on potential changes in nutrient loading to the river due to potentially higher (or lower) hypolimnetic nutrient concentrations relative to existing outlet concentrations during the proposed hypolimnetic withdrawal pumping period. Two hypolimnetic withdrawal scenarios are evaluated:

- **10 cfs Hypolimnetic Withdrawal** - Replace 10 cfs of flow to river at weir boundary with lake hypolimnetic water from the 15 m depth for the period July 15 – September 15.
- **20 cfs Hypolimnetic Withdrawal** - Replace 20 cfs of flow to river at weir boundary with lake hypolimnetic water from the 15 m depth for the period July 15 – September 15.

The evaluation was based on a comparison to Sammamish River nutrient loading estimated as part of the development of a water quality model of the Sammamish River (King County 2009). Comparisons were based on the results for the period 1995-2002 and analyses of

[1] The Sammamish River is designated as core summer salmonid habitat with a standard of 16 ^{o}C based on the 7-day moving average of the daily maximum temperature (Chapter 173-201A of the Washington Administrative Code).

lake nutrient profiling data collected over the same period that were conducted for this report.

1.1 Background

Welch et al. (1980) report that Lake Sammamish has a surface area of 19.8 km^2, holds approximately 3.5 x 108 m^3 of water, and has a mean residence time of 1.8 yr. The lake has a maximum depth of about 32 m and a mean depth of 17.7 m (Welch et al. 1980). The lake is an elongated fiord-like trough about 13 km long oriented along a north-south axis reflecting its glacial provenance. The lake typically stratifies thermally beginning in April and de-stratifies in November. As the lake stratifies, the hypolimnion becomes progressively depleted of oxygen resulting in anaerobic bottom waters in late summer. As hypolimnetic oxygen levels decline, nitrogen and phosphorus concentrations generally increase as a result of a combination of particulates settling from the epilimnion, nutrient release from anoxic bottom sediments and a slight excess of inflow over outflow (Birch and Spyridakis 1981).

The lake basin has undergone a fairly dramatic transformation beginning in the 1860s with the first European-American settlements along the lake shore. Hop farming and then logging, dairies and coal and clay mining were the primary endeavors of these settlers (Fish 1967). By 1940 a secondary wastewater treatment plant (WWTP) was built for the town of Issaquah with a capacity of 0.15 MGD (Lazoff 1980). By 1960, Issaquah Creek was receiving effluent from the Issaquah WWTP, a milk processing plant, a state fish hatchery (established in 1936) and runoff from sand and gravel operations.

Based on studies conducted by Isaac et al. (1966) on Lake Sammamish and similar studies related to an effort to divert secondary effluent from nearby Lake Washington (Edmondson 1968, 1969), wastewater from the Issaquah WWTP and the milk processing plant were completely diverted from Lake Sammamish by 1968. Lake Washington quickly recovered (Edmondson 1994), while the recovery of Lake Sammamish did not progress as quickly as expected based on flushing alone (Welch et al. 1975, Welch 1977). The delayed recovery of Lake Sammamish is well documented and has been attributed to a delayed reduction in sediment phosphorus release rates and the relatively smaller proportion of the total phosphorus load that was diverted (Birch et al. 1980; Welch et al., 1980; Welch 1985; Welch et al. 1986).

1.2 Objectives

The overall objective of the work described in this report was to use nutrient loading estimates calculated as part of the development of a 2-D Sammamish River water quality model (King County 2009) to evaluate the effect of two temperature management alternatives currently under consideration as part of the King County Flood District's Willowmoor Floodplain Restoration Project.

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Specific tasks to meet these objectives were:

- Interpolate nutrient (phosphorus and nitrogen) concentration time series from specific depths in Lake Sammamish near the proposed withdrawal location (Station 0611) based on routine nutrient profiling data collected by King County.
- Calculate potential loading changes resulting from replacing 10 or 20 cfs of surface outlet flow with hypolimnetic water.
- Summarize results in tabular and graphical format and include an assessment of the effects of the hypothetical withdrawal on river nutrient loading during the period July 15 to September 15.

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2.0. METHODS

A Matlab script was developed to interpolate each nutrient profile collected at Station 0611 (see Figure 1) at 1 m intervals and these uniform profiles were then interpolated to a daily time frequency for the period 1995 to 2002. Station 0611 is the station closest to the proposed hypolimnetic withdrawal location.

The nutrient time series for the 15 m depth was used in combination with daily outlet and withdrawal flow values (and interpolated weir outlet concentrations) to estimate how nutrient loading would potentially change in response to replacing a portion of the weir outlet flow with hypolimnetic water between July 15 and September 15 each year.

Loading estimates under existing conditions for each nutrient were then summarized for each year for the July 15 to September 15 period and compared to the existing (or baseline) estimates for the same years and period. The nutrient concentration time series were also averaged across years for each day between July 15 to September 15 for the outlet concentration and the concentrations observed at 10, 15 and 25 m at Station 0611 to illustrate why loading of a particular nutrient was expected to increase or decrease. The relative change in nutrient loading was also compared to estimated loading from Big Bear Creek for the same time period to give some context for expected magnitude of effect of the estimated change (either up or down).

The nutrients that were evaluated included:

- Total Phosphorus (TP)
- Soluble Reactive Phosphorus (SRP) [2]
- Total Nitrogen (TN)
- Nitrate+Nitrite Nitrogen (NO3-N)
- Ammonia Nitrogen (NH3-N)

Because the original Sammamish River nutrient loading estimates for NO3-N and NH3-N were presented as the dissolved inorganic nitrogen (i.e., the sum of the two soluble nitrogen compounds) (King County 2009), these two compounds were also summed for comparison in this report.

[2] The King County laboratory reports Soluble Reactive Phosphorus using the term Orthophosphate Phosphorus.

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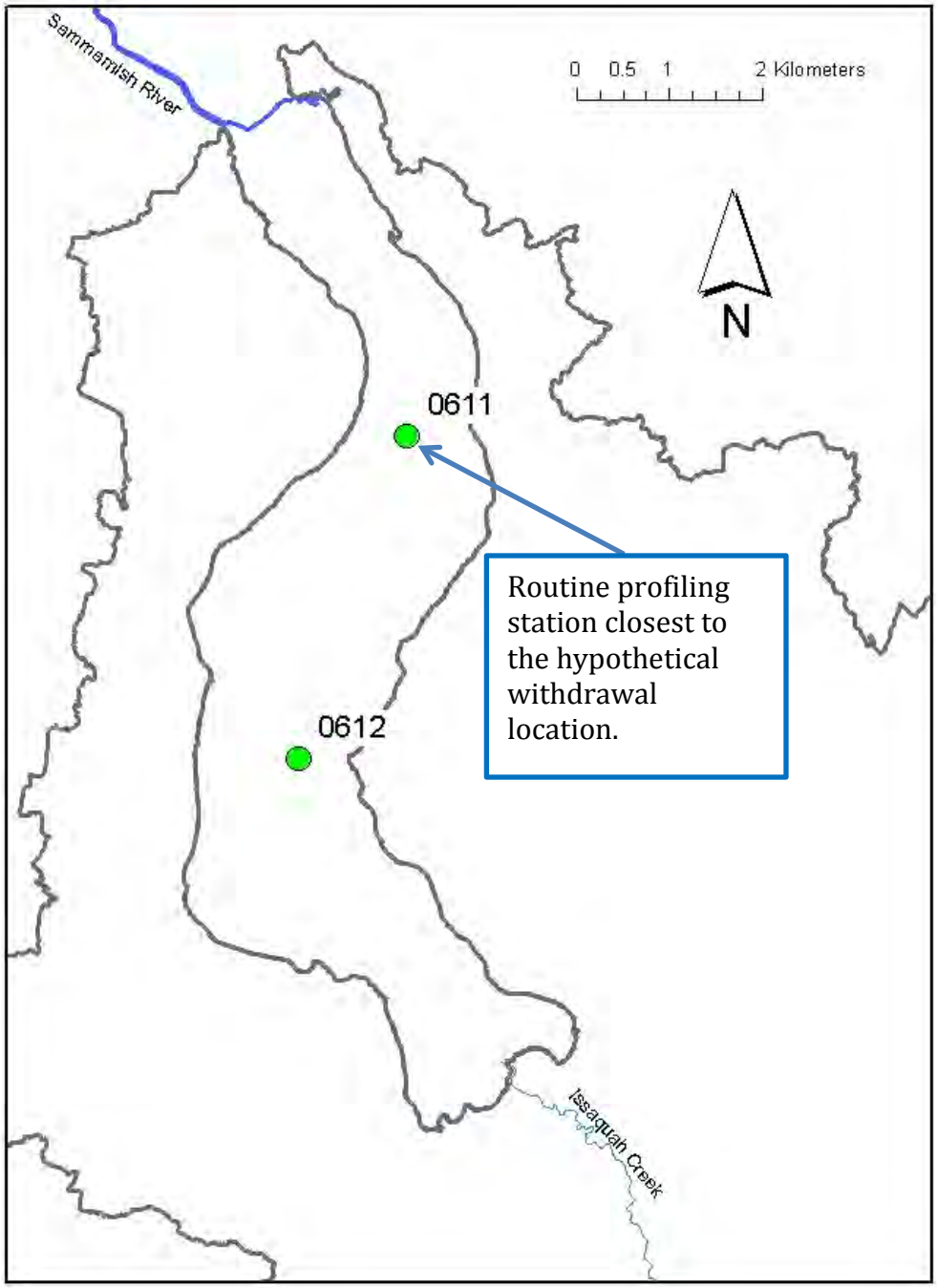

Figure 1. Map showing Lake Sammamish and locations of central routine water quality profiling stations 0611 and 0612. Major inflow (Issaquah Creek) and the lake outflow (Sammamish River) also shown.

3.0. RESULTS

In general, phosphorus (TP and SRP) loading was slightly lower on average under the hypothetical withdrawal conditions relative to the 1995-2002 existing conditions (Table 1). In comparison to existing loading, a 4 and 9 percent reduction is estimated for TP and SRP loading, respectively, under the 20 cfs withdrawal scenario. It should also be noted that the estimated magnitude of change in phosphorus loading appears to be much smaller than the inter-annual variability in existing loading conditions at the weir.

Although TP and SRP concentrations do increase between July 15 and September 15 in the deeper portion of the hypolimnion (e.g., 20 m depth), concentrations at 15 m remain below or very near the concentrations observed at the lake outlet during this time period (see Figures 2 and 3).

Larger changes are estimated for nitrogen loading, with an estimated increase in TN and DIN loading (Table 1). TN loading is estimated to increase between 10 and 21 percent and DIN loading is estimated to increase between 60 and 120 percent depending on the scenario. It should also be noted that the estimated magnitude of change in nitrogen loading, although rather large, appears to be much smaller than the inter-annual variability in existing loading conditions at the weir.

TN loading is estimated to increase because TN concentrations between 10 and 20 m at Station 0611 are typically higher than concentrations observed at the lake outlet (see Figure 4). DIN loading is estimated to increase for the same reason; DIN concentrations between 10 and 20 m are all more than the DIN concentrations observed at the lake outlet between July 15 and September 15.

To put these potential increases and decreases in loading in some perspective, loading from all surface runoff sources to the Sammamish River for the period July 15 to September 15 for the period 1995-2002 calculated as part of the development of a Sammamish River water quality model (King County 2009) are compared to the hypolimnetic withdrawal scenario loading estimates in Table 2. The first observation that can be made upon reviewing Table 2 is that nutrient loading to the Sammamish River during summer is dominated by loading from Lake Sammamish due to the generally lower flow and nutrient concentrations in tributaries during this time period.

Comparison of changes in phosphorus loading (between 0.03 and 0.10 kg day^{-1}) indicate that the magnitude of estimated decreases in loading are of smaller in magnitude to estimated loading from Big Bear Creek and similar in magnitude to loading from Little Bear and Swamp Creek (Table 2). The increase in TN loading (between about 5 and 10 kg day^{-1}) is generally larger than the estimated loading from any of the four major tributaries to the river (Table 2). The increase in DIN loading (between 7.3 and 14.6 kg day^{-1}) is generally about an order of magnitude higher than the average estimated loading from river tributaries (Table 2).

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Table 1. Daily average nutrient loads (July 15-September 15) to the Sammamish River from Lake Sammamish for 1995-2002 for existing conditions and the 10 and 20 cfs hypolimnetic withdrawal scenarios.

Scenario	year	TP	SRP	TN	DIN
			kg day^{-1}		
Weir outlet	1995	2.27	0.19	27.2	6.0
Weir outlet	1996	2.47	0.57	56.6	16.8
Weir outlet	1997	4.84	2.65	103.2	32.7
Weir outlet	1998	1.86	0.23	29.3	6.2
Weir outlet	1999	2.89	0.31	63.9	17.3
Weir outlet	2000	1.55	0.20	28.7	7.5
Weir outlet	2001	2.92	0.31	36.3	4.8
Weir outlet	2002	2.21	0.29	29.0	4.1
	Avg ± 1 SD	2.63 ± 1.01	0.59 ± 0.84	46.8 ± 26.8	11.9 ± 9.9
wd10cfs	1995	2.04	0.16	34.8	13.8
wd10cfs	1996	2.41	0.57	58.6	24.0
wd10cfs	1997	4.63	2.55	108.8	41.9
wd10cfs	1998	1.52	0.20	34.7	13.8
wd10cfs	1999	3.61	0.34	67.4	23.9
wd10cfs	2000	1.45	0.17	36.4	16.6
wd10cfs	2001	2.85	0.28	37.9	8.5
wd10cfs	2002	2.13	0.27	34.1	11.0
	Avg ± 1 SD	2.58 ± 1.09	0.57 ± 0.81	51.6 ± 26.4	19.2 ± 10.8
wd20cfs	1995	1.82	0.13	42.5	21.7
wd20cfs	1996	2.34	0.58	60.6	31.1
wd20cfs	1997	4.41	2.45	114.4	51.2
wd20cfs	1998	1.18	0.17	40.0	21.5
wd20cfs	1999	4.33	0.37	70.9	30.5
wd20cfs	2000	1.34	0.14	44.0	25.8
wd20cfs	2001	2.77	0.26	39.6	12.1
wd20cfs	2002	2.05	0.25	39.2	18.0
	Avg ± 1 SD	2.53 ± 1.25	0.54 ± 0.78	56.4 ± 26.1	26.5 ± 11.8

TP = Total Phosphorus, SRP = Soluble Reactive Phosphorus, TN = Total Nitrogen, DIN = Dissolved Inorganic Nitrogen (sum of nitrate+nitrate and ammonia nitrogen)

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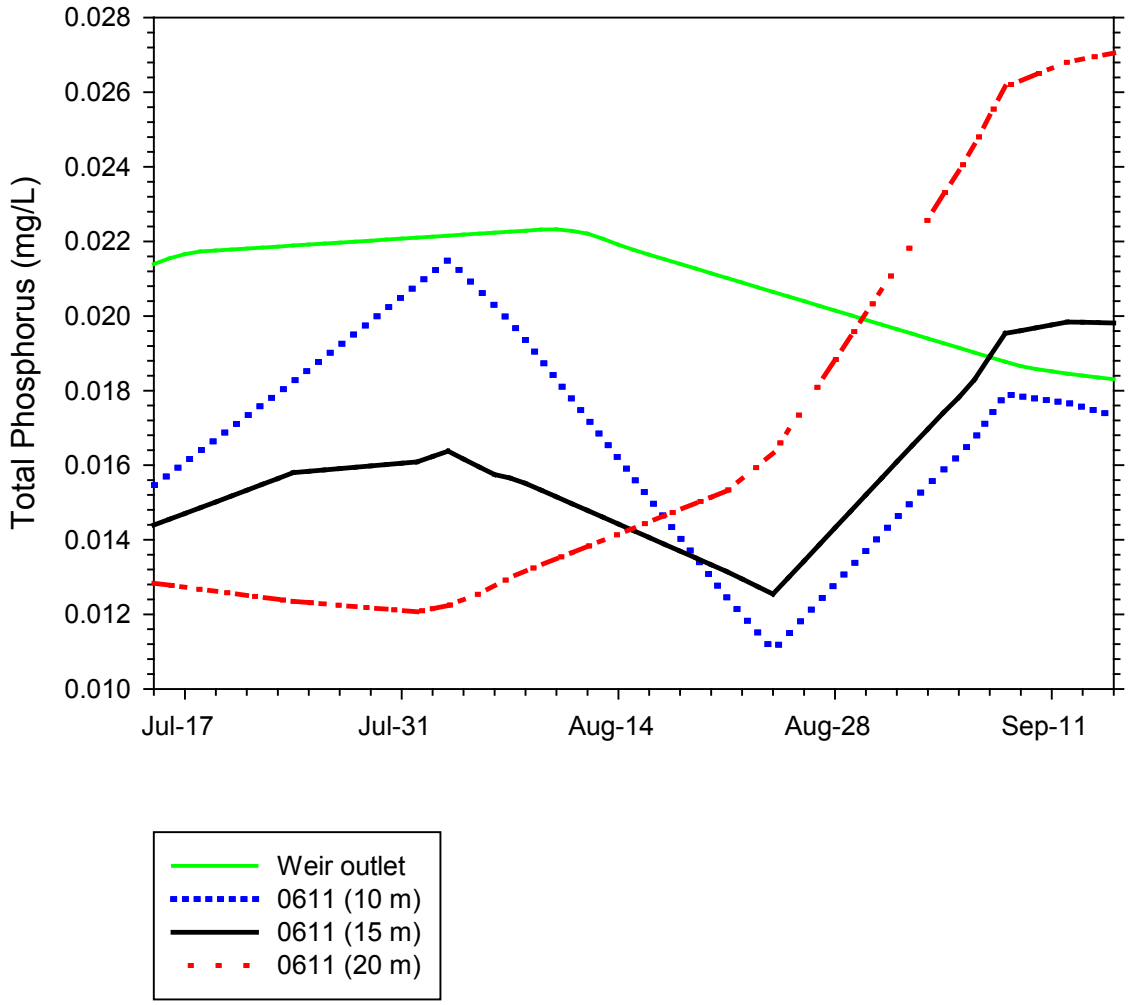

Figure 2. Daily average total phosphorus (TP) concentrations at the weir outlet and at Station 0611 (10, 15 and 20 m depths) based on the eight years of routine monitoring data (1995-2002) collected at these two locations.

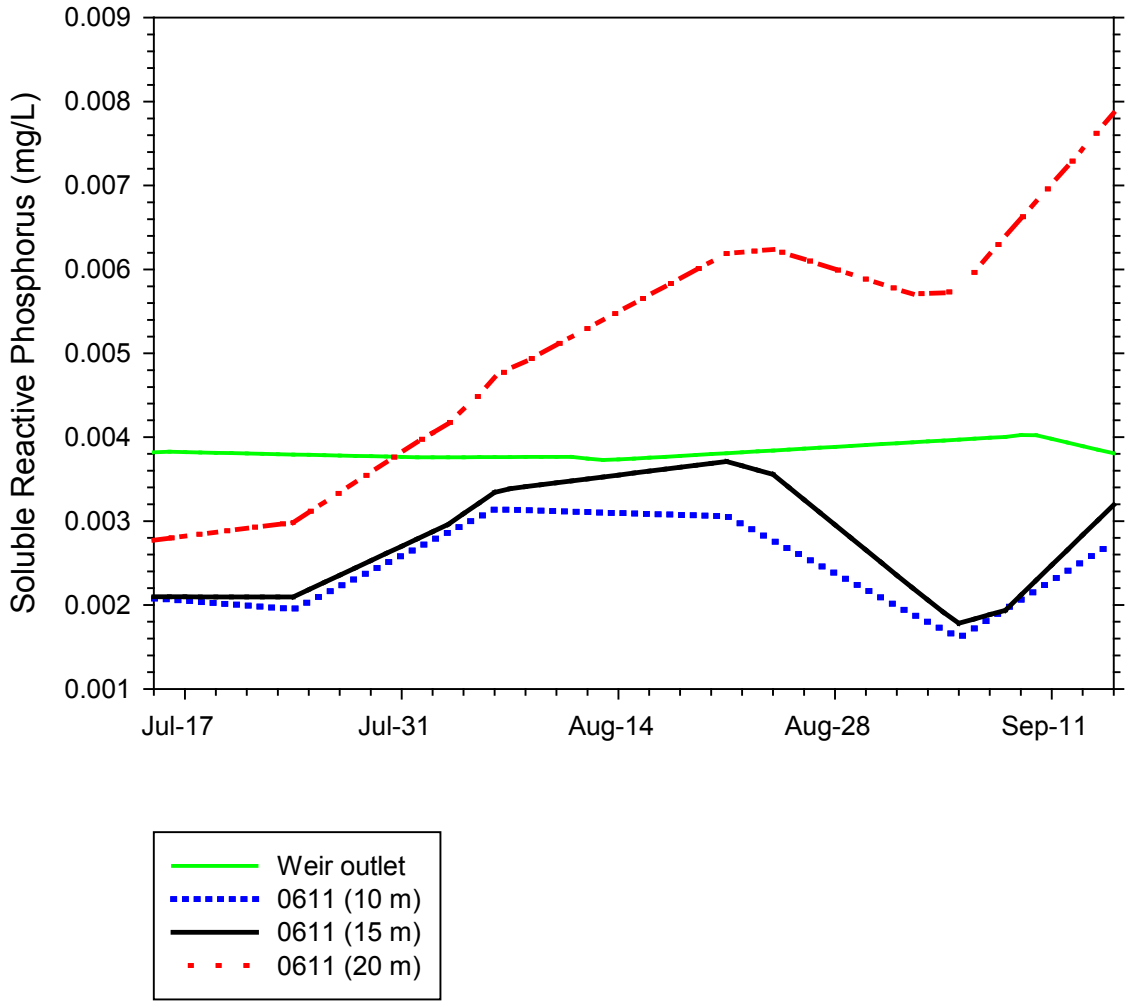

Figure 3. Daily average Soluble Reactive Phosphorus (SRP) concentrations at the weir outlet and at Station 0611 (10, 15 and 20 m depths) based on the eight years of routine monitoring data (1995-2002) collected at these two locations.

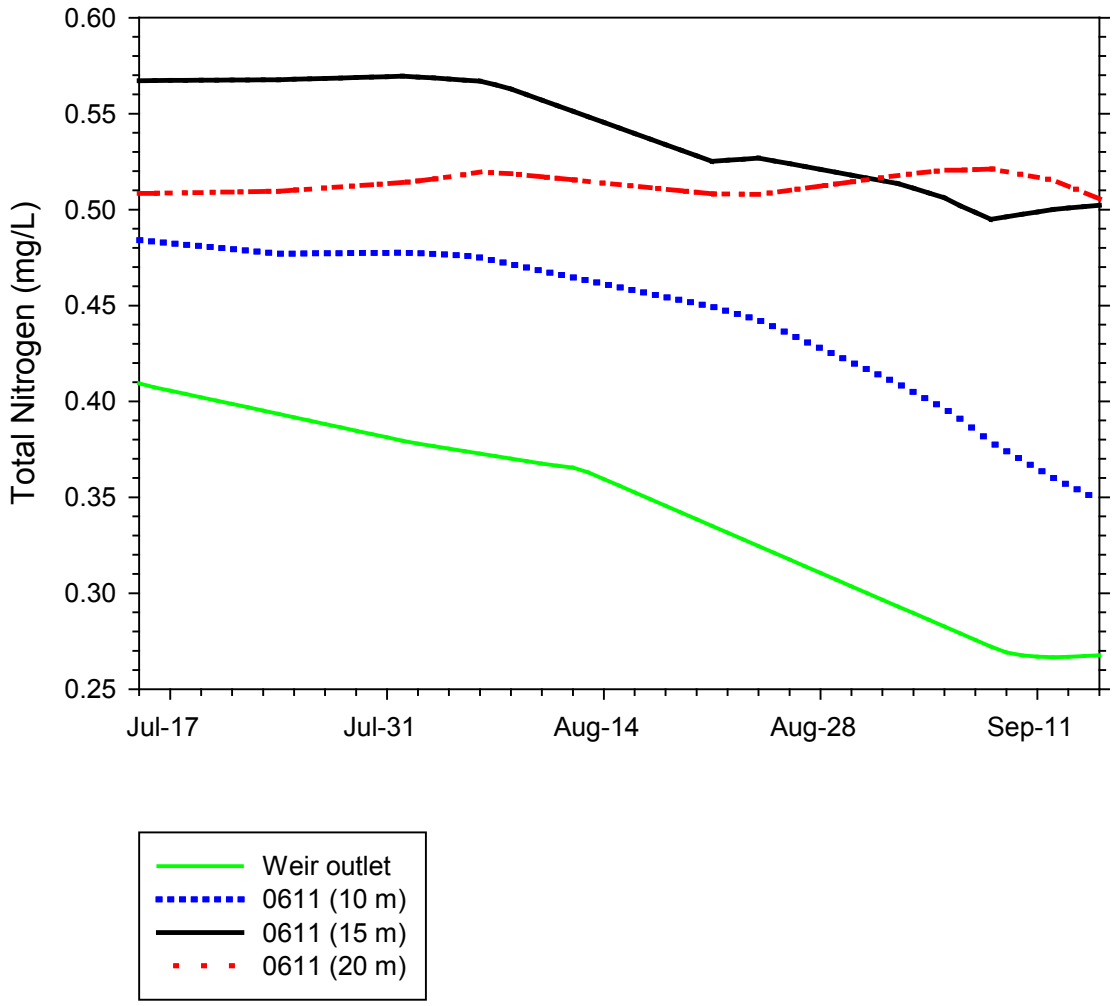

Figure 4. Daily average total nitrogen (TN) concentrations at the weir outlet and at Station 0611 (10, 15 and 20 m depths) based on the eight years of routine monitoring data (1995-2002) collected at these two locations.

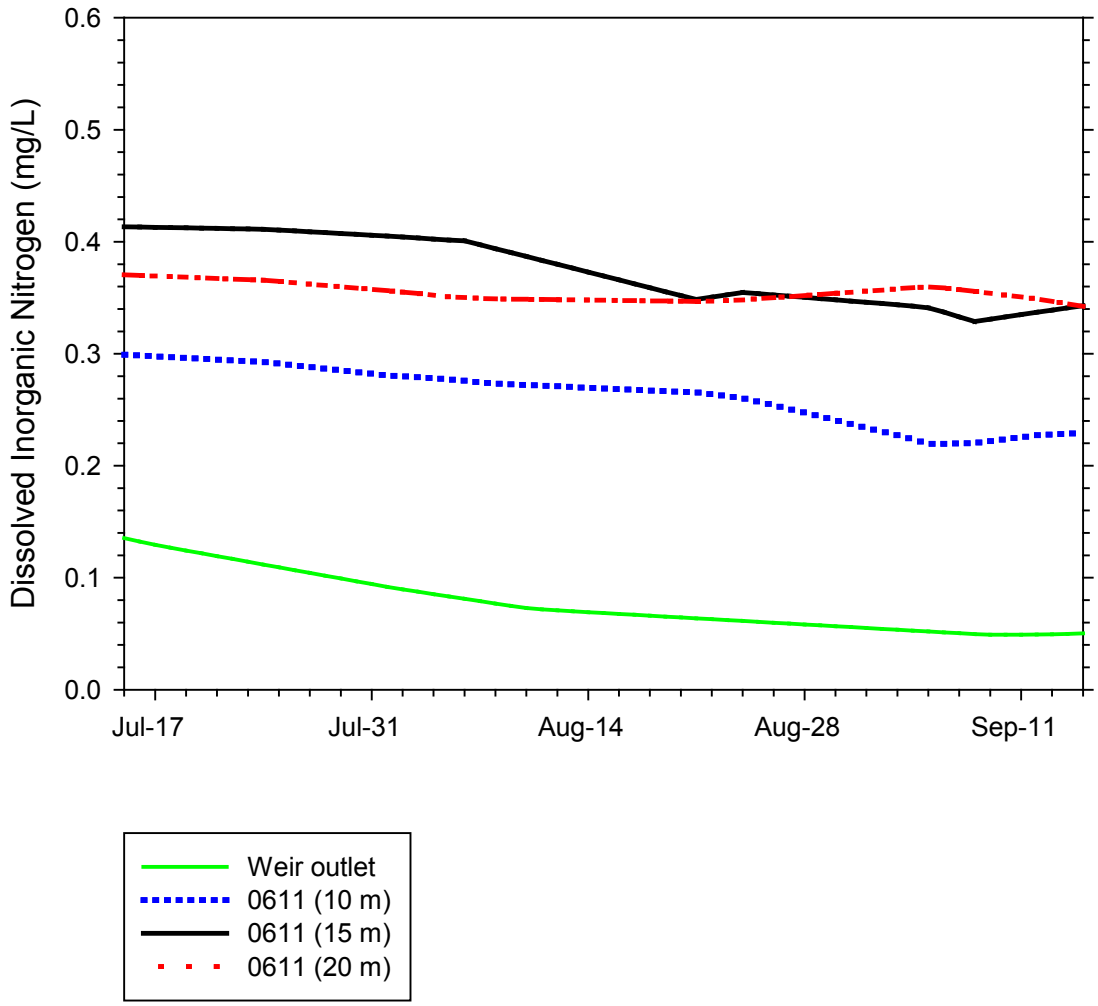

Figure 5. Daily average dissolved inorganic nitrogen (DIN) concentrations at the weir outlet and at Station 0611 (10, 15 and 20 m depths) based on the eight years of routine monitoring data (1995-2002) collected at these two locations.

Table 2. Average daily nutrient loads to the Sammamish River from all sources for the period July 15-September 15 (1995-2002) for existing conditions. Estimated loading for the two hypolimnetic withdrawal scenarios are provided for comparison.

Scenario	TP	SRP	TN	DIN
		kg day^{-1}		
Big Bear	0.17	0.07	1.8	1.0
Distributed	0.06	0.03	0.8	0.6
Little Bear	0.09	0.04	1.0	0.8
North	0.20	0.10	2.3	1.7
Swamp	0.07	0.03	0.9	0.6
Weir	2.63	0.59	46.8	11.9
wd10cfs	2.58	0.57	51.6	19.2
Δ (wd10cfs – Weir)	-0.05	-0.03	4.8	7.3
wd20cfs	2.53	0.54	56.4	26.5
Δ (wd20cfs – Weir)	-0.10	-0.05	9.6	14.6

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4.0. CONCLUSIONS

Loading of dissolved phosphorus (the most biologically available form of this nutrient) is estimated to decrease rather than increase as a result of replacing a portion of Lake Sammamish surface outlet flow to the Sammamish River with cool hypolimnetic water during the period of July 15 to September 15. Total phosphorus loading is also estimated to decrease slightly.

Total nitrogen loading is estimated to increase from 10 to 20 percent and dissolved inorganic nitrogen loading is estimated to increase from 60 to 120 percent depending on the magnitude of the hypolimnetic withdrawal (10 or 20 cfs).

In general, existing inter-annual variability in nutrient loading from the lake to the Sammamish River appears to be larger than the magnitude of estimate changes (increasing or decreasing) resulting from the hypolimnetic withdrawal scenarios.

Determining the potential effect of an increase in nitrogen loading on the aquatic condition of the Sammamish River is beyond the scope of the work conducted for this report, but in general, freshwater systems in this region are generally considered to be phosphorus limited. Changes in soluble forms of nutrients would be expected to have the greatest impact on aquatic productivity.

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Estimating the Thermal Effects of a Hypothetical Hypolimnetic Withdrawal from Lake Sammamish

September 2014

King County

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DRAFT - Estimating the Thermal Effects of a Hypothetical Hypolimnetic Withdrawal From Lake Sammamish

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Natural Resources and Parks
Water and Land Resources Division

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EXECUTIVE SUMMARY

This report describes the results of the application of an existing 2-dimensional (vertical and longitudinally) lake temperature model developed for Lake Sammamish to evaluate the effect of two Sammamish River temperature management scenarios on the thermal structure of Lake Sammamish:

- **10 cfs Hypolimnetic Withdrawal** - Replace 10 cfs of flow to river at weir boundary with lake hypolimnetic water from the 15 m depth for the period July 15 – September 15.
- **20 cfs Hypolimnetic Withdrawal** - Replace 20 cfs of flow to river at weir boundary with lake hypolimnetic water from the 15 m depth for the period July 15 – September 15.

In addition to modeling these two management alternatives, a **Baseline** model run representing existing lake conditions was also executed to provide a basis for comparison of the effect of each alternative to a consistent benchmark.

Based on the modeling results, withdrawal of up to 20 cfs of water from the 15 m depth in Lake Sammamish between mid-July to mid-September (conceptually replacing the equivalent amount of lake outlet flow) does not appear to have a significant effect on lake thermal structure or significantly impact favorable lake habitat for kokanee. This is likely due to selective withdrawal of colder water below the thermocline as relatively strong lake thermal stratification is established by July with the seasonal thermocline established at a depth less than 15 meters until late September or October when the lake begins to cool and the thermocline begins to extend to the 15 meter depth or deeper.

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1.0. INTRODUCTION

Listing of Puget Sound Chinook under the federal Endangered Species Act (ESA) has triggered an intensive effort to identify causes of salmon population declines and measures that can be taken to maintain or improve existing conditions. The King County Flood Control District is investigating options to improve summer temperature conditions in the upper Sammamish River that would potentially benefit adult Chinook migrating through the river to spawn in the Big Bear Creek basin, tributaries to Lake Sammamish (including Issaquah Creek) or return to the hatchery on Issaquah Creek.

Summer temperature conditions in the upper Sammamish River consistently exceed the applicable state standard of 16 ^{o}C[1] as well as temperature thresholds considered to be potentially lethal to salmonids (e.g, 21 ^{o}C). Extremely high river temperatures in 1998 were believed to have contributed to Chinook pre-spawn mortality observed in the river that year (Fresh et al. 1999, Martz et al. 1999). It has also been suggested that the generally higher pre-spawn mortality rate of Chinook observed in Bear and Issaquah creeks relative to pre-spawn mortality in the Cedar River between 2002 and 2005 may be due in part to the relatively high temperatures experienced by fish migrating through the river (Berge et al. 2006). Fresh et al. (1999) suggested that the upper reach of the Sammamish River (perhaps exacerbated by high temperatures in the Ship Canal) represented a significant impediment to the passage of adult Chinook destined to spawn in the Issaquah Creek basin affecting the long-term viability of the population.

This report describes the results of the application of an existing lake temperature model developed for Lake Sammamish to evaluate the effect of two Sammamish River temperature management scenarios on the thermal structure of Lake Sammamish:

- **10 cfs Hypolimnetic Withdrawal** - Replace 10 cfs of flow to river at weir boundary with lake hypolimnetic water from the 15 m depth for the period July 15 – September 15.
- **20 cfs Hypolimnetic Withdrawal** - Replace 20 cfs of flow to river at weir boundary with lake hypolimnetic water from the 15 m depth for the period July 15 – September 15.

In addition to modeling these two management alternatives, a **Baseline** model run representing existing lake conditions was also executed to provide a basis for comparison of the effect of each alternative to a consistent benchmark.

A worst-case scenario was also conducted in which the surface outlet from the lake to the Sammamish River was replaced with an equivalent year-round hypolimnetic withdrawal.

[1] The Sammamish River is designated as core summer salmonid habitat with a standard of 16 ^{o}C based on the 7-day moving average of the daily maximum temperature (Chapter 173-201A of the Washington Administrative Code).

1.1 Background

As part of King County's Sammamish-Washington Analysis and Modeling Program (SWAMP), a 3-D hydrodynamic model of Lake Sammamish was developed (King County 2008) along with a suite of other models, including HSPF watershed models of the Sammamish basin (King County 2003) and a laterally-averaged 2-D model of the Sammamish River (King County 2009); the outlet of Lake Sammamish. In addition to the 3-D model of Lake Sammamish, a laterally-averaged 2-D model of the lake was also developed to troubleshoot the development of the 3-D model, which at that time had previously been applied to only one lake; nearby Lake Washington (Kim et al. 2006; Cerco et al. 2006).

The Lake Sammamish 3-D model is CH3D-Z (curvilinear hydrodynamics in three dimensions, Z-grid version) and the 2-D model is CE-QUAL-W2 Version 3.5. Both of these models were developed by the U.S. Army Corps of Engineers and have been used to assess a variety of hydrodynamic and water quality problems. For example, CH3D-Z has been used to simulate the hydrodynamics of Chesapeake Bay and provide the hydrodynamic input to the Chesapeake Bay water quality model (Cerco and Cole 1993) and CE-QUAL-W2 has been used in hundreds of lake and reservoir modeling studies (Cole and Wells 2006).[2]

More recently the 3-D and 2-D Lake Sammamish temperature models were tested and applied to the evaluation of potential global warming impacts on lake kokanee habitat (King County 2013). The response of the two models to predicted future warming was similar. For this particular application, the 2-D model was selected for estimating the potential impacts of hypothetical summer lake withdrawals primarily because of the more flexible features of the CE-QUAL-W2 model that readily allow the modeling of withdrawal scenarios.[3] Depending on the estimated effects on lake thermal structure based on the 2-D model, a more resource intensive investigation using a 3-D model could be undertaken.

1.2 Objectives

The overall objective of the work described in this report was to use the existing 2-D Lake Sammamish temperature model to evaluate two temperature management alternatives currently under consideration as part of the King County Flood District's Willowmoor Floodplain Restoration Project.

Specific tasks to meet these objectives were:

- Revise input files as needed to create the two temperature management scenarios.
- Summarize results in tabular and graphical format and include an assessment of the effects of the hypothetical withdrawal on lake thermal structure.

[2] CE-QUAL-W2 application history: http://www.ce.pdx.edu/w2/

[3] Version 3 of the CE-QUAL-W2 model includes the implementation of a selective withdrawal algorithm for lateral withdrawals based on withdrawal flow and vertical water density structure at the designated centerline of the withdrawal point.

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2.0. METHODS

For information on the development and testing of the model, the reader is referred to King County (2013). In general, statistical comparisons of model output to observed temperatures indicated reasonably low bias and error. Mean bias was 0.16 ^{o}C and the root mean square error (RMSE) was 1.08 ^{o}C for the period 1995-2002 based on comparison to over 4,000 temperature data points collected at various locations and depths in the lake. These error statistics are similar to many other well calibrated temperature models surveyed by Arhonditsis and Brett (2004). The ultimate acceptance of a model requires the evaluation of a host of factors and no specific pass/fail criteria exist. In general, model performance was considered adequate for conducting the alternatives analyses described in this report.

The longitudinal resolution of the 2-D grid is illustrated in Figure 1. The lake is represented by 22 longitudinal segments and vertical resolution was defined using 0.91 m thick layers resulting in a close approximation of the 3-D model vertical layering scheme. The QUICKEST-ULTIMATE numerical transport solution scheme was used with the recommended time weighting factor (THETA) of 0.55. The vertical turbulence algorithm W2N was used with an implicit scheme and a maximum vertical eddy viscosity of 0.01 $m^2 s^{-1}$. The model time step was optimized and averaged about 100 seconds in each model run, which resulted in 8-year simulations (1995-2002) that took approximately 30 minutes to run on a 64-bit Windows PC equipped with two 2.66 GHz quad core processors. Model output was written to a self-describing binary file format (NetCDF) during runtime resulting in an 841 MB file for each 8-year model run.

Model input files were developed to represent withdrawals of 10 and 20 cfs for the period July 15 through September 15 each year between 1995 and 2002. A file was also developed that represented replacing the surface outlet flow with an equivalent year-round hypolimnetic withdrawal. The withdrawal point was specified to take place at the 15 m depth at segment 17 which represents the model segment just north of Station 0611 (see Figure 1).

2.1 Estimating Effects on Lake Thermal Structure

The analytical tools developed as part of the assessment of global warming impacts on Lake Sammamish kokanee habitat (King County 2013) were used to evaluate the potential effects of the hypothetical withdrawal scenarios on lake thermal structure and kokanee habitat. Details of those methods can be found in King County (2013). The methods are briefly described below.

2.1.1 Lake Analyzer

Model output from the central lake monitoring location (Station 0612) was processed and analyzed using Lake Analyzer (Read et al. 2011), a Matlab program designed for analyzing high resolution lake profiling data that is also well suited to analyzing lake temperature

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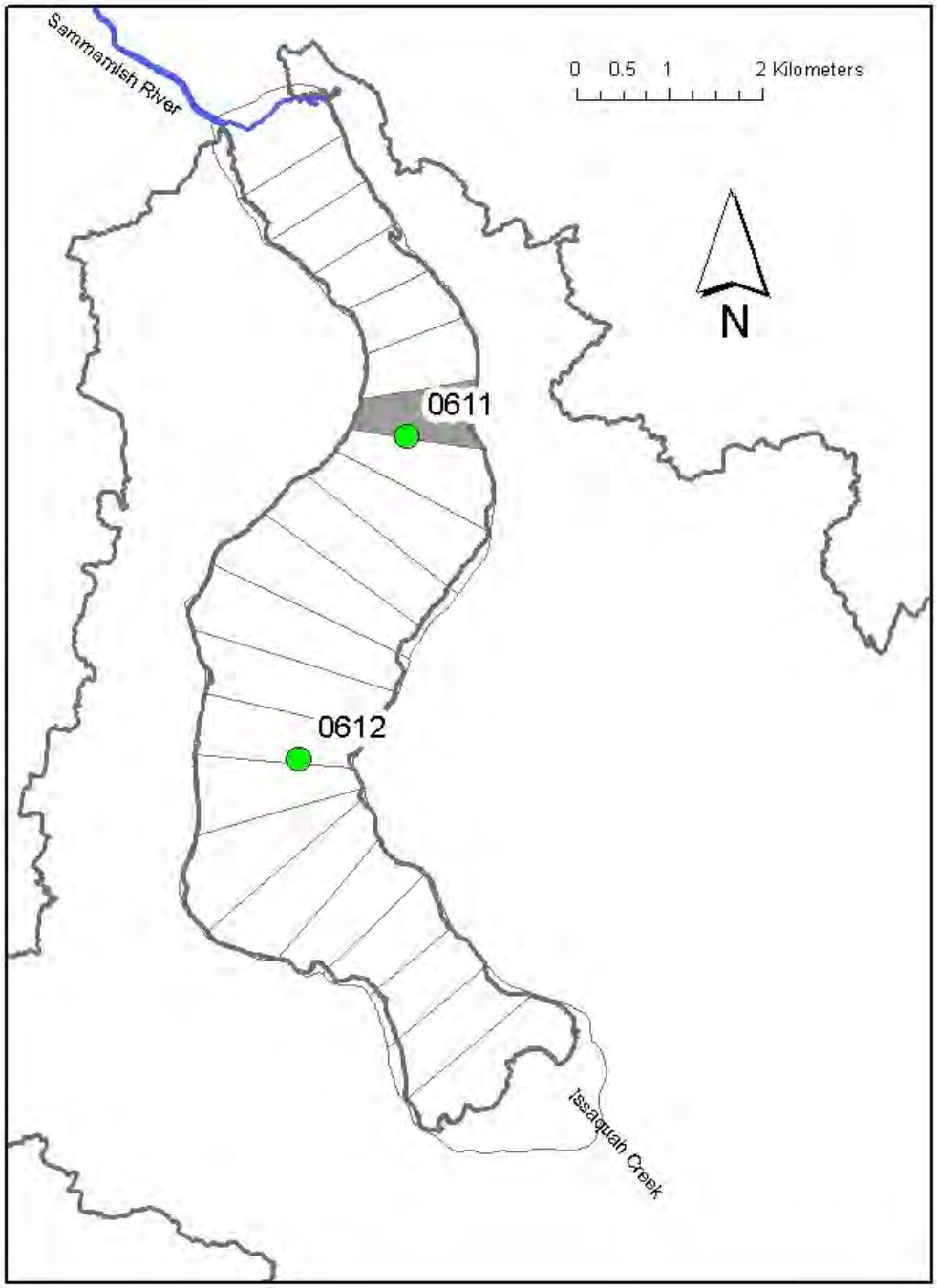

Figure 1. Map showing the longitudinal segmentation of the Lake Sammamish CE-QUAL-W2 grid and locations of routine water quality profiling stations. Major inflow (Issaquah Creek) and the lake outflow (Sammamish River) also shown. The segment where the hypothetical hypolimnetic withdrawal was placed is shaded gray.

model output. Lake Analyzer calculated a number of metrics relevant to analyses of lake thermal regimes, including, but not limited to, thermocline depth and thermal resistance to mixing (Schmidt stability index). Lake Analyzer also produced color contour plots of temperature that visually illustrated changes in lake temperature under different management scenarios.

2.1.2 17 ^{o}C Isotherm

Model output for the grid cell representing Station 0612 was also processed using Matlab scripts that determined the isotherms for 17 ^{o}C, which was identified as a kokanee avoidance threshold (i.e., kokanee would avoid areas of the lake with a temperature greater than 17 ^{o}C) (Kirk Krueger, Washington Department of Fish and Wildlife, pers. comm., email, May 28, 2013).

2.1.3 Favorable Habitat Volume for Kokanee

An analysis of the observed DO data collected from the central long-term monitoring station (Station 0612) was conducted to estimate the daily volume of the lake with DO concentrations less than 4 mg/L. The daily volume of the lake for each model scenario and temperature threshold was subtracted from the volume of the lake with DO concentrations below 4 mg/L to provide an estimate of the daily habitat volume for each temperature threshold accounting for the DO squeeze. Following Berge (2009), the volume of the lake with temperatures below 17 ^{o}C (based on model output) and DO concentrations greater than 4 mg/L (based on observed data) were characterized as “favorable” salmonid habitat.

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3.0. RESULTS

3.1 Lake Analyzer

3.1.1 Thermocline Depth

There appeared to be no significant effect of a July 15-September 15 hypolimnetic withdrawal on thermocline depth. The monthly average thermocline depth (1995-2002) was essentially the same for the Baseline, 10 cfs, and 20 cfs withdrawal scenarios (Figure 2). Replacing the outlet withdrawal with a year-round hypolimnetic withdrawal did have an apparent effect on the thermocline depth (deepening), particularly from about the beginning of June through September (see Figure 2).

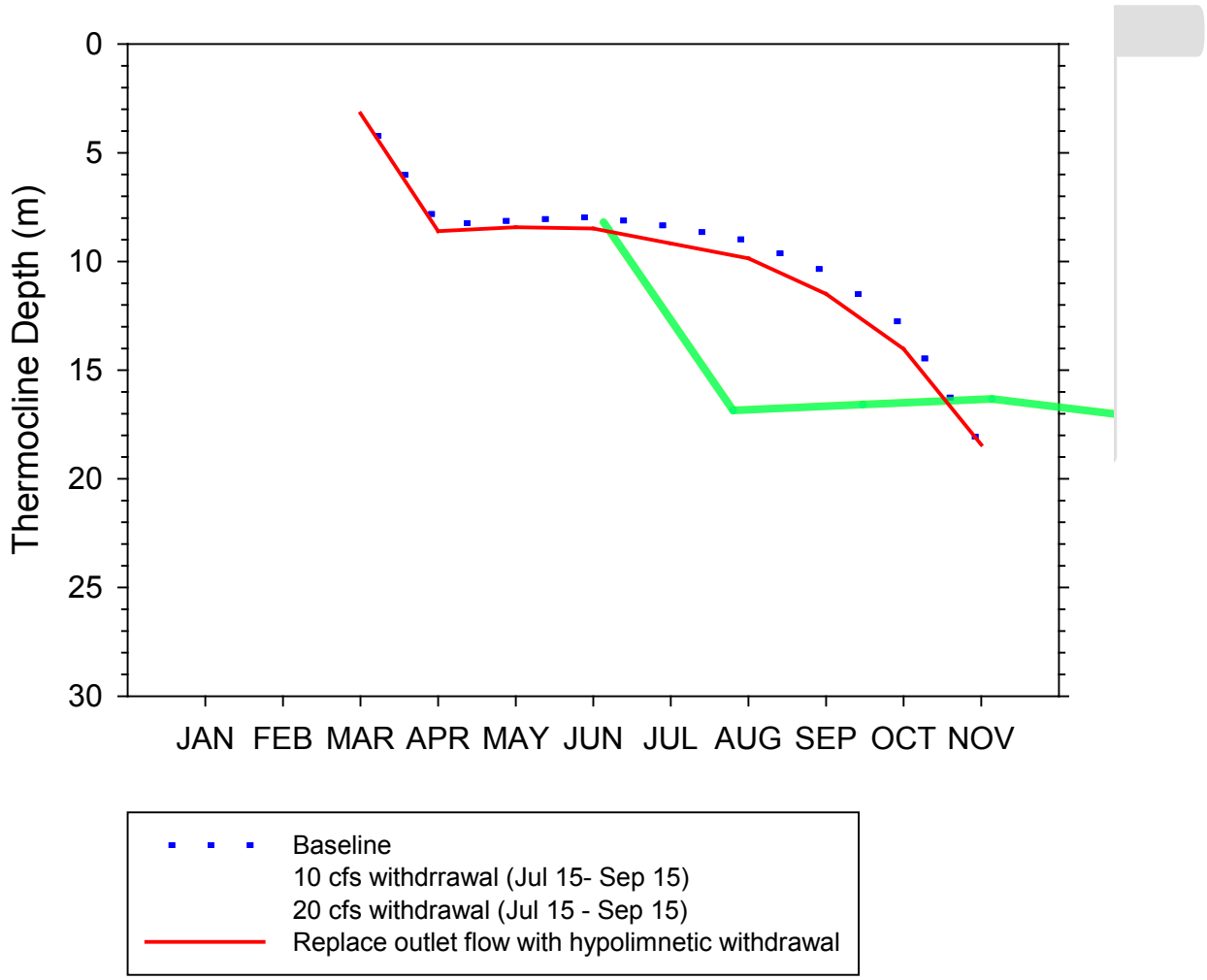

Figure 2. Monthly averaged thermocline depths based on the eight years of output from the 2-D CE-QUAL-W2 Lake Sammamish model.

3.1.2 Schmidt Stability

There appeared to be no significant effect of a July 15-September 15 hypolimnetic withdrawal on lake thermal stability as measured by the Schmidt stability index. Monthly average Schmidt stability (1995-2002) was essentially the same for the Baseline, 10 cfs, and 20 cfs withdrawal scenarios (Figure 2). Replacing the outlet withdrawal with a year-round hypolimnetic withdrawal did have a small effect on Schmidt stability (increased) (see Figure 3).

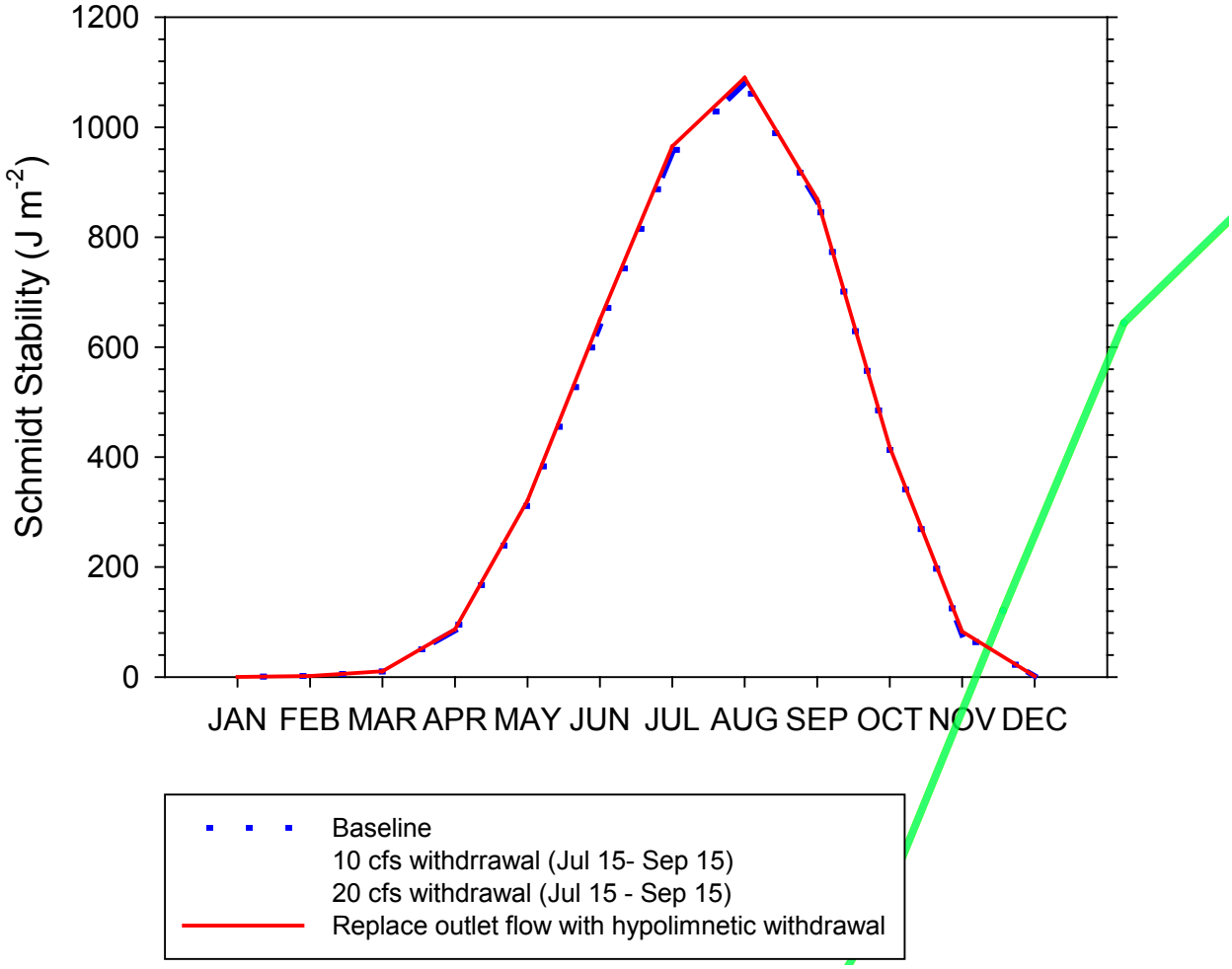

Figure 3. Monthly averaged Schmidt stability based on the eight years of output from the 2-D CE-QUAL-W2 Lake Sammamish model.

3.1.3 Color Contour Plots of Temperature

A comparison of color contour plots of temperature (1995-2002) for the model location representing Station 0612 was essentially the same for the Baseline and 20 cfs withdrawal scenarios (Figure 4).

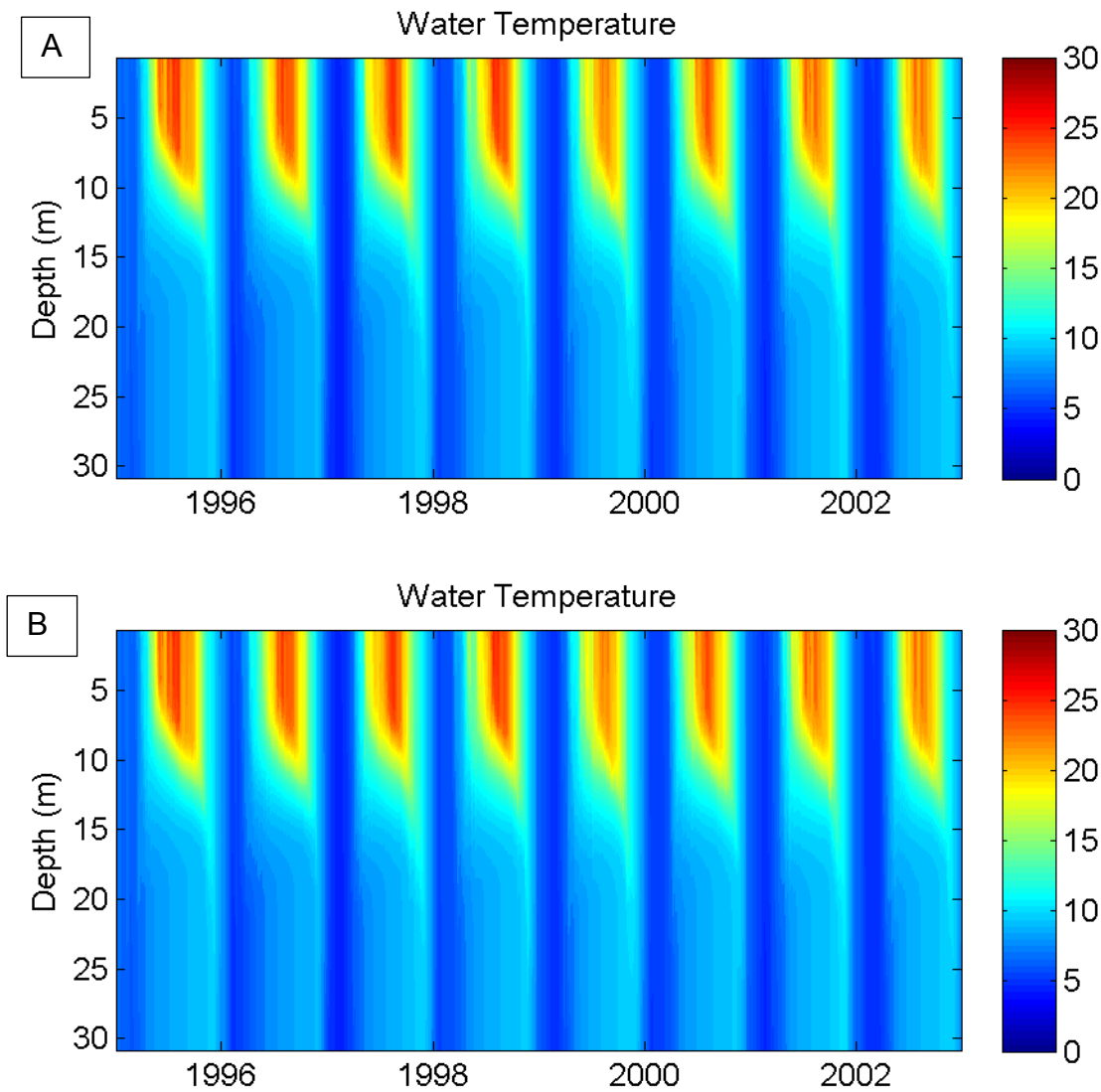

Figure 4. Color contour depth vs time (1995-2002) plots of lake temperature at the central lake station (0612) based on the 2-D model: (A) is the baseline model run, (B) is the 20 cfs hypolimnetic withdrawal scenario.

3.2 17 °C Isotherm

There appeared to be no significant effect of a July 15-September 15 hypolimnetic withdrawal on the 17 °C isotherm (Figure 5). The monthly average 17 °C isotherm (1995-2002) was essentially the same for the Baseline, 10 cfs, and 20 cfs withdrawal scenarios (Figure 5). Replacing the outlet withdrawal with a year-round hypolimnetic withdrawal did have an apparent effect on the depth of the 17 °C isotherm (deepening) (see Figure 5).

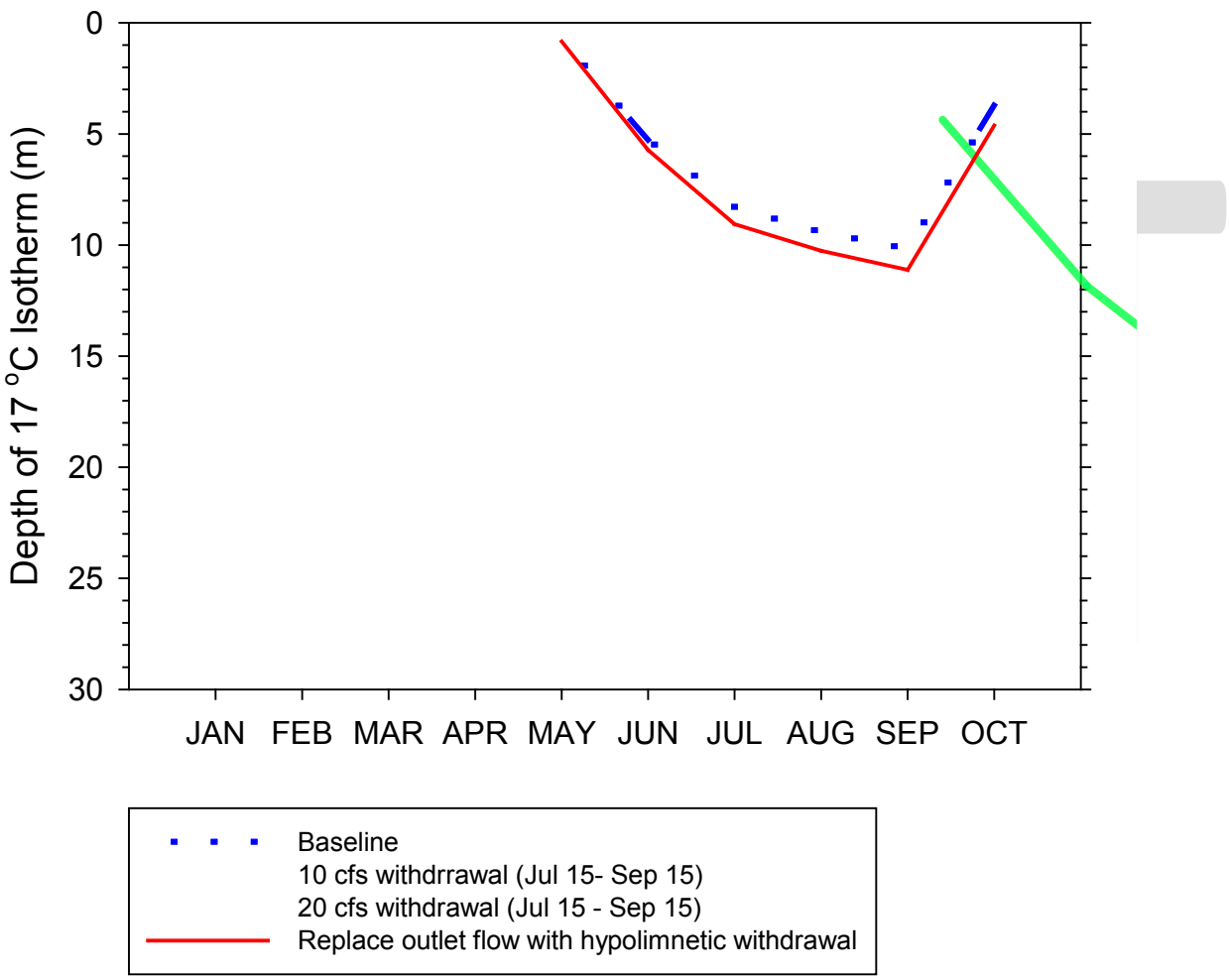

Figure 5. Monthly averaged 17 °C isotherms based on the eight years of output from the 2-D CE-QUAL-W2 Lake Sammamish model.

3.3 Favorable Habitat Volume for Kokanee

There appeared to be no significant effect of a July 15-September 15 hypolimnetic withdrawal on the monthly average favorable habitat volume for kokanee (Table 1 and Figure 5). Reductions in monthly average favorable habitat volume were half a percent or less in August, September and October with no significant changes predicted in other months (Table 1). Replacing the outlet withdrawal with a year-round hypolimnetic withdrawal had a more substantial effect on the predicted amount of favorable habitat volume with reductions as large as almost 5 percent (see Table 1).

Table 1. Average monthly (May-October) favorable salmonid habitat volumes (shown as percent of total lake volume) predicted by the 2-D CE-QUAL-W2 Lake Sammamish model for each of the three temperature thresholds.

Scenario	May	Jun	Jul	Aug	Sep	Oct
Baseline	95.7	67.6	42.7	27.7	15.8	50.5
10 cfs hypolimnetic withdrawal (Jul 15-Sep 15)	95.7	67.6	42.7	27.5	15.5	50.2
20 cfs hypolimnetic withdrawal (Jul 15-Sep 15)	95.7	67.6	42.7	27.4	15.3	50.2
Replace outlet with year-round hypolimnetic withdrawal	95.3	65.0	38.8	23.4	11.1	46.0

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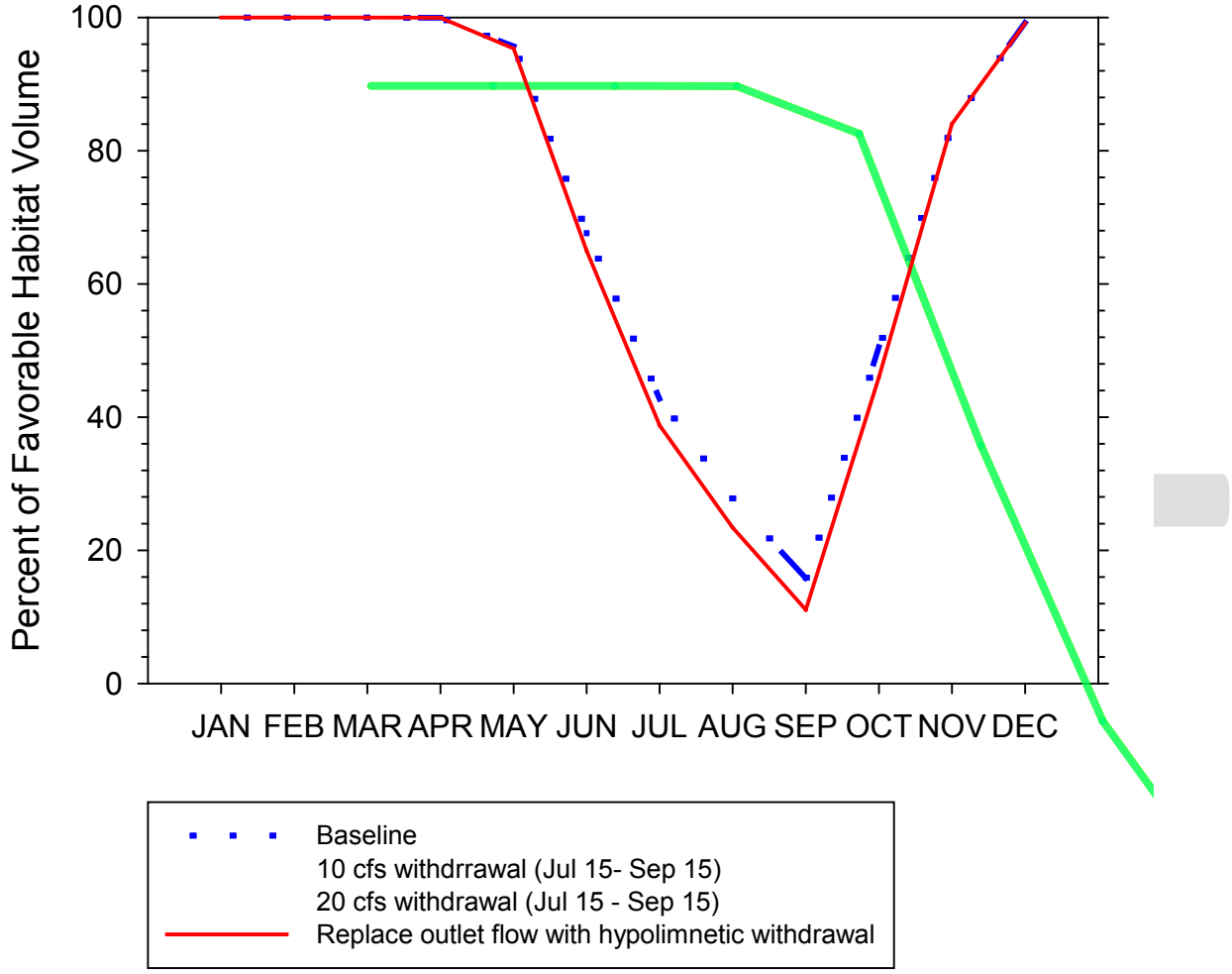

Figure 6. Monthly averaged favorable salmonid habitat volume based on eight years of ouput from the 2-D CE-QUAL-W2 Lake Sammamish model (volume <17 °C and greater than 4 mg DO per liter) isotherms based on the eight years of output from the 2-D CE-QUAL-W2 Lake Sammamish model.

4.0. CONCLUSIONS

Based on the 2-D modeling results, withdrawal of up to 20 cfs of water from the 15 m depth in Lake Sammamish between mid-July to mid-September (conceptually replacing the equivalent amount of lake outlet flow) does not appear to have a significant effect on lake thermal structure or significantly impact favorable lake habitat for kokanee. This is likely due to selective withdrawal of colder water below the thermocline as relatively strong lake thermal stratification is established by July with the seasonal thermocline established at a depth less than 15 meters until late September or October when the lake begins to cool and the thermocline begins to extend to the 15 meter depth or deeper (see Figure 2).

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