

Fisher Slough Tidal Marsh Restoration

2012 Monitoring Report

Skagit River System Cooperative, LaConner, WA



Photos looking west into Fisher Slough Blind Ch 1; July 2012 and February 2013

Photos by Karen Wolf & Rich Henderson of SRSC

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Section 1: Introduction

The Nature Conservancy's (TNC) Fisher Slough Tidal Marsh Restoration Project (Fisher Slough Project) is being monitored to document changing conditions in the original and restored freshwater tidal habitats following reintroduction of tidal hydrology and reconnection of stream floodplains on the site in order to evaluate success of restoration efforts. This monitoring report compares established baseline (pre-project) conditions with changing-project conditions, to test hypotheses derived from the project objectives.

Monitoring results should be used to guide adaptive management of the restoration project to achieve and maintain project goals over the long term. Consequently, any failures to meet project goals over the near term should not be viewed as project failures; rather they should be viewed as opportunities to learn from experience and make informed corrections that allow improved site management and project success over the long term. Furthermore, discovery of any near-term shortcomings in restoration results should highlight the need not only for adaptive management, but also for continued monitoring to inform management and ensure project success. When project monitoring ceases to provide any surprising results or demonstrate failures, and when the restoration project appears to have reached a dynamic equilibrium condition, then monitoring can be deemed no longer necessary.

All phases of the restoration construction are now complete (as of October 31, 2011). Planned and unplanned deviations to floodgate operation during established operational periods occurred in WY2012 and may have resulted in some restoration target goals not being met, including water elevations, water temperature, or water dissolved oxygen. Data in this report are presented for the first water year after restoration construction was completed, regardless of the deviations. In some sections of this report results are given for time periods when floodgate operation deviations occurred to show conditions that might be achieved if deviations to the floodgate operation had not taken place.

The Fisher Slough Project site is located in Skagit County, Washington, just south of the town of Conway, at the downstream end of the Carpenter Creek/Hill Ditch watershed and near the confluence of Steamboat Slough with Tom Moore Slough on the south fork of the Skagit River (Figure 1-1). Fisher Slough has been subjected to channelization and levee construction as part of flood control, irrigation and drainage, and agricultural development on the Skagit River delta for the past 150 years.

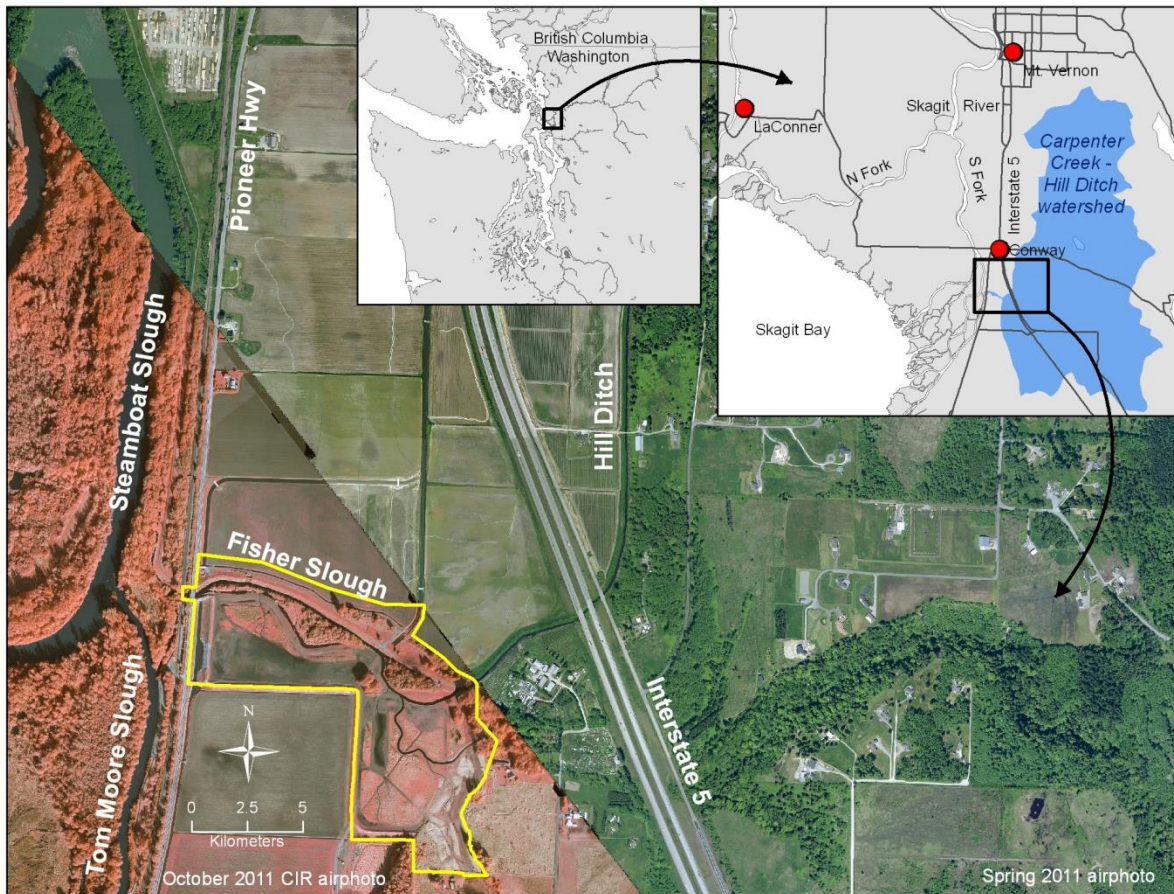


Figure 1-1. Location of the Fisher Slough Project. Project area is outlined in yellow.

1.1 Project Purpose

The purpose of the Fisher Slough Project is to restore landscape processes and salmonid habitat functions within Fisher Slough, while providing additional benefits to local landowners and farmers, including improved flood protection and drainage. Specifically, the project reestablishes riparian floodplain and tidal processes within Fisher Slough and its tributaries. The Nature Conservancy, which owns most of the 60-acre restoration site, worked collaboratively with Skagit County Public Works, Diking District 3, Drainage and Irrigation District 17, and local landowners to implement this project (Figure 1-2). The Fisher Slough Project consisted of three elements:

Project Element 1 – Completed in the fall of 2009, this element consisted of the replacement of the existing floodgates at the Pioneer Highway crossing with new self-regulating floodgates to allow greater tidal exchange and fish access upstream of the floodgate, while still providing flood protection to adjacent farmland. The new floodgate is designed and operated to maximize tidal exchange (i.e., the new gates are open for a longer timeframe during the year) and also to improve fish access during the spring migration period for Chinook salmon (*Oncorhynchus tshawytscha*) (Tetra Tech 2008). At the same time, a small flapgate located below the south floodgate was

retrofitted with a gate that can be propped open to allow fish passage, in the summer, when water levels drop below the floodgate sill.

Project Element 2 – Started in 2010 and completed in 2011, this element involved the realignment of Big Ditch from its historical configuration where it crossed under Fisher Slough. Big Ditch was within the old levee setback area. The ditch was moved in order to remove a fish passage barrier, to make way for more complete levee setback, and to allow it to continue functioning as part of the drainage system for the adjacent and upstream landowners. Project Element 2 included excavating a new route for Big Ditch so that it crosses under Fisher Slough near Pioneer Highway, demolishing the old box culvert crossing, and filling in the old Big Ditch location.

Project Element 3 – Completed in the fall of 2011 (in WY2012), this element included building a new levee setback, removing the original south levee, excavating pilot tidal channels, re-routing Big Fisher and Little Fisher Creeks, and planting some marsh and riparian areas.

This monitoring report documents data collected between October 1, 2011 and September 30, 2012, Water Year 2012 (WY2012). The purpose of the WY2012 data collection is for comparison of site conditions in terms of ecological indicators that are expected to change in function as a result of completed Project Elements 1-3. Construction of the dike setback (Project Element 3) was completed one month after the start of WY2012; therefore most data collected in WY2012 are used to document post-project conditions for the twelve individual hypotheses summarized in Table 2.1.

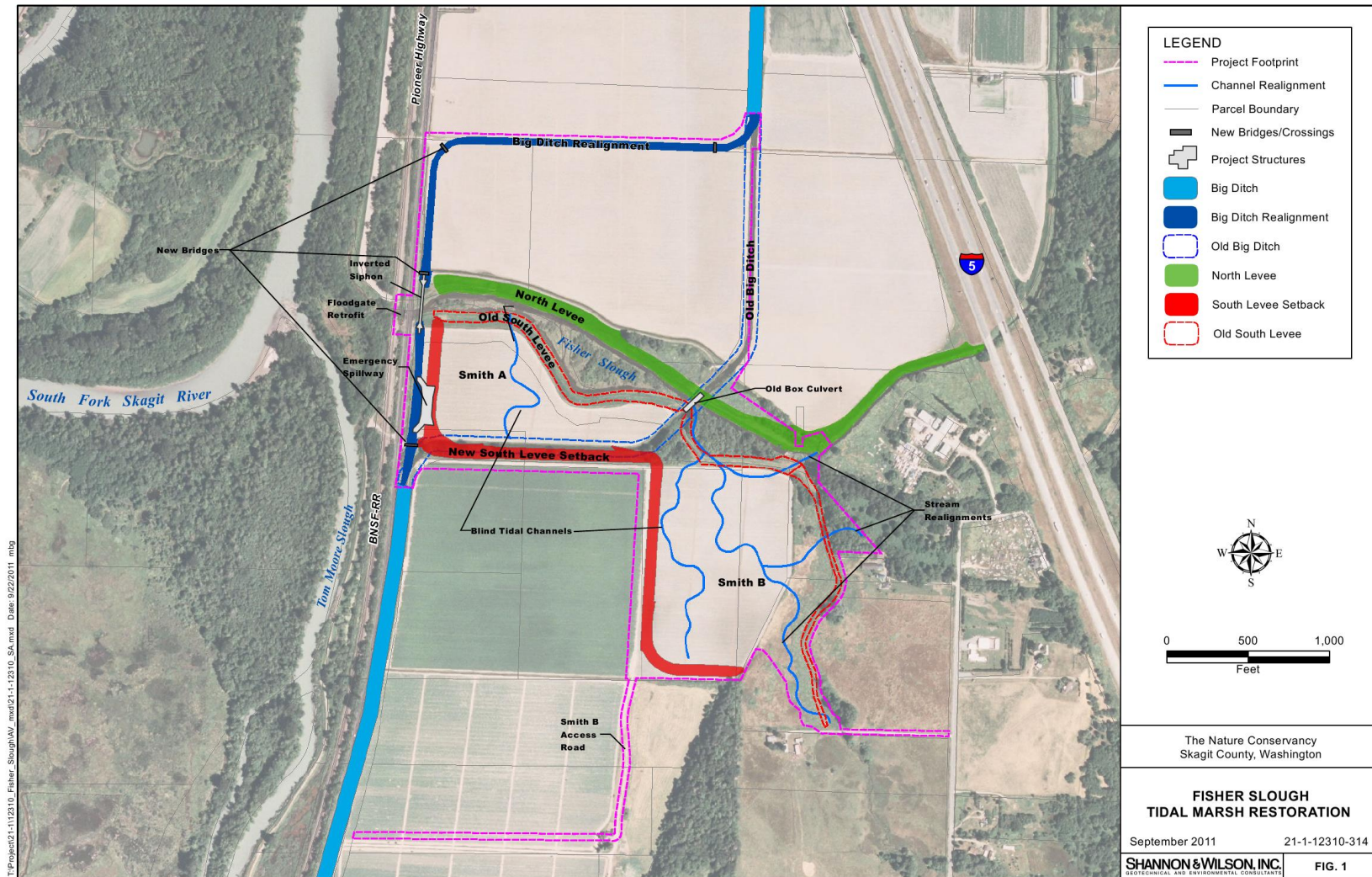


Figure 1-2. Fisher Slough tidal marsh post-restoration project site map.

1.2 Project Objectives

The goal of restoration monitoring at Fisher Slough is to evaluate the success of restoration efforts by documenting changing conditions from pre-project to restored habitats after the reintroduction of tidal hydrology and reconnection of stream floodplains on the site. Specifically, the monitoring program is designed to track progress toward the primary project objectives (Parametrix 2010):

1. Restore the ecological processes and structure to support and maintain a functional freshwater tidal wetland that supports target species, such as Chinook salmon;
2. Restore and improve freshwater tidal rearing habitat for Chinook salmon;
3. Restore fish passage for access by spawning coho (*Oncorhynchus kisutch*) and chum salmon (*Oncorhynchus keta*); and
4. Improve flood storage to protect agricultural uses of adjacent properties.

Restoration of Fisher Slough is expected to reestablish landscape processes and habitats within the project site and improve hydrologic function upstream in the Carpenter Creek watershed. Monitoring efforts for biotic response variables and landscape changes include the collection of data associated with surface water levels, groundwater levels, water quality (dissolved oxygen [DO] and temperature), vegetation, marsh elevations, channel cross sections and fish monitoring.

In summary, the monitoring efforts are to determine whether this project achieves its ecological, fish, and flood protection objectives, and if not, recommend corrective actions for adaptive management. Thus, the Fisher Slough monitoring effort can act as a template for future projects.

1.3 Monitoring Methods

Methods used for monitoring the Fisher Slough Project are detailed in Parametrix (2010) unless otherwise noted in sections below. Locations of monitoring equipment are shown in Figure 1-3.

Data collected at the site Big Ditch Crossing have been reported for some of the parameters of Hypotheses 1 and 2. This location is now a blind channel area due to the channel relocation and dike setback construction completed in 2011. In 2012 a site in the new main channel above the historical location of the Big Ditch siphon was chosen as a replacement site for the Big Ditch Crossing site. This site is called Upper Main Channel and has a Solinst Edge model 3001 data logger to record WSE and water temperature, and an AquiStar® data logger to record dissolved oxygen. Data from this site are used in this report and should be used in all future monitoring reports. The original WSE and water temperature data logger is still deployed at the old Big Ditch Crossing site, now called Blind Ch 3.

There were two other logger sites established in the new blind channel areas, Blind Ch 1 and Blind Ch 2. Both sites have a Solinst Gold model 3001 data logger to record WSE and water temperature. An AquiStar® data logger, which records dissolved oxygen, is rotated between these two locations and Blind Ch 3 (Figure 1-3).

Hypotheses 1.2 and 1.4 involve tidal amplitude and MHHW immediately upstream of the floodgates. In WY2009 the Solinst data logger immediately upstream of the floodgate became buried in sand, so data collected at the Big Ditch Crossing site were reported in the target parameters. These data have been removed from Tables 2-1 and H1-1 in this report per a request from TNC, as the Big Ditch Crossing site is not immediately upstream of the floodgate, as called for in the Restoration Target.

The data set for 2009 at the site Upstream Floodgate was re-evaluated and it was determined that the logger had not become inundated by sand until late May, and therefore provides accurate data during the spring juvenile Chinook migration period. The results have been updated for WY2009 in Tables 2-1 and H1-1.



Figure 1-3. Location of barometric pressure (barologger), groundwater, water surface (WSE), and DO monitoring equipment for Fisher Slough project site. Datalogger at Downstream Floodgate also includes floodgate-door-openness monitoring. Project area is outlined in blue.

Section 2: Results and Discussion

In this section we address the twelve hypotheses associated with the four Fisher Slough project objectives (Table 2-1). We describe current conditions and relate them to restoration targets.

Groundwater elevations (Appendix A) are not specifically related to project objectives and hypotheses, but there is an interest in tracking groundwater elevations at several locations during and after the restoration project because of concerns about effects on neighboring farmland. Determining what factors groundwater elevations are responding to would require more extensive sampling than currently planned; however, by tracking groundwater elevations at a few locations, any significant anomalies can be evaluated and used to determine whether there is a need for further investigation.

Table 2-1. Summary of conditions and restoration targets associated with objectives, hypotheses, and parameters for Fisher Slough.

Objective	Hypothesis	Parameters	Pre-project Condition (before 2009)	WY2009 Condition	WY2010 Condition	WY2011 Condition	WY2012 Condition	Restoration Target
1: Restore the ecological processes and structure to support and maintain a functional freshwater tidal wetland that supports target species, such as Chinook salmon.	H1: Replacement/ revised operation of the floodgate (post-project condition) will result in increased tidal amplitude and water elevations upstream of the new floodgate, compared to pre-project conditions.	Gate operations result in higher water levels and greater tidal amplitude upstream of the floodgates.		Mean tidal amplitude during spring migration (measured by Solinst data logger): Downstream: 2.08 ft, Upstream: 1.56ft	Mean tidal amplitude from May 2 to May 31 (measured by floodgate monitoring instrumentation): Downstream:2.16 ft, Upstream: 1.59 ft	Mean tidal amplitude during Spring Migration (measured by floodgate monitoring instrumentation): Downstream: 1.77 ft, Upstream: 1.61ft	Mean tidal amplitude during Spring Migration Period (March 1 to May 31) relative to the flood gate: Downstream: 1.46 ft, Upstream: 1.01 ft	After floodgate replacement, tidal amplitude upstream of floodgates will increase during the spring juvenile salmon migration period.
		When floodgates are open, compare tidal amplitude immediately upstream of floodgate to downstream of floodgate.		Mean tidal amplitude during Spring Migration Period (measured by Solinst data loggers): Downstream: 1.51 ft, Upstream: 1.44 ft	Mean tidal amplitude from May 3 to May 31 (measured by floodgate monitoring instrumentation): Downstream: 1.94 ft, Upstream: 1.58 ft	Mean tidal amplitude during Spring Migration Period (measured by floodgate monitoring instrumentation): Downstream: 1.68 ft, Upstream: 1.61 ft	Mean tidal amplitude during Spring Migration Period(March 1 to May 31) relative to the flood gate, when open: Downstream: 1.04 ft, Upstream: 1.02 ft	Tidal amplitude immediately upstream of floodgates will match amplitude downstream of floodgates (gates open).
		MHHW upstream of floodgates. during the entire monitoring year (1 October through 30 September)	Surface Data collected but not converted to MHHW	MHHW at Big Ditch crossing is 8.59 ft NAVD88 for the whole year.	MHHW at Big Ditch crossing is 8.56 ft NAVD88 for the whole year even though floodgates were disengaged during construction of Project Element 2 during the Summer Irrigation Period.	MHHW upstream of the floodgate was 8.65 ft NAVD88 at Big Ditch Crossing for all of WY2011. During non-construction operating times, MHHW was 9.48 ft NAVD88.	MHHW at Upper Main Channel site (replacement site for Big Ditch Crossing) was 8.87 ft NAVD88. (March 23 - Sept 30, 2012).	MHHW will be 8.8 ft NAVD88 upstream of floodgates at Big Ditch Crossing ^a .
		MHHW immediately upstream of floodgate during spring migration.	6 to 7 ft NAVD88 (Tetra Tech 2008).	MHHW immediately upstream of the floodgates was 9.43 ft NAVD88 during Spring Migration Period	MHHW immediately upstream of the floodgates was 9.53 ft NAVD88 from May 3-31.	MHHW immediately upstream of the floodgates was 10.00 ft NAVD88 during Spring Migration Period, when no construction was occurring.	MHHW immediately upstream of the floodgates was 9.5 ft NAVD88 during Spring Migration Period.	After floodgate replacement, MHHW immediately upstream of the floodgates will be 9.5 ft NAVD88 during Spring Migration.
		Floodgate openness during spring migration.	Not measured	Not measured. New Floodgates installed in Fall 2009. Beamer et al. (2010) estimated upstream passage as 49% during spring migration.	Floodgate position open 90% of the time May 2 through May 31, the period of migration that was monitored (Shannon & Wilson 2010).	Floodgates open more than 90% of the time during Spring Migration period (92.3% and 93.4% for the north and middle doors, respectively).	Floodgates open less than 90% of the time during Spring Migration period (85.25% for both the north and middle doors).	Floodgate position will be open 90% of time during spring migration.
	H2: Restoration of tidal exchange will twice daily increase mixing of waters on project site, increasing oxygen levels & reducing temps compared to pre-project conditions, particularly during summer months.	DO levels in Fisher Slough.	Not measured	<8 mg/L upstream of the floodgates during 5 of the days sampled (June – Sept).	DO data loggers were not functional. Spot DO measurements were collected during fish monitoring and are contained in the 2010 Fish Report (Beamer et al. 2011).	<8 mg/L upstream of floodgates on 22 days from June 5 to June 26 (data is for the time period prior to floodgate being disengaged due to construction).	DO levels were <8 mg/L at the Upstream Floodgate site on 99 of 122 days (81.1% of the time) from June 1 through Sept 30 (data includes all dates, June 1 through Sept 30). DO levels were <8 mg/L at the Upstream Floodgate site on 82 of 104 days (78.8% of the time) from June 1 through Sept 30 (data excludes time when floodgate was disengaged for Dike District 3 maintenance project Aug 3-20).	Increased DO during summer; daily minimum >8.0 mg/L upstream of floodgates by 2015.

Objective	Hypothesis	Parameters	Pre-project Condition (before 2009)	WY2009 Condition	WY2010 Condition	WY2011 Condition	WY2012 Condition	Restoration Target
		Temperature levels in Fisher Slough.	18.4 to 19.4 °C (7-day maximum in summer) (Tetra Tech 2007).	The summer 7-day maximum temperature occurred July 25 to July 31, ranging from 22.5 to 24.2°C, averaging 23.3°C at Big Ditch crossing.	Floodgates were disengaged during the summer months for construction activities. Therefore temperature data collected in 2010 is not comparable to previous years.	The summer 7-day maximum temperature occurred June 20 through June 26, ranging from 15.6 to 18.2°C and averaging 17.1°C at Big Ditch crossing (data is for the time period prior to floodgate being disengaged due to construction).	The summer 7-day maximum temperature occurred Aug 12 to 18, ranging from 21.5 to 23.5°C and averaging 22.6 °C at Upper Main Channel (data includes all dates, June 1 through Sept 30). The summer 7-day maximum temperature occurred Aug 30 to Sept 5, ranging from 21.8 to 23.0°C and averaging 22.2°C at Upper Main Channel (data excludes time when floodgate was disengaged for Dike District 3 maintenance project Aug 3-20).	Decreased temperatures during summer; highest 7-day maximum temperature average within 12 to14 °C (WDOE 2004).
	H3: Relocation of the confining levees will restore 50 acres of tidal marsh which will result in a total of 60 acres of freshwater tidal marsh area—the area of tidally inundated freshwater wetland will increase.	Water level elevations relative to site elevations—calculated total area of the project site that is inundated at 9.5 ft NAVD88 (as measured upstream of the floodgates).	9.8acres inundated at MHHW (9.5 ft NAVD88 at the floodgates) (Tetra Tech 2008).	9.8acres inundated at MHHW (9.5 ft NAVD88 at the floodgates) (Tetra Tech 2008).	Not measured	9.8acres inundated at MHHW (9.5 ft NAVD88 at the floodgates) (Tetra Tech 2008).	An additional 45.9 acres inundated at MHHW (9.5 ft NAVD88) because of dike set-back, for a total of 55.7 acres	[1] Increase in area inundated at MHHW upstream of floodgates by 2015. [2] Increase in area of freshwater wetland vegetation [3] 60 acres of freshwater tidal wetland by 2015. [4] Photo-documentation shows significant increase in total area that is inundated by 2015. [5] The percent of the project area inundated at MHHW of 9.5ft NAVD88 increases by 2015.
		Time series of water level elevations (for % inundation curves).	Not measured	Not measured	Not measured	Not measured (but see Fig. H3-1)	See Figure H3-1 in 2012 Monitoring Rpt (this paper).	
		Site elevation.	From LiDAR: 1.5 to 16 ft NAVD88	From LiDAR: 1.5 to 16 ft NAVD88	Not measured	Not measured	From TIN: 0 to 16 ft NAVD88	
		Number of days or percent of period site inundated.	Not measured	Not measured	Not measured	Not measured	Between March 5 and Sept 30, WSE was ≥ 9.5 ft NAVD88 17.8% of the time in Blind Ch 1 (Smith A) and 17.7% of the time in Blind Ch 2 (Smith B).	
		Percent of the project site that is inundated at MHHW (9.5 ft NAVD88 at the floodgates).	16.3%, based on 9.8 acres of the 60 acre site.	16.3%, based on 9.8 acres of the 60 acre site.	Not measured	16.3%, based on 9.8 acres of the 60 acre site.	92.8%, based on 55.7 acres of the 60 acre site	
	H4: Restored tidal exchange/levee setback and greater inundation will result in accretion and aggradation of the ground surface in tidal marsh areas.	Sedimentation rates across the newly exposed marsh/floodplain area.	Not measured	Not measured	Not measured	Not measured. Sediment stakes were installed in 2011.	Spatially variable, but mean rate not different from zero.	Mean sedimentation rates are positive by 2015.
		Elevation of the newly exposed marsh/floodplain area.	Not measured	Not measured	Not measured	Baseline condition measured at stakes and with as-built survey.	10 of 16 pins positive. Deposition at channel margins; erosion in one location on site.	More pins with positive (accretion) as opposed to negative (erosion) sedimentation.

Objective	Hypothesis	Parameters	Pre-project Condition (before 2009)	WY2009 Condition	WY2010 Condition	WY2011 Condition	WY2012 Condition	Restoration Target
	H5: Restoration of tidal, fluvial, and sediment processes (and limited planting) will result in recolonization of the site by native freshwater wetland emergent, scrub-shrub, and forested wetland, and riparian plants as predicted by Hood (Tetra Tech 2007) and TNC (Tetra Tech 2009).	Total area of the site with native and non-native vegetation communities, determined from vegetation mapping in aerial photographs (in acres).	Not measured	Not measured	Not measured	Not measured	Not measured	Photo-documentation shows significant change in plant community species composition and type by 2015. Total area mapped with tidal freshwater wetland plant communities increases (60 acres by 2015).
		Cover of vegetation species—aquatic, herbaceous, scrub-shrub, forest.	Not measured	Not measured	Vegetative cover data for the five treatment areas ranged from 0-17% bare ground to 0-39% native species to 44-100% introduced species.	Not measured	Not measured	By 2015, >30% cover of freshwater tidal wetland plant species.
		Species richness—total number of species observed on the site from species lists compiled during vegetation sampling.	Only calculated at the transect level. 21 native species present on transects during 2006 survey.	Not measured	97 species observed, 48 of which were native species.	Not measured	Not measured	Increased native plant species richness compared to 2010 conditions.
		Elevation ranges and inundation times of vegetation species.	Elevation ranges (NAVD88), % inundation ^b Mud-channel: 0 to 5.5 feet, 100% Low marsh: 6.0 to 6.5 feet, 46.9-65.5% High marsh: 7.0 to 7.5 feet, 20.5–32.9% Riparian: 8.0 to 10.0 feet, 4.7-11.9% Upland: 10.5 to 14 feet, 0-2.6% (Tetra Tech 2009)	Not measured	Elevation ranges and inundation times are the same as 2006. There were no changes to the existing levees.	Not measured	Not measured	Elevation ranges (NAVD88) and % inundation for major vegetation types will be similar to: Mud-channel: 0 to 4.5 feet, 95-100% Low marsh: 4.5 to 7.0 feet, 50-95% High marsh: 7.0 to 8.5 feet, 15-50% Riparian: 8.5 to 10.0 feet, 5-15% Upland: >10 feet, 0-5%
	H6: Restoring a natural and more variable tidal regime will reduce the cover of reed canarygrass in areas where it occurs pre-project.	Total area of RCG, determined from vegetation mapping in aerial photographs.	Not measured	Not measured	There are approximately 19.30 acres of RCG in the project site.	Not measured	There are 3.0 ac of RCG in the restored tidal floodplain, 1.7 ac in the pre-restoration wetland, 7.8 ac in uplands: total of 12.5 ac.	There are approximately 19.30 acres of RCG in the project site.
		Mean elevation of RCG on the site.	Not measured	Not measured	Mean RCG elevation in vegetation plots is 8.87 ft NAVD88: range is from 5.45 to 18.44 ft NAVD88.	Not measured	Mean RCG elevation in the tidal zone is 7.6 ft NAVD88: tidal zone range is 4.1 to 10.5 ft NAVD88.	Mean RCG elevation in vegetation plots is 8.87 ft NAVD88: range is from 5.45 to 18.44 ft NAVD88.
		Mean cover of RCG in vegetation plots.	RCG cover in the five vegetation treatment areas ranged from 10-70% cover in 2006.	Not measured	Mean percent RCG canopy cover in vegetation plots was 60%, ranging from 5-100%.	Not measured	Not measured	Mean percent RCG canopy cover in vegetation plots was 60%, ranging from 5-100%.

Objective	Hypothesis	Parameters	Pre-project Condition (before 2009)	WY2009 Condition	WY2010 Condition	WY2011 Condition	WY2012 Condition	Restoration Target
	H7: Restored tidal exchange will re-introduce sediment transport and scouring of tidal channels on the project site, resulting in the creation of greater overall channel area and a more complex channel network compared to pre-project conditions.	Channel area (total channel area estimated from aerial photographs and elevations using GIS).		3.4 acres of channel area	Not measured	3.7 acres of channel area	4.8 acres of channel area.	Total channel area and length will increase by 2015
		Channel cross sections and longitudinal profiles (estimate area).	Not measured	Not measured	Not measured	Not measured	14.2 ft ² for Blind Channel 1 25.5 ft ² for Blind Channel 2	
		Total length of channel network (estimated from aerial photographs using GIS).	Not measured	4.858 ft	Not measured	5000 ft excavated or remnant after rerouting Fisher Slough	9,664 ft total	After Project Element 3 is complete, the total length of channel network will be at least 9664 feet.
		Channel density (total length divided by project area).	Not measured	0.0114 ft	Not measured	0.0117 length per unit area (i.e., 5000 ft/9.8 ac)	0.0040	
		Distance upstream to head of blind tidal channel.	Not measured	Not measured	Not measured	Not measured	1397 ft for longest channel	
		Number of tidal channels		3		4	6	
2: Restore and improve freshwater tidal rearing habitat for Chinook salmon (<i>Oncorhynchus tshawytscha</i>).	H8: Chinook salmon abundances (0+ year class) will be similar above and below the floodgates (post replacement) during peak migration periods.	Juvenile Chinook salmon: Seasonal density up and downstream of floodgate and at reference sites	Not measured	There was no significant difference in log transformed mean wild juvenile Chinook density between sites up and downstream of the floodgates from February to August 2009 (Beamer et al. 2010).	Log transformed mean density of wild juvenile Chinook salmon was significantly higher downstream of the floodgate than upstream in 2010 (Beamer et al. 2011).	There was no significant difference in the log transformed mean wild juvenile Chinook density between sites up and downstream of the floodgates from February to June 2011 (Beamer et al. 2013a).	There was no significant difference in the log transformed mean wild juvenile Chinook density between sites up and downstream of the floodgates from February to July 2012 but overall abundance was much higher (Beamer et al. 2013b).	By 2015, trends suggest higher relative density of age-0+ Chinook above floodgates compared to pre-2010 conditions.
	H9: Juvenile Chinook salmon will utilize restored channels and marshes at densities similar to other Skagit freshwater tidal marshes, adjusted for landscape connectivity	Juvenile Chinook salmon: Seasonal density up- and downstream of floodgate and at reference sites	Not measured	Nine out of ten Fisher Slough monitoring sites were within the scatterplot of seasonal fish density and landscape connectivity for long-term Skagit delta monitoring sites (Beamer et al. 2010).	Three out of ten Fisher Slough monitoring sites were within the scatterplot of seasonal fish density and landscape connectivity for long-term Skagit delta monitoring sites (Beamer et al. 2011).	All but one Fisher Slough monitoring site located upstream of the floodgate fell outside (lower) the scatterplot of seasonal fish density and landscape connectivity for long-term Skagit delta monitoring sites (Beamer et al. 2013a).	All Fisher Slough monitoring sites were within the scatterplot of seasonal fish density and landscape connectivity for long-term Skagit delta monitoring sites (Beamer et al. 2013b).	Seasonal juvenile Chinook salmon densities within the Fisher Slough Restoration Project are not lower than seasonal juvenile Chinook salmon densities of other Skagit River tidal delta systems when adjusted for landscape connectivity.

Objective	Hypothesis	Parameters	Pre-project Condition (before 2009)	WY2009 Condition	WY2010 Condition	WY2011 Condition	WY2012 Condition	Restoration Target
3: Restore passage for coho and chum salmon spawning access.	H10: Floodgate operation will improve fish passage opportunity for coho and chum compared to pre-project conditions.	Number of days floodgates are open from October 1 to February 28 or 29.	Gates were open for 34% of the time during the fall of 2006 (Tetra Tech 2008).	Not measured	Not measured	At least one of three floodgate doors was open on 143 of 151 days (Oct 1-Feb 28).	At least one of three floodgate doors was open on 121 of 121 days Nov 1, 2011 to Feb 29, 2012 when no restoration construction was occurring.	After floodgate replacement, gates open at least once per day October to February 28 or 29.
	H11: Removal of the passage barrier at Big Ditch will result in more natural channel profile through this area.	Longitudinal channel profile at Big Ditch crossing.	Not measured	Not measured; assumed to be the same as 'before removal' RTK GPS survey done in June 2011.	Not measured; assumed to be the same as 'before removal' RTK GPS survey done in June 2011.	'Before removal' RTK GPS survey in June 2011 found average sill height to be 1.5 ft higher than the surrounding streambed upstream and downstream of the sill.	Sill no longer present; some mild channel aggradation upstream and downstream of the sill; profile more natural following sill removal.	By 2015, passage barrier (sill) at Big Ditch can no longer be seen in channel profile.
		Mean water depth at crossing.	Not measured	Average 2.05 ft deep during adult coho and chum upstream migration period (Oct 1 – Dec 31).	Average 1.81 ft deep during adult coho and chum upstream migration period (Oct 1 – Dec 31).	Average 1.81 ft deep during adult coho and chum upstream migration period (Oct 1 – Dec 31, 2010).	Average 2.83 ft deep during adult coho and chum upstream migration period (Oct 1 – Dec 31, 2011).	Mean water depth at crossing increases after passage barrier at Big Ditch is removed.
4: Improve flood storage and protect adjacent farm uses.	H12: Levee setback and restoration of tidal exchange will result in 310 acre-feet available for flood water storage (i.e., greater floodplain and channel area) during high flows.	Change in flood storage capacity	64 acre-feet of storage (Tetra Tech 2009).	Not measured	Under construction, not measured.	309 acre-feet of storage (PSE 2011).	Not measured; assumed to be same as WY2011 (309 acre-feet of storage).	At least 247 acre-feet of new flood storage (about 310 acre-feet total).

^aDue to tidal muting expected on the site from the design and operation of floodgates, MHHW upstream of the floodgates (near Big Ditch crossing) is expected to be about 8.8 NAVD88 (TNC 2009).

^bOriginal vegetation communities delineated in 2006 differ from 2009-2015.

^cElevation ranges from Draft Technical Memorandum #1.7 – Vegetation Survey (Appendix A.2, Final Design Report, Tetra Tech 2009a).

^dThe intent of this hypothesis is that the floodgate and its operation have no negative effect on fish passage.

DEFINITIONS: mg/L = milligrams per liter; GIS = geographic information system; NAVD88 = North American vertical datum 1988; MHHW = mean higher high water; DO = dissolved oxygen; LiDAR = Light detection and ranging; TIN = Triangulated irregular network; RCG = reed canarygrass; RTK GPS = real time kinematic global positioning system

2.1 Objective 1

Restore the ecological processes and structure to support and maintain a functional freshwater tidal wetland that supports target species, such as Chinook salmon.

2.1.1. Hypothesis H1

Replacement/revised operation of the floodgate (post-project condition) will result in increased tidal amplitude and water elevations upstream of the new floodgate, compared to pre-project conditions, particularly during the Spring Juvenile Chinook Migration Period (March 1 through May 31).

Data originally reported for WY2009 for upstream of the floodgate was from the site Big Ditch Crossing, and was compared to data from the site Downstream Floodgate. Data from the site Upstream Floodgate was not used due to the logger becoming inundated by sand. This data was later re-evaluated and it was discovered that the logger was not buried until after the Spring Migration period of WY2009, and provided accurate data through that time period. Therefore, the reporting has been updated for WY2009 (for the first, second and fourth targets).

Table H1-1. Fisher Slough water surface elevations, tidal amplitude, and MHHW.

Parameter	Before WY2009	WY2009 Condition	WY2010 Condition	WY2011 Condition	WY2012 Condition	Restoration Target
Gate operations result in higher water levels and greater tidal amplitude upstream of the floodgates.		Mean tidal amplitude during spring migration (measured by Solinst data logger): Downstream: 2.08 ft Upstream: 1.56ft	Mean tidal amplitude from May 2 to May 31 (measured by floodgate monitoring instrumentation): Downstream: 2.16 ft, Upstream: 1.59 ft	Mean tidal amplitude during spring migration (measured by floodgate monitoring instrumentation): Downstream: 1.77 ft, Upstream: 1.61ft	Mean tidal amplitude during Spring Migration (March 1 to May 31) relative to the floodgate: Downstream: 1.46 ft, Upstream: 1.01 ft	After floodgate replacement, tidal amplitude upstream of floodgates will increase during the spring juvenile salmon migration period.
When floodgates are open, compare tidal amplitude immediately upstream of floodgate to downstream of floodgate.		Mean tidal amplitude during Spring Migration Period (measured by Solinst data loggers): Downstream: 1.51 ft, Upstream: 1.44 ft	Mean tidal amplitude from May 3 to May 31 (measured by floodgate monitoring instrumentation): Downstream: 1.94 ft, Upstream: 1.58 ft	Mean tidal amplitude during Spring Migration Period (measured by floodgate monitoring instrumentation): Downstream: 1.68 ft, Upstream: 1.61 ft	Mean tidal amplitude during Spring Migration (March 1 to May 31) relative to the flood gate, when open: Downstream: 1.04 ft, Upstream: 1.02 ft	Tidal amplitude immediately upstream of floodgates will match amplitude downstream of floodgates (gates open).

Parameter	Before WY2009	WY2009 Condition	WY2010 Condition	WY2011 Condition	WY2012 Condition	Restoration Target
MHHW upstream of floodgates during the entire monitoring year (1 October through 30 September)	Surface Data collected but not converted to MHHW	MHHW at Big Ditch crossing is 8.59 ft NAVD88 for the whole year.	MHHW at Big Ditch crossing is 8.56 ft NAVD88 for the whole year even though floodgates were disengaged during construction of Project Element 2 during the Summer Irrigation Period.	MHHW upstream of the floodgate was 8.65 ft NAVD88 at Big Ditch Crossing for all of WY2011. During non-construction operating times, MHHW was 9.48 ft NAVD88.	MHHW at Upper Main Channel site (replacement site for Big Ditch Crossing) was 8.87 ft NAVD88 (March 23 – Sept 30, 2012).	MHHW elevations will be 8.8 ft NAVD88 upstream of floodgates at Big Ditch Crossing.
MHHW immediately upstream of floodgate during spring migration.	6 to 7 ft NAVD88 (Tetra Tech 2008).	MHHW immediately upstream of the floodgates was 9.43 ft NAVD88 during Spring Migration Period	MHHW immediately upstream of the floodgates was 9.53 ft NAVD88 from May 3-31.	MHHW immediately upstream of the floodgates was 10.00 ft NAVD88 during Spring Migration Period, when no construction was occurring.	MHHW immediately upstream of the floodgates was 9.5 ft NAVD88 during Spring Migration Period.	After floodgate replacement, MHHW elevations immediately upstream of the floodgates will be 9.5 ft NAVD88 during Spring Migration.
Floodgate openness during spring migration.	Not Measured	Not measured. New Floodgates installed in Fall 2009. Beamer et al. (2010) estimated upstream passage as 49% during spring migration.	Floodgate position open 90% of the time May 2 through May 31, the period of migration that was monitored (Shannon & Wilson 2010).	Floodgates open more than 90% of the time during Spring Migration period (92.3% and 93.4% for the north and middle doors, respectively).	Floodgates open less than 90% of the time during Spring Migration period (85.25% for both the north and middle doors).	Floodgate position will be open 90% of time during spring migration.

2.1.1.1 Surface water levels above and below floodgates

Restoration target: After floodgate replacement, tidal amplitude upstream of floodgates will increase during the spring juvenile salmon migration period.

Target met? No, mean tidal amplitude upstream of the floodgate was 0.45 feet lower than the mean tidal amplitude downstream of the floodgate in WY2012.

The difference between upstream and downstream in WY2012 was 0.45 feet, in WY2011 the difference was 0.16 feet, in WY2010 the difference was 0.57 feet and in WY2009 the difference was 0.52 feet (Table H1-1). The differences in tidal amplitude results each year are due in part to the floodgate operation conditions in each year. Numerous adjustments to the floodgate and a broken hydraulic arm during the Spring Juvenile Chinook Migration Period in WY2012 were contributing factors to the doors not being open as much as they should have been. These conditions are discussed in further detail in

H1.5 and in Beamer and Henderson (2013). In WY2011 the floodgate operation included adjustments to the closing setting but did there was not any control arm failure and the resulting difference in tidal amplitude was the least of the four years (0.16 feet). The WY2010, the first year after floodgate replacement, there're were of numerous adjustments to the settings and time needed to "dial in" the monitoring equipment resulting in only a short time period of accurate data. The difference in tidal amplitude was 0.57 feet. In WY2009, pre-restoration, the floodgate doors operated on a gravity system and the difference was 0.52 feet.

Note: This restoration target has been re-written to reflect the reality that floodgates, regardless of how they are operated, are designed to reduce tidal amplitude relative to natural conditions. Thus, the phrase "...to match the downstream tidal amplitude..." has been deleted. Tidal amplitudes can be matched only when floodgates are open and this is reflected in the subsequent restoration target (Section 2.1.1.2).

2.1.1.2 Difference in tidal amplitude above and below floodgates

Restoration target: Tidal amplitude immediately upstream of floodgates will match amplitude downstream of floodgates (gates open).

Target met? Yes. During the Spring Juvenile Chinook Migration Period from March 1 to May 31, 2012 tidal amplitude upstream and downstream of the floodgates was nearly equivalent, within 0.02 feet (Table H1-1). Similarly, 2009 and 2011 tidal amplitude upstream averaged only 0.07 feet lower than tidal amplitude downstream. The tidal amplitude in 2010 was measured over a shorter period of time (May 3 to May 31) and the difference was 0.57 feet (Table H1-1).

This target does not explicitly specify the spring migration period; however, Hypothesis 1 emphasizes the spring period and results for this target in years 2009 and 2010 were for the spring period.

2.1.1.3 MHHW upstream of floodgates

Restoration target: MHHW will be 8.8 ft NAVD88 upstream of floodgates at the old Big Ditch crossing.

Target met? Yes. The MHHW upstream of the floodgates above the old Big Ditch Crossing at the new site Upper Main Channel was 8.87 ft NAVD88 for the time period March 23 through September 30, 2012. The floodgates were not operated per criteria in the Operation and Management plan during this entire time period and were disengaged from August 3- 20.

Floodgate management during WY2012 was not typical of the anticipated future management regime, because (1) floodgate was disengaged for October due to restoration construction and completion of Project Element 3, (2) numerous adjustments to the floodgate and a broken hydraulic arm occurred during the Spring Juvenile Chinook Migration Period, and (3) floodgate was disengaged August 3-20 to help provide low water conditions upstream of the Fisher Slough project area for a Dike District 3 maintenance project in the Hill Ditch area. Thus, the MHHW calculated on an annual basis will likely change in years when the planned management schedule is implemented.

The original hypothesis used data collected at the old Big Ditch Crossing which is now a blind channel area due to the channel relocation and dike setback construction completed in 2011. A Solinst Edge Model 3001 data logger was installed at a replacement site in the new main channel above the historical location of the Big Ditch siphon on March 23, 2012. This site is called Upper Main Channel. Programming problems with this logger occurred shortly after it was installed, resulting in sporadic data until May 24, 2012. The MHHW was 8.87 ft NAVD88 for the entire record of WY2012 when the Upper Main Channel logger was in place and recording correctly. The floodgate was disengaged from August 3 through August 20, 2012 to help provide low water conditions upstream of the Fisher Slough project area for a Dike District 3 maintenance project in the Hill Ditch area. During the period when the floodgates were not disengaged (i.e., were operating under normal conditions) the MHHW above the old Big Ditch Crossing at the Upper Main Channel site was 9.15 ft NAVD88 (Figure H1-1). This is 0.35 feet higher than the target goal.

The data logger at Blind Ch 3 (formerly the Big Ditch Crossing site) was in place and recorded data during the entire water year, whereas the logger at the new Upper Main Channel site recorded data for a shorter time period during the water year. Blind Ch 3 is located 30 meters from the Upper Main Channel site and data from Blind Ch 3 were used in the 2009, 2010 and 2011 reports (TNC 2011, TNC 2012, Beamer et al. 2112). We present the results from Blind Ch 3 in WY 2012 as a comparison to the data presented in those three reports. Mean higher high water at Blind Ch 3 was 8.57 ft NAVD88 in WY2012 for the time period November 1, 2011 through September 30, 2012. Data recorded October 1 through October 31, 2011, when the floodgates were disengaged during the Project Element 3 construction time, was not included. This is 0.23 feet lower than the restoration target goal.

Figure H1-2 has been added to this report per TNC's request for comparison of current conditions to pre-floodgate conditions (WY2009).

2.1.1.4 MHHW immediately upstream of floodgate during spring migration (March 1 – May 31)

Restoration target: MHHW immediately upstream of the floodgates will be 9.5 ft NAVD88 during spring migration (as of 2010).

Target met? Yes. MHHW immediately upstream of the floodgates during the Spring Juvenile Chinook Migration Period was 9.5 ft NAVD88. This is right at the target level.

The MHHW exceeded the restoration target goal all three years (WY2010, WY2011, and WY2012) after the floodgate replacement in 2009. The MHHW value in 2009 has been updated was calculated at 9.43 ft NAVD88 during the Spring Juvenile Chinook Migration Period (Table H1-1).

2.1.1.5 Floodgate door openness during spring migration (March 1 – May 31)

Restoration target: Floodgate position will be open 90% of time during spring migration.

Target met? No. Overall, both the north and middle doors were open 85.25% of the time.

Deviations to floodgate operations during WY 2012 for the Spring Juvenile Chinook Salmon Migration Period occurred due to problems with setting the gate closure elevation and to a broken gate regulation

mechanism. Under normal operation during this period (i.e., not flooding periods), the floodgates should have a minimum closure setting of 9.5 ft NAVD88. This means when WSE was less than 9.5 ft NAVD88 immediately downstream of the Fisher Slough floodgate structure, at least one of the three floodgate doors should have been open. Fifty of the eighty (65%) floodgate closures during this period occurred with WSE < 9.5 ft NAVD88, which reduced the amount of time gates were open (Beamer and Henderson 2013). During the spring migration period, at least one floodgate was open 85.48 % of the time that the water surface elevation immediately downstream of the Fisher Slough floodgate structure was less than the floodgate control elevation of 9.5 ft NAVD88 (Beamer and Henderson 2013). Overall, the north and middle doors were open 85.25% of the time. Another measure of openness is the angle of the doors relative to the floodgate structure. In WY2012 the results for floodgate door angle openness were as follows, with mean door angle openness (and standard deviation) by door and tidal stage, and number of observations:

- North door (when door was open):
 - During ebb conditions = 58.5 (15.4) degrees, n=63,407
 - During non-ebb conditions = 57.2 (17.2) degrees, n=49,537
- Middle door (when door was open):
 - During ebb conditions = 55.9 (15.9) degrees, n=63,393
 - During non-ebb conditions = 48.8 (16.4) degrees, n=49,547

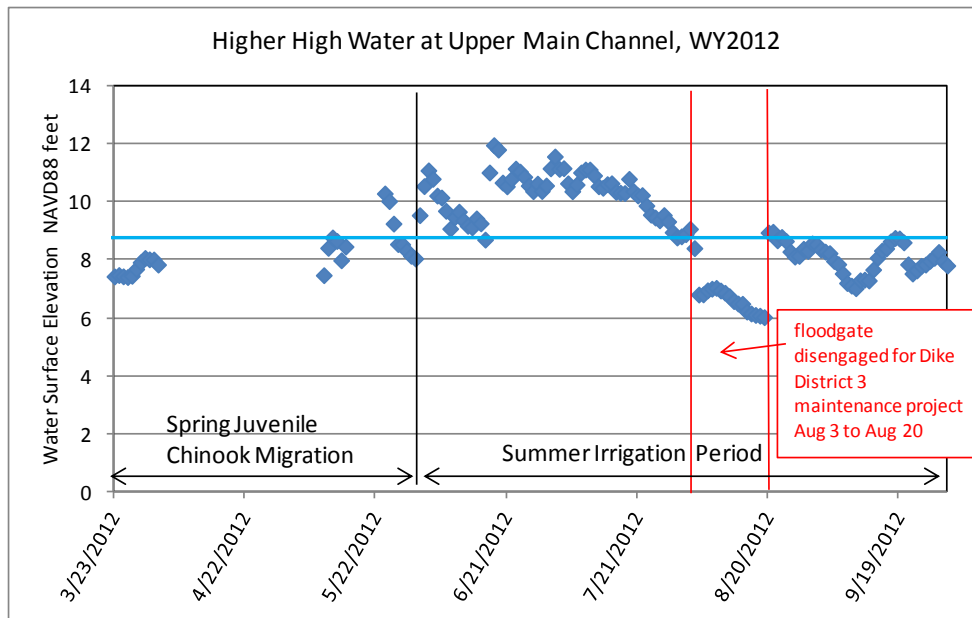


Figure H1-1. Daily higher high water elevations (HHW) for WY2012 at Upper Main Channel. The Solinst data logger was installed on March 23, 2012, but programming problems caused intermittent data until May 24. Vertical black line delineates floodgate operation management periods. The vertical red lines show the time period when the floodgates were disengaged August 3 to August 20 for a Dike District 3 maintenance project in Hill Ditch located upstream of the Fisher Slough project area. Horizontal blue line at 8.8 feet NAVD88 shows the restoration target goal for water surface elevation.

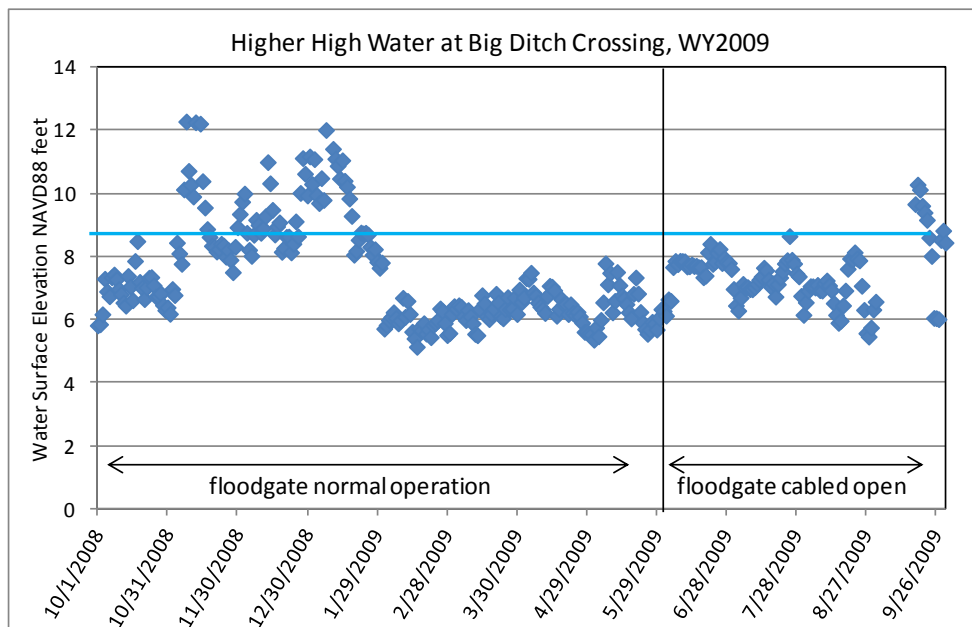


Figure H1-2. Daily higher high water at Big Ditch Crossing for WY2009. Vertical black line marks change from floodgate being operated under normal conditions (acting as a neutral velocity floodgate) to floodgate doors being cabled open for summer irrigation. The horizontal blue line at 8.8 feet NAVD88 shows the target goal for water surface elevation. Note different x-axis between the two figures.

2.1.2 Hypothesis H2

Restoration of tidal exchange will increase twice daily mixing of waters in Fisher Slough on the project site, increasing oxygen levels and reducing temperatures compared to pre-project conditions, particularly during the summer months.

Table H2-1. Fisher Slough water quality parameters.

Parameter	Before 2009	WY2009 Condition	WY2010 Condition	WY2011 Condition	WY2012 Condition	Restoration Target
DO levels in Fisher Slough.	Not measured.	<8 mg/L upstream of the floodgates during 5 of days sampled (June – Sept).	DO data loggers were not functional. Spot DO measurements were collected during fish monitoring and are contained in the 2010 Fish Report (Beamer et al. 2011).	<8 mg/L upstream of floodgates on 22 days from June 5 to June 26 (data is for the time period prior to floodgate being disengaged due to construction).	DO levels were <8 mg/L at the Upstream Floodgate site on 99 of 122 days (81.1% of the time) from June 1 through Sept 30 (data includes all dates, June 1 through Sept 30). DO levels were <8 mg/L at the Upstream Floodgate site on 82 of 104 days (78.8% of the time) from June 1 through Sept 30 (data excludes time when floodgate was disengaged for Dike District 3 maintenance project Aug 3-20).	Increased DO during summer; daily minimum >8.0 mg/L upstream of floodgates by 2015.
Temperature levels in Fisher Slough.	18.4 to 19.4°C (7-day maximum in summer) (Tetra Tech 2007).	The summer 7-day maximum temperature occurred July 25 to July 31, ranging from 22.5 to 24.2°C, averaging 23.3°C at Big Ditch crossing.	Floodgates were disengaged during the summer months for construction activities. Therefore temperature data collected in 2010 is not comparable to previous years.	The summer 7-day maximum temperature occurred June 20 through June 26, ranging from 15.6 to 18.2°C and averaging 17.1°C at Big Ditch Crossing (data is for the time period prior to floodgate being disengaged due to construction).	The summer 7-day maximum temperature occurred Aug 12 to 18, ranging from 21.5 to 23.5°C and averaging 22.6 °C at Upper Main Channel (data includes all dates, June 1 through Sept 30). The summer 7-day maximum temperature occurred Aug 30 to Sept 5, ranging from 21.8 to 23.0°C and averaging 22.2°C at Upper Main Channel (data excludes time when floodgate was disengaged for Dike District 3 maintenance project Aug 3-20).	Decreased temperatures during summer; highest 7-day maximum temperature average within 12 to 14°C (WDOE 2004).

The water quality data will be used to determine whether the expected increase in tidal influence creates a decrease in water temperatures and an increase in DO concentrations during the summer months (Table H2-1).

2.1.2.1 Dissolved oxygen

Restoration target: Increased DO during summer; daily minimum >8.0 mg/L upstream of the floodgates by 2015.

Target met? No. Target not met in 2012 for 99 days out of 121 days (81.8% of the time) during the summer June 1 through Sept 30 at Upstream Floodgate (includes data for all dates). Target was not met on 82 of 104 days (78.8% of the time) during the time June 1 through Sept 30 but excluding dates when the floodgate was disengaged for a Dike District 3 maintenance project Aug 3-20.

In 2012, continual-read dissolved oxygen loggers (Instrumentation Northwest [INW] model Aquistar® Smart Sensor with an integrated GDL Data logger) were deployed at four sites to augment the DO spot measurements taken by SRSC during fish monitoring. They were installed approximately 15 cm above the substrate of the channel and programmed to record data at 15-minute intervals. Three were located upstream of the floodgate: one at Upstream Floodgate, mounted on the floodgate headwall; one at a new site in the Upper Main Channel; the third rotated through the three blind channel areas on approximately a two-week rotation. The fourth DO logger was located downstream of the floodgate (Downstream Floodgate), also mounted on the floodgate wall. The loggers at Downstream Floodgate, Upper Main Ch, and the roving logger at Blind Ch 3 were all installed on March 29; the one at Upstream Floodgate on May 5 (Figure 1-3). These data loggers record the oxygen level in parts per million (ppm), while the hypothesis in this report calls for data in milligrams per liter (mg/L). The units are equivalent to each other. All data loggers were removed in early October just after WY2012 ended.

Problems were encountered with all the continual-read DO loggers. They would periodically record a value of negative 90, indicating a communication problem between the sensor probe and the data housing. These -90 values were removed from the data set. Two DO loggers, one deployed at the Upper Main Channel site and the one rotated between the blind channel lobes, had other problems as well. They recorded negative values ranging from -0.01 to -31.3 ppm. This is a physical impossibility in water. High DO levels in the range of 20 to 31 ppm were also recorded by the logger at the Upper Main Channel site. The high DO levels occurred late in the summer when water temperatures were high (17 to 22 °C) and when lower DO levels would have been expected. In some cases the DO values went from +28 to -28 to +28 and then to -27 ppm within an hour's time, further making the data suspect. These were returned to INW at the end of the season, where they were determined to have internal damage. Data was removed from the data set starting when the negative number issue first occurred (July 6 for the logger used in the blind channels and August 28 for the one at Upper Main Channel). Even excluding the error codes and suspect data, the restoration target was not met, as DO levels less than 8 mg/L were recorded before the problems were encountered with the data.

At the Upstream Floodgate site the logger functioned properly other than the communication errors, all of which occurred after September 16. There were 99 of 122 days during the summer when DO levels were less than 8 mg/L (81.1% of the time) for data for the entire summer period. The floodgate was disengaged for 18 days from August 3 through August 20 to help facilitate low water for a Dike District 3 maintenance project at Hill Ditch upstream of Fisher Slough. With data removed from the data set for

this time period, the DO level was <8.0 mg/L on 82 of 104 days (78.8% of the days) (Table H2-1, Appendix C, Table 1).

The DO level at the site Upper Main Channel fell below 8.0 mg/L on 28 of 122 days (23.0% of the time) including data for the entire summer period and on 21 of 104 days (20.2% of the time) for data excluding the time period when the floodgate was disengaged (Appendix C, Table 1).

In the combined blind channel areas the DO level was below 8.0 mg/L on 9 of 37 days (24.3% of the time) from June 1 through July 5 (Appendix C, Table 1). The data after that time was suspect as the DO loggers started recording data with negative numbers.

The hypothesis calls for dissolved oxygen values during the summer months but in WY2012 the daily average DO levels started to fall below the goal even before the start of the Summer Irrigation Period. The DO levels dropped below the restoration goal of 8 mg/L starting on May 14 at the site Upstream Floodgate, with eleven days of DO below 8.0 mg/L between May 14 and May 31 (Appendix C, Table 1).

Spot measurements were taken by SRSC's fish monitoring crew from February 14 to July 24, 2012 during fish sampling, using a YSI Professional Plus DO meter. Measurements were taken at the surface and bottom of the water column at four different sampling locations in the main channel area and in the three blind channel areas upstream of the floodgate, as well as at three sites downstream of the floodgate. Data taken in each portion of the water column were averaged by the day for the four main channel sites, the sites within each blind channel area and the sites downstream of the floodgate, and are reported in Appendix C, Tables 2 and 3. The daily average DO levels were above 8.0 mg/L for both the surface and bottom of the water column at all sites from February through July except: Blind Ch 2 on May 15 and July 18; Blind Ch 3 on May 24 and July 24; and the combined main channel sites on May 24 (bottom readings only) (Appendix C, Tables 2 and 3).

Low DO is present in Fisher Slough starting in late spring or early summer. This phenomenon has been suspected and confirmed over all four years of monitoring, 2009 through 2012. Prior to 2012, the Fisher Slough monitoring sites were exclusively in existing narrowly confined channel area, so factors influencing DO likely were primarily from exterior sources (areas up- or downstream of the restoration project area). In fact, in 2011 and years prior, very low DO from upstream in Carpenter Creek/Hill Ditch (Skagit County Public Works 2012) appears to have contributed to low DO in Fisher Slough. Low DO probably occurred in Hill Ditch in the summer months of 2012, although Skagit County water quality data were not available at the time this report was written. Starting in 2012 much more area was available to tidal inundation because of completion of the dike setback restoration. Therefore, factors influencing habitat conditions had more potential to originate from within the restoration project area as well as from exterior sources. Processes influencing DO from within the restoration project area likely are related to cycles (day/night, tidal) affecting vegetation and algae. Vegetation and algae growing in the dike setback area creates oxygen during daylight and uses oxygen during night hours. Decomposing vegetation and algae within the dike setback will reduce DO. Regardless of the cause of low DO, tidal dilution is an immediate remedy, which can be influenced by floodgate operations such as holding the gate open (the normal operational plan for the floodgate's Summer Irrigation management period).

Longer-term remedies for low DO might include restoration of riparian or nutrient-input areas located upstream.

Recommendation: We recommend that protective cages be installed around the standpipes housing the DO probes to help keep floating green algae and detritus away from the probes. This should be done at the Upper Main Channel site and in the three blind channel lobes. The DO sites Upstream Floodgate and Downstream Floodgate did not have major problems and will not need the protective cages. Desiccant packs should be added to each DO logger housing in order to help prevent moisture damage to the data control box. All four loggers should be calibrated by INW prior to deployment in 2013. We recommend continuing comparison of DO levels measured during SRSC's fish monitoring to DO levels recorded by the continuous-reading loggers in order to determine the accuracy of the continual-read data loggers.

2.1.2.2 Temperature

Restoration target: Decreased temperatures during summer; highest 7-day maximum temperature average within 12-14 °C.

Target met? No. The 7-day average maximum temperature restoration target was exceeded at the five logger sites upstream of the floodgate during the Summer Irrigation Period regardless of the floodgate operation. The 7-day maximum temperature average in 2012 was higher than that recorded in WY2009 and lower than that recorded WY2011 (Table H2-1).

Water temperature was measured using Solinst® Levellogger Model 3001 Gold and/or Edge data loggers that were deployed at the downstream headwall of the floodgate (Downstream Floodgate), in the Upper Main Channel, at the historic Big Ditch Crossing (now called Blind Ch 3), and at the new blind channel areas (Blind Ch 1 and Blind Ch 2). Water temperature data at the upstream side of the floodgate headwall site (Upstream Floodgate) was taken using an Instrumentation Northwest Aquistar® model PS9805 vented data logger. A Campbell Scientific data monitor, model CR1000 with communication software version PC200W, was used to store and download data. All data readings were taken at 15-minute intervals and averaged by the day. Temperature data was removed from the data set when the channel was dry. The data loggers at Downstream Floodgate, Upstream Floodgate and Blind Ch 3 were in place during the entire water year. The data loggers in Blind Ch 1 and Blind Ch 2 were installed on March 5 and the logger at Upper Main Ch was installed on March 23.

The highest 7-day average maximum temperature at Upper Main Channel site occurred August 12 to 18, ranging from 21.5 °C to 23.5 °C and averaging 22.62 °C (Table H 2-2). This was during the time when the floodgates were disengaged between August 3 and 20 for a maintenance project in the Hill Ditch area. During the time when the floodgate was operated normally (not disengaged) the 7-day maximum occurred August 30 to September 5, ranging from 21.8 °C to 23.0 °C and averaging 22.18 °C (Tables H2-1 and H2-3).

The highest 7-day average maximum temperature exceeded the target restoration goal of 12 -14 °C at all locations occurring during the time the floodgate was disengaged between August 3 and 20 and is shown in Table H2-2. The highest 7-day average maximum temperature at all locations for the time

period when the floodgate was operated normally (not disengaged) is shown in Table H 2-3. The low water resulting from the floodgates being closed increased the water temperatures; however this was not the only time period where high water temperatures existed at Fisher Slough. The restoration target goal was also exceeded both prior to and after the floodgate disengagement at all five upstream sites. The restoration target is for cooler water temperatures in the summer months, June through September. In WY2012 water temperatures exceeded the goal even before the summer time period. The water temperatures were higher than the target goal starting April 7 in the blind channel areas and starting May 8 in the main channel areas. The daily maximum water temperature at each site is shown in Figure H2-1. The 7-day average maximum temperature with the floodgate-disengagement-data removed is shown in Table H2-3. Blind Ch 3 had the lowest 7-day average. This is most likely due to the shade provided by the riparian zone.

Water flowing downstream from Hill Ditch into the Fisher Slough Restoration project area is warmer than water flowing into the project area on flood tides when the floodgate is open. We found support for this by examining results from long-term monitoring sites in Skagit County's Water Quality Monitoring Program. One nearby site is located in the South Fork Skagit River (at Conway boat ramp) and represents the water mass downstream of the floodgate. The other nearby site is Carpenter Creek/Hill Ditch (at Cedardale Rd) and represents the water mass upstream of the floodgate. Each site is monitored at two-week intervals by Skagit County. Water temperature varied seasonally at the South Fork site from approximately 14.5 to 17.5 °C, the highest temperature occurring during summer months and the lowest during winter months (Water Years 2004 – 2011, Skagit County Public Works 2012). In contrast, while water temperature also varied seasonally at the Hill Ditch site, the highest temperatures were much higher than at the South Fork site, with readings ranging from approximately 17.5 to 24 °C (Water Years 2004 – 2011, Skagit County Public Works 2012). Again, the highest temperatures occurred during summer months and the lowest during winter months. Regardless of the cause of high temperature, tidal dilution is an immediate remedy, which can be influenced by floodgate operations such as holding the gate open (the normal operational plan for the floodgate's Summer Irrigation management period). Longer-term remedies for high temperature in Hill Ditch might include restoration of the riparian zone.

Table H2-2. Seven-day average maximum temperature at Fisher Slough in WY2012 for the entire time period.

Site	Maximum 7-day average maximum temperature (degrees Celsius)	Standard deviation of 7-day average maximum temperature	Date range of maximum 7-day average maximum temperature
Downstream Floodgate	22.54	2.09	Aug 16 to 22
Upstream Floodgate	22.95	1.42	Aug 17 to 23
Upper Main Channel	22.62	0.72	Aug 12 to 18
Blind Ch 1	29.21	3.56	Aug 14 to 20
Blind Ch 2	24.23	2.09	Aug 14 to 20
Blind Ch 3 (formerly Big Ditch Crossing)	21.46	0.57	Aug 14 to 20

Table H2-3. Seven-day average maximum temperature at Fisher Slough in WY2012 excluding data from Aug 3 to Aug 20, when floodgate was disengaged for Dike District 3 maintenance project in Hill Ditch.

Site	Maximum 7-day average maximum temperature (degrees Celsius)	Standard deviation of 7-day average maximum temperature	Date range of maximum 7-day average maximum temperature
Downstream Floodgate	22.35	0.39	Sept 1 to 7
Upstream Floodgate	22.54	0.38	Sept 2 to 8
Upper Main Channel	22.18	0.40	Aug 30 to Sept 5
Blind Ch 1	25.85	0.87	Aug 27 to Sept 2
Blind Ch 2	23.95	0.67	Aug 30 to Sept 5
Blind Ch 3 (formerly Big Ditch Crossing)	19.24	0.46	Aug 29 to Sep 4

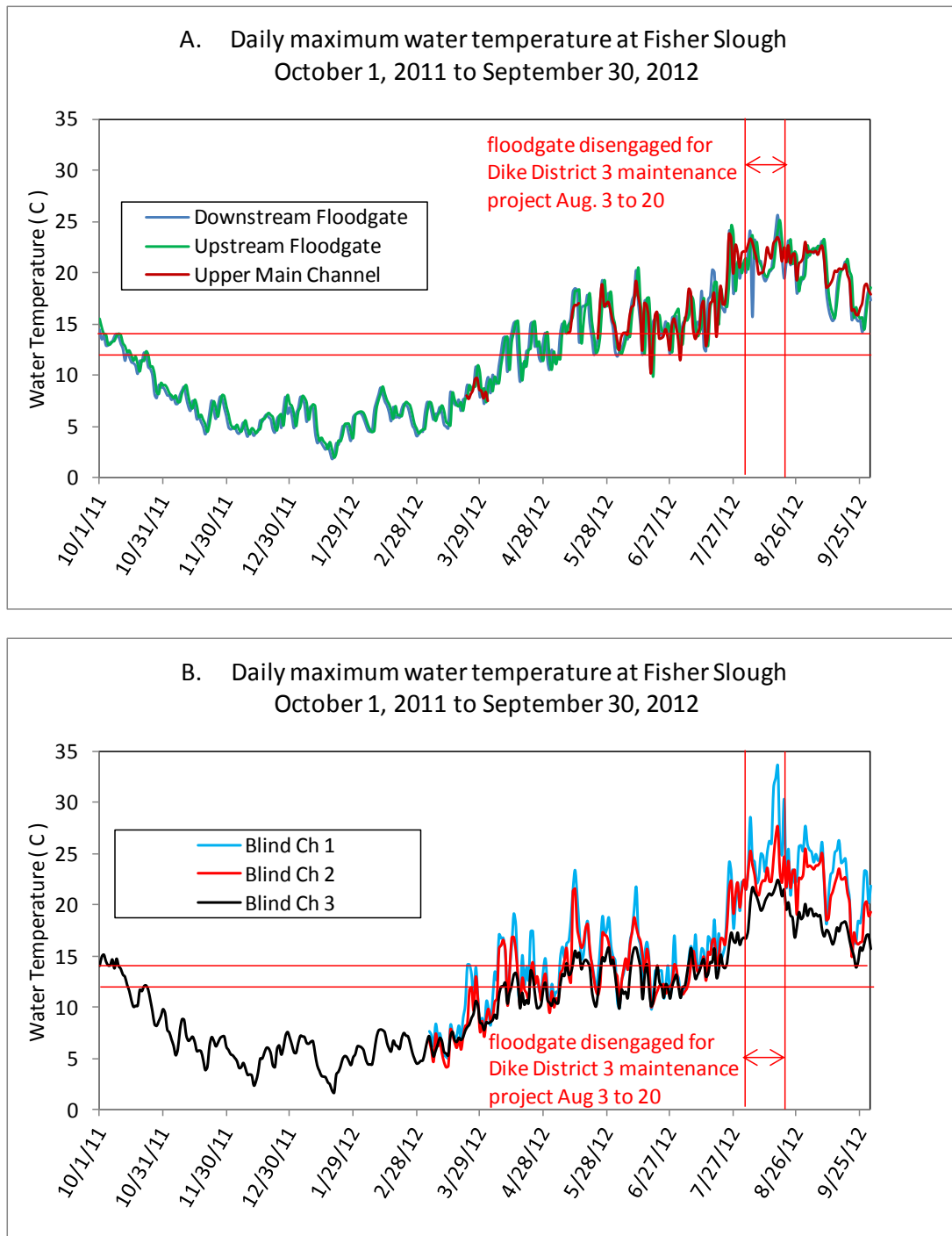


Figure H2-1. Maximum daily water temperature at Fisher Slough in Water Year 2012. Horizontal red lines show restoration target goal for highest maximum 7 day average during Summer Irrigation Period (June 1-September 30) of 12 to 14 degrees Celsius. Vertical red lines indicate time period the floodgates were disengaged during a Dike District 3 maintenance project in the Hill Ditch area. Panel A is main channel areas and Panel B is blind channel areas. The logger at Upper Main Channel was installed on March 23, 2012 and had recorded data intermittantly until May 24. Loggers at Blind Ch1 and 2 were installed on March 5, 2012.

2.1.3 Hypothesis H3

Relocation of the confining levees will restore 50 acres of tidal marsh which will result in a total of 60 acres of freshwater tidal marsh area—the area of tidally inundated freshwater wetland will increase.

The number of days and percent of time that the pre-restoration 9.8-acre tidal marsh was inundated was not calculated because the LiDAR data for this area are unreliable. Most of the vegetated portions of this area consist of scrub-shrub vegetation from which bare earth elevation is not reliably derived from LiDAR sampling (Hood 2007). Thus, only changes to the 45.9 acres that were restored through dike set-back are considered here. This is also the area of greatest interest, because it has undergone the most significant transformation through restoration.

Table H3-1. Area of tidally inundated freshwater wetlands.

Parameter	Before WY2009	WY2009 Condition	WY2010 Condition	WY2011 Condition	WY2012 Condition	Restoration Target
Water level elevations relative to site elevations—calculated total area of the project site that is inundated at 9.5 ft NAVD88 (as measured upstream of the floodgates).	9.8 acres inundated at MHHW (9.5 ft NAVD88 at the floodgates) (Tetra Tech 2008).	9.8 acres inundated at MHHW (9.5 ft NAVD88 at the floodgates) (Tetra Tech 2008).	Not measured	9.8 acres inundated at MHHW (9.5 ft NAVD88 at the floodgates) (Tetra Tech 2008)	An additional 45.9 acres inundated at MHHW (9.5 ft NAVD88) because of dike set-back, for a total of 55.7 acres	[1] Increase in area inundated at MHHW upstream of floodgates by 2015. [2] Increase in area of freshwater wetland vegetation. [3] 60 acres of freshwater tidal wetland by 2015. [4] Photo-documentation shows significant increase in total area that is inundated by 2015. [5] The percent of the project area inundated at MHHW of 9.5ft NAVD88 increases by 2015.
Time series of water level elevations (for % inundation curves).	Not measured	Not measured	Not measured	Not measured (but see Fig. H3-1)	See Figures H3-2, H3-3	
Site elevation.	From LiDAR: 1.5 to 16 ft NAVD88	From LiDAR: 1.5 to 16 ft NAVD88	Not measured	Not measured	From TIN: 0 to 16 ft NAVD88	
Number of days or percent of period site inundated.	Not measured	Not measured	Not measured	Not measured	Between March 5 and Sept 30, WSE was $\geq$ 9.5 ft NAVD88 17.8% of the time in Blind Ch 1 (Smith A) and 17.7% of the time in Blind Ch 2 (Smith B).	
Percent of the project site that is inundated at MHHW (9.5 ft NAVD88 at the floodgates).	16.3%, based on 9.8 acres of the 60 acre site.	16.3%, based on 9.8 acres of the 60 acre site.	Not measured	16.3%, based on 9.8 acres of the 60 acre site	92.8%, based on 55.7 acres of the 60 acre site	

2.1.3.1 Water levels and total site area

Restoration target: Increase in area inundated at MHHW upstream of floodgates by 2015.

Target met? Yes. The dike setback restored 45.9 acres of land below 9.5 ft NAVD88 to tidal inundation in addition to the pre-existing 9.8 acres, for a total of 55.7 acres (Fig H3-1).

2.1.3.2 Water level elevations (and wetland area)

Restoration target: Increase in area of freshwater wetland vegetation.

Target met? Yes; 45.9 additional acres of newly restored land are now inundated at MHHW (9.5 ft NAVD88 elevation) and wetland vegetation is colonizing the newly inundated area (see H5).

Recommendation: This target is related to vegetation and we suggest that it is covered under Hypothesis 5, and should be removed as a target here.

2.1.3.3 Site elevations

Restoration target: 60 acres of freshwater tidal wetland by 2015.

Target met? No, although 55.7 acres are now experiencing tidal inundation at MHHW (9.5 ft NAVD88 elevation) and wetland vegetation is colonizing the site (see H5).

The 55.7-acre figure was calculated by summing the acreage of the pre-restoration wetland (9.8 ac) with the post-restoration acreage inundated at the 9.5-ft elevation (45.9 ac). There are two reasons why the acreage does not add up to 60. First, there are some high islands within the restoration site tidal floodplain that add up to about 1.6 acres; second, the site perimeter (which encompasses 60 acres) appears to coincide with the tops of the dikes, but the 9.5-ft elevation line is near the base of the dikes. While the distance between these two lines is small and appears insignificant, the area sums up to approximately 2.6 acres. These two areas equal 4.2 acres, accounting for the difference.

2.1.3.4 Number of days or percent of period project inundated

Restoration target: Photo-documentation shows significant increase in total area that is inundated by 2015.

Target met? Yes, see Figure H3-2 and H3-3 and photos present in the results related to Hypothesis H5.

This hypothesis relates to the new tidal marsh areas created from the dike setback. Instead of reporting only qualitative data from photo interpretation, we also report results from water surface elevation data. Data loggers were deployed in the two new blind channel areas on March 5, recording water level data on 15-minute intervals through the end of the water year September 30. During this period the area in Blind Channel 1 (Smith A) was inundated at or above the 9.5-ft level 17.8 % of the time and at Blind Channel 2 (Smith B) 17.7 % of the time. Figure H3-4 shows inundation in new marsh area.

Recommendation: The recommendation is to make one of two possible changes:

1) We suggest this restoration target, as written, is not quantitative and is covered by the remaining three targets for this Hypothesis, and therefore should be removed,

or

2) We suggest changing the language of this restoration target to use data recorded by the water elevation loggers deployed in the blind channel areas to calculate the inundation time period when the WSE is greater than or equal to 9.5 feet NAVD88.

2.1.3.5 Percent of project site inundated at MHHW of 9.5ft NAVD88

Restoration target: The percent of the project area inundated at MHHW of 9.5 ft NAVD88 increases by 2015.

Target met? Yes, inundation increased from 16.3% to 92.8% of the project area.

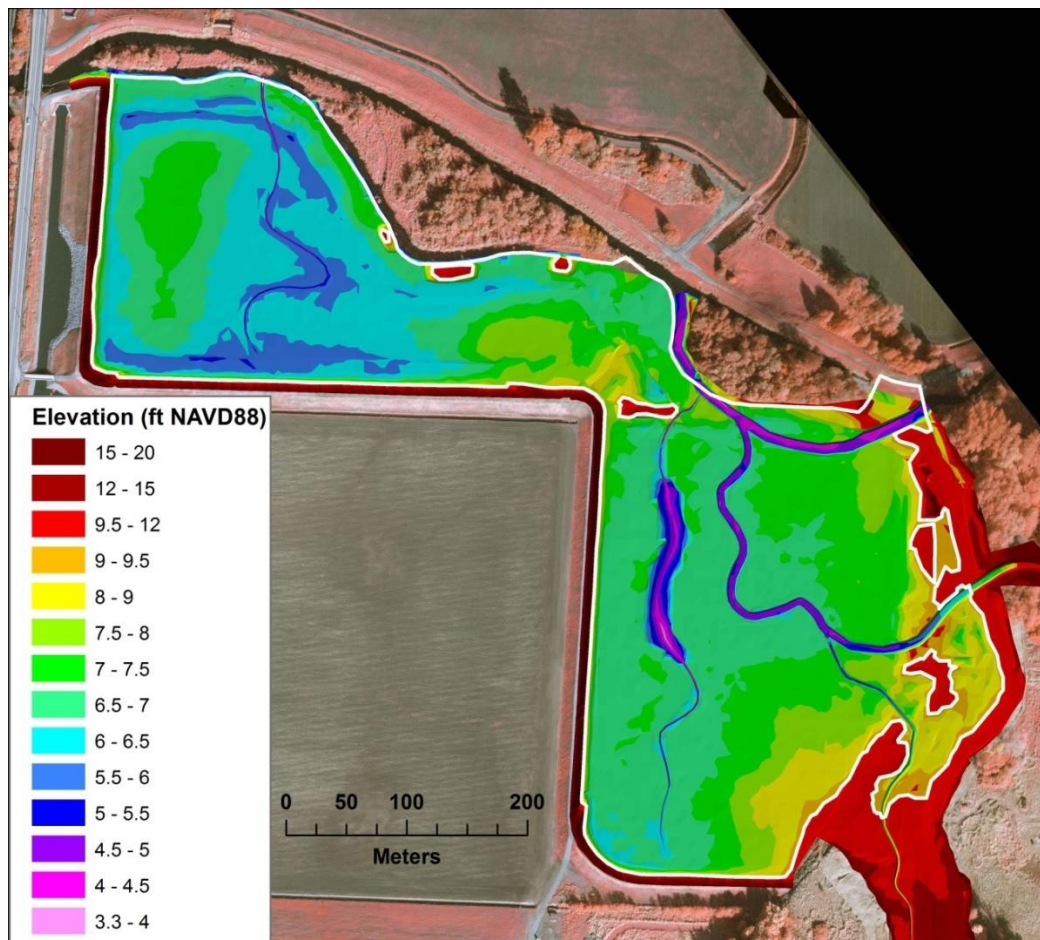


Figure H3-1 Site elevations. The white outline shows 45.9 acres of restored tidal plain that floods up to 9.5 ft NAVD88; this in addition to the pre-existing tidal marsh of 9.8 acres equals 55.7 acres of tidal floodplain. No elevation is shown for the pre-existing tidal marsh due to the unreliability of LiDAR where dense shrub vegetation predominates and where vertical errors can be on the order of 2 feet. Within the restored tidal plain several high islands above 9.5 feet elevation amount to ~1.6 acres collectively, and a ~29-ft wide strip between the dike top and the 9.5-ft elevation at the base of the dikes amounts to ~2.6 acres. These account for the difference between the tidal floodplain acreage (55.7) and the active (tidal floodplain-centered) target acreage (~60).

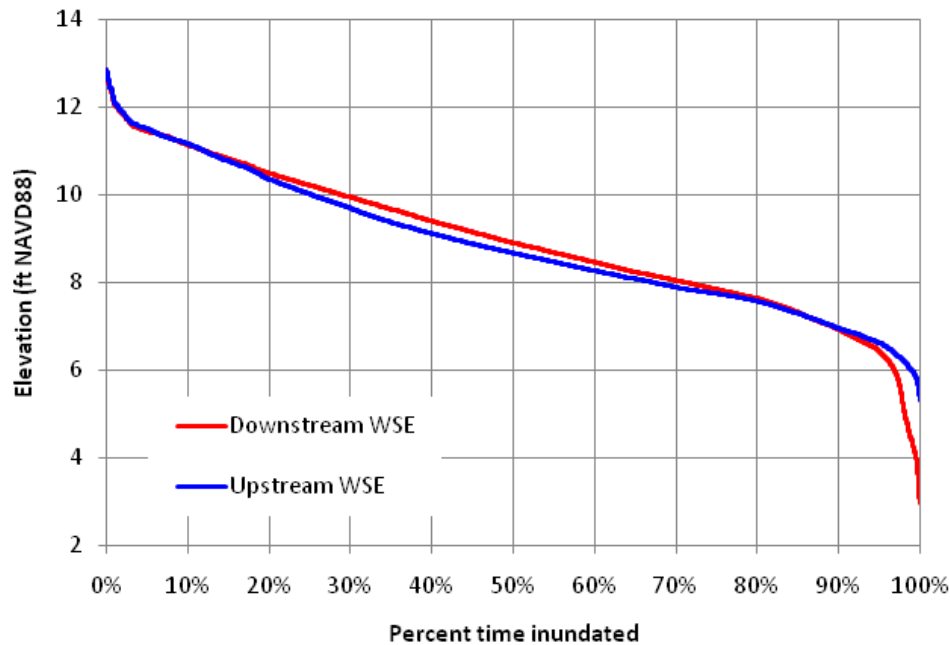
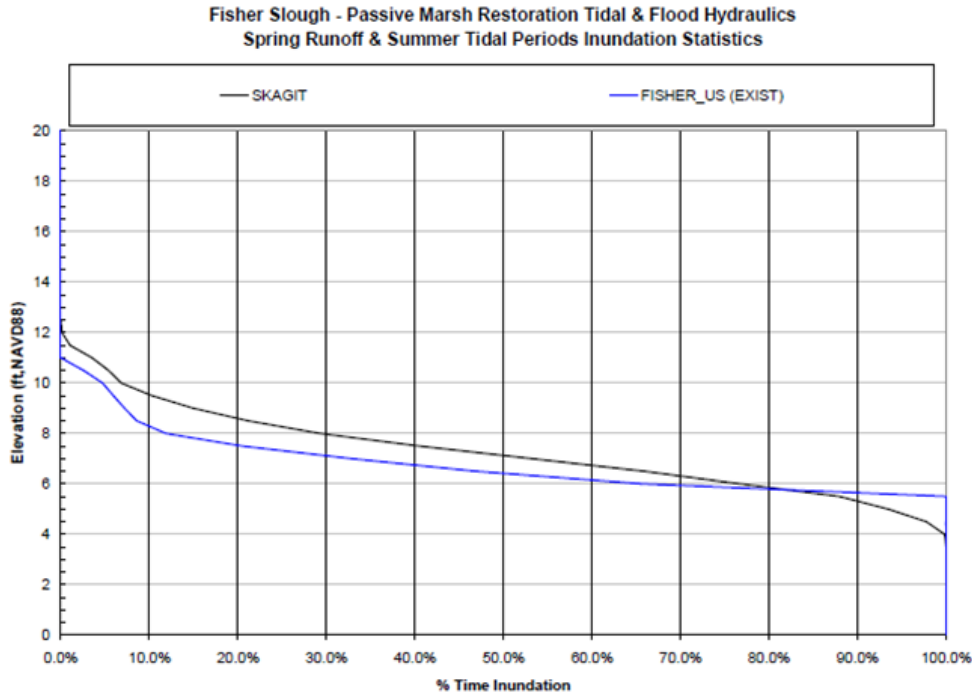


Figure H3-2. Comparison of pre-restoration (top frame, Tetra Tech [2009b]) and 2012 post-restoration (bottom frame) inundation curves. Upstream/downstream labels in the lower frame are relative to the floodgate. Spring-summer time periods are graphed in both frames. Note the difference in inundation curves between upstream and downstream of the flood gate has diminished following restoration.

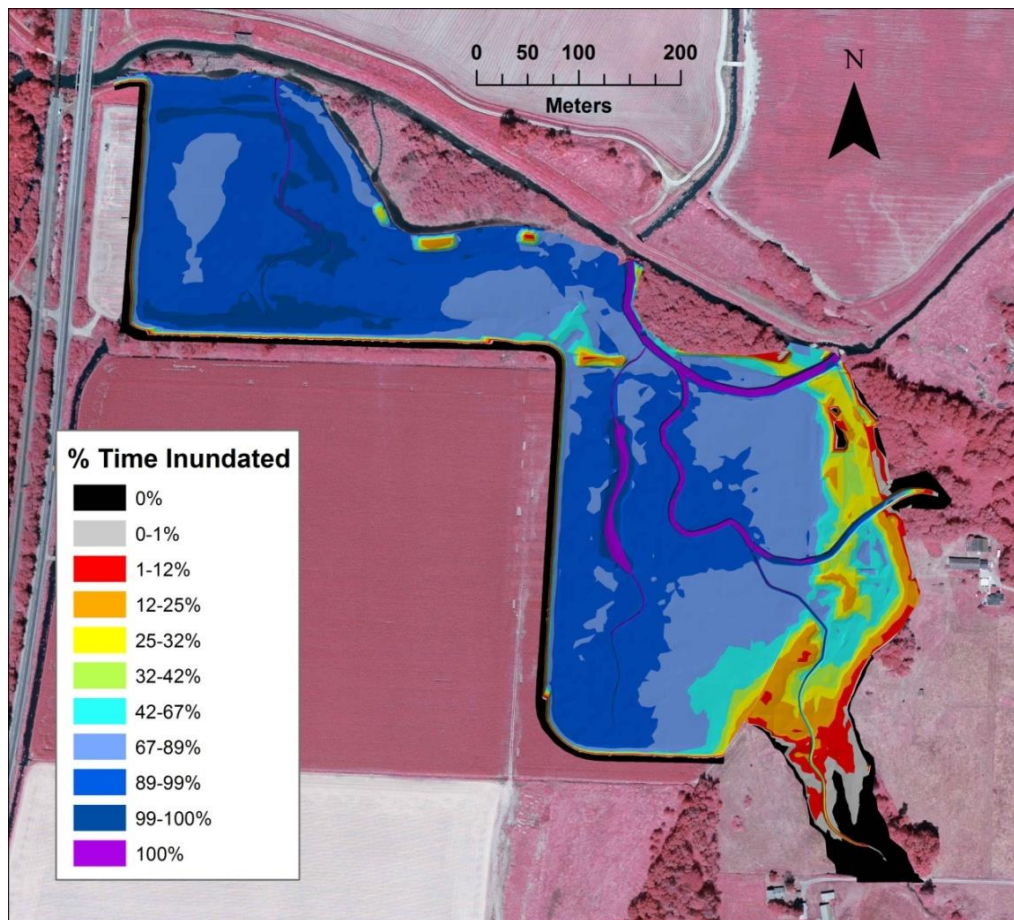


Figure H3-3. Spatial distribution of inundation times based on spring through summer 2012 water surface elevation monitoring upstream of the Fisher Slough floodgates. Note: some areas are ponded a majority of the time.



Figure H3-4. Ducks using the flooded portions of the newly restored Fisher Slough acreage in Blind Channel 1 (September 24, 2012); a water surface elevation logger is visible in one of the excavated tidal channels in the background. See photos in section H5 for additional examples of site inundation.

2.1.4 Hypothesis H4

Restored tidal exchange/levee setback and greater inundation will result in accretion and aggradation of the ground surface in tidal marsh areas.

Table H4-1. Sedimentation and elevation rates.

Parameter	Before WY2009	WY2009 Condition	WY2010 Condition	WY2011 Condition	WY2012 Condition	Restoration Target
Sedimentation rates across the newly exposed marsh/floodplain area.	Not measured	Not measured	Not measured	Not measured. Sediment stakes installed in 2011.	Spatially variable, but mean rate not different from zero.	Mean sedimentation rates are positive by 2015.
Elevation of newly exposed marsh/floodplain area.	Not measured	Not measured	Not measured	Baseline condition measured at stakes and with as-built survey.	10 of 16 pins positive. Deposition at channel margins; erosion in one location on site.	More pins with positive (accretion) as opposed to negative (erosion) sedimentation.

2.1.4.1 Sedimentation rates

Restoration target: Mean sedimentation rates are positive by 2015.

Target met? No. While there has been a mean increase in elevation of 0.7 cm at the sediment pins, a paired-sample t-test indicates this is not significantly different from zero ($t = 0.5025$, $p = 0.6226$, $df = 15$).

2.1.4.2 Elevation of the newly exposed marsh/floodplain area

Restoration target: More pins with positive (accretion) as opposed to negative (erosion) sedimentation.

Target met? Yes; ten pins showed positive elevation change, while six were negative.

As per the Monitoring and Adaptive Management Plan (MAMP, Parametrix 2010), overall changes in project site elevations associated with the restoration will be evaluated by comparing pre-project LiDAR data with LiDAR data collected again in 2015. However, more sensitive measurement (greater vertical resolution) of elevation changes and sedimentation rates will occur at 16 sediment stakes established in September 2011 as per the MAMP near pre-determined permanent vegetation plots (Figure H4-1).

The sediment stakes consist of 2-m rebar pounded one meter into the ground. In 2011, an RTK-GPS (3-cm horizontal and vertical resolution) was used to measure stake-top elevations; a tape measure was used to measure ground elevation relative to the stake top (Table H4-2). These methods are the same as those described in the MAMP. Consultation with Dr. John Rybczyk of Western Washington University indicated that these methods were sufficient and appropriate for the intended monitoring objectives.

The first year of post-project measurements (Water Year 2012, measured in September 2012) are compared to those of the baseline condition (measured in September 2011) in Table H4-2.

Table H4-2. Sedimentation stake measurements.

Stake ID	Ground elevation (NAVD88 m)	Rod Top to Ground 2011 (ft)	Rod Top to Ground 2012 (m)	Net Sedimentation (cm)
13-10	2.87	0.90	0.89	1.2
13-3	2.83	0.93	0.98	-5.3
13-7	2.90	0.90	0.93	-2.8
3-3	2.91	1.00	0.94	6.3
3-4	2.92	0.97	0.965	0.7
4-4	2.91	0.91	0.91	0.4
4-5	2.55	0.84	0.95	-10.5
4-6	2.76	0.88	0.945	-6.9
4-7	2.81	0.88	0.90	-2.4
5-1	3.09	1.09	1.05	3.6
5-9	2.59	0.97	0.86	11.2
6-10	2.90	0.93	0.89	4.4
6-4	2.84	0.92	0.87	5.1
7-3	3.50	0.98	0.985	-0.7
7-4	3.20	0.97	0.96	0.5
9-8	2.56	0.93	0.865	6.5

When the data are evaluated without consideration of spatial organization, the mean difference between pre- and post-restoration elevations is 0.7 cm, which a paired-sample t-test indicates is not significant ($t = 0.5025$, $p = 0.6226$, $df = 15$). However, when spatial organization is taken into account it appears that erosion is concentrated in one location on the site, while deposition occurs primarily near channel margins (Figure H4-1). Nevertheless, it is too early to make any predictions about future trends in elevation change.

A new blind tidal channel appears to be in the process of initiation near the eastern-most portion of the Fisher Slough Project site (green triangle in Figure H4-1). A significant volume of water is ponding on the marsh surface and draining into Fisher Slough at this point. The amount of flow is apparently sufficient to initiate a nick in the Fisher Slough bank which suggests potential for further development into a tributary tidal channel. No other similar nicks were observed in the bank of Fisher Slough.

The early results suggest the possibility that the restoration targets are simplistic, at least as measured by sediment pins. Erosion and sedimentation appear likely to vary spatially, with greater sedimentation in proximity to tidal channel margins and erosion occurring where new tidal channels are developing. The limited spatial sampling allowed by 16 sediment pins is unlikely to capture the true extent of this spatial variation. More extensive LiDAR data (due in 2015) may do so depending on the amount of vertical change relative to the vertical resolution of the LiDAR.



Figure H4-1. Top frame: Sediment stake locations (see Table H4-1 for elevations). Project area is outlined in red. Bottom frame: Elevation change at sediment pins (shown on October 2011 airphoto). Negative values (blue) indicate erosion; positive values (orange-red) indicate sedimentation. Green triangle indicates likely new tidal channel initiation.

2.1.5 Hypothesis H5

Restoration of tidal, fluvial, and sediment processes (and limited planting) will result in recolonization of the site by native freshwater wetland emergent, scrub-shrub, and forested wetland and riparian plants as predicted by Hood (2007) and TNC (Tetra Tech 2009a).

Table H5-1. Vegetation parameters.

Parameter	Before WY2009	WY2009 Condition	WY2010 Condition	WY2011 Condition	WY2012 Condition	Restoration Target
Total area of the site with native and non-native vegetation communities, determined from vegetation mapping in aerial photographs (in acres).	Not measured	Not measured	Not measured	Not measured	Not measured	Photo-documentation shows significant change in plant community species composition and type by 2015. Total area mapped with tidal freshwater wetland plant communities increases (60 acres by 2015).
Cover of vegetation species—aquatic, herbaceous, scrub-shrub, forest.	Not measured	Not measured	Vegetative cover data for the five treatment areas ranged from 0-17% bare ground, 0-39% native species and 44-100% introduced species.	Not measured	Not measured	By 2015, >30% cover of freshwater tidal wetland plant species.
Species richness—total number of species observed on the site from species lists compiled during vegetation sampling.	Only calculated at the transect level. 21 native species present on transects during 2006 survey.	Not measured	97 species observed of which 48 were native species.	Not measured	Not measured	Increased native plant species richness compared to 2010 conditions.
Elevation ranges and inundation times of vegetation species.	Elevation ranges (NAVD88), % inundation Mud-channel: 0 to 5.5 feet, 100% Low marsh: 6.0 to 6.5 feet, 46.9-65.5% High marsh: 7.0 to 7.5 feet, 20.5-32.9% Riparian: 8.0 to 10.0 feet, 4.7-11.9% Upland: 10.5 to 14 feet, 0-2.6% (Tetra Tech 2009b)	Not measured	Elevation ranges and inundation times are the same as 2006. There were no changes to the existing levees.	Not measured	Not measured	Elevation ranges (NAVD88) and % inundation for major vegetation types will be similar to: Mud-channel: 0 to 4.5 feet, 95-100% Low marsh: 4.5 to 7.0 feet, 50-95% High marsh: 7.0 to 8.5 feet, 15-50% Riparian: 8.5 to 10.0 feet, 5-15% Upland: >10 feet, 0-5%

2.1.5.1 Native and non-native vegetation

Restoration target: Photo-documentation shows significant change in plant community species composition and type by 2015. Total area mapped with tidal freshwater wetland plant communities increases (60 acres by 2015).

Target met? This target was not rigorously quantified. However, photo-documentation shows change in plant community species composition for many photo points between 2010 and 2012, demonstrating the site in October 2012 was in the early stages of developing a freshwater tidal marsh vegetation community. See discussion below.

2.1.5.1 Vegetation cover

Restoration target: By 2015, >30% cover of freshwater tidal wetland plant species.

Target met? Not measured.

2.1.5.1 Species richness

Restoration target: Increased native plant species richness compared to 2010 conditions.

Target met? Not measured.

2.1.5.1 Elevation and inundation

Restoration target: Elevation ranges (NAVD88) and % inundation for major vegetation types will be similar to: Mud-channel: 0 to 4.5 feet, 95-100%; Low marsh: 4.5 to 7.0 feet, 50-95%; High marsh: 7.0 to 8.5 feet, 15-50%; Riparian: 8.5 to 10.0 feet, 5-15%; Upland: >10 feet, 0-5%.

Target met? Not measured.

Vegetation was not sampled quantitatively in 2012, but photo points first established in 2010 were revisited in September 2012, where plot-scale and landscape-scale photos were taken at each location. All of the sediment pin locations were also photo locations, so both have the same identifying code. There are a few additional photo points; these are located in previous monitoring reports, so their location is not presented in this report. The 2012 and 2010 photos are presented below in juxtaposition to allow comparison and evaluation of vegetation change. Figure numbers coincide with photo point numbers.

Pre-restoration riparian vegetation present on islands previously exposed to tidal influence may experience little change, because the ecological niches of mature vegetation are typically broader than their recruitment niche, i.e., this vegetation may persist even if there is some change in hydroperiod due to the general resilience of mature vegetation. The agricultural fields exposed to restored tidal influence should develop tidal marsh vegetation as predicted by Hood (2007), Tetra Tech (2009b), and TNC (2011). Precise agreement between predicted and observed vegetation may not occur, depending on floodgate management. Inundation frequency within the project area could be greater or lesser than that experienced in reference Skagit River delta marshes depending on seasonally-varying floodgate management and flood events.

In general, the site in October 2012 was in the early stages of developing a freshwater tidal marsh vegetation community. Many areas formerly covered by pasture grasses or clover are now either bare mud or are covered by patches of wetland plants such as sedges (*Carex lyngbyei*, *Eleocharis palustris*), water plantain (*Alisma triviale*), burr-reed (*Sparganium* spp.), wapato (*Sagittaria* spp.), and others. Reed canarygrass (*Phalaris arundinacea*) is also present in some areas (see next section, H6). Some areas in the western lobe of the site that appear to be subject to greater inundation are dominated by an unidentified alga or are unvegetated. These are also areas that showed evidence of erosion (see previous section, H4).



Figure 3-3a (plot-scale, left side), b (landscape-scale, right side) for 2012 (top) and 2010 (bottom).



Figure 3-4a (plot-scale, left side), b (landscape-scale, right side) for 2012 (top) and 2010 (bottom).



Figure 4-4a (plot-scale, left side), b (landscape-scale, right side) for 2012 (top) and 2010 (bottom).



Figure 4-5a (plot-scale, left side), b (landscape-scale, right side) for 2012 (top) and 2010 (bottom). Note that the 2010 photos show a dike in the background (removed by 2012) that obscures view of distant shrub vegetation.



Figure 4-6a (plot-scale, left side), b (landscape-scale, right side) for 2012 (top) and 2010 (bottom).

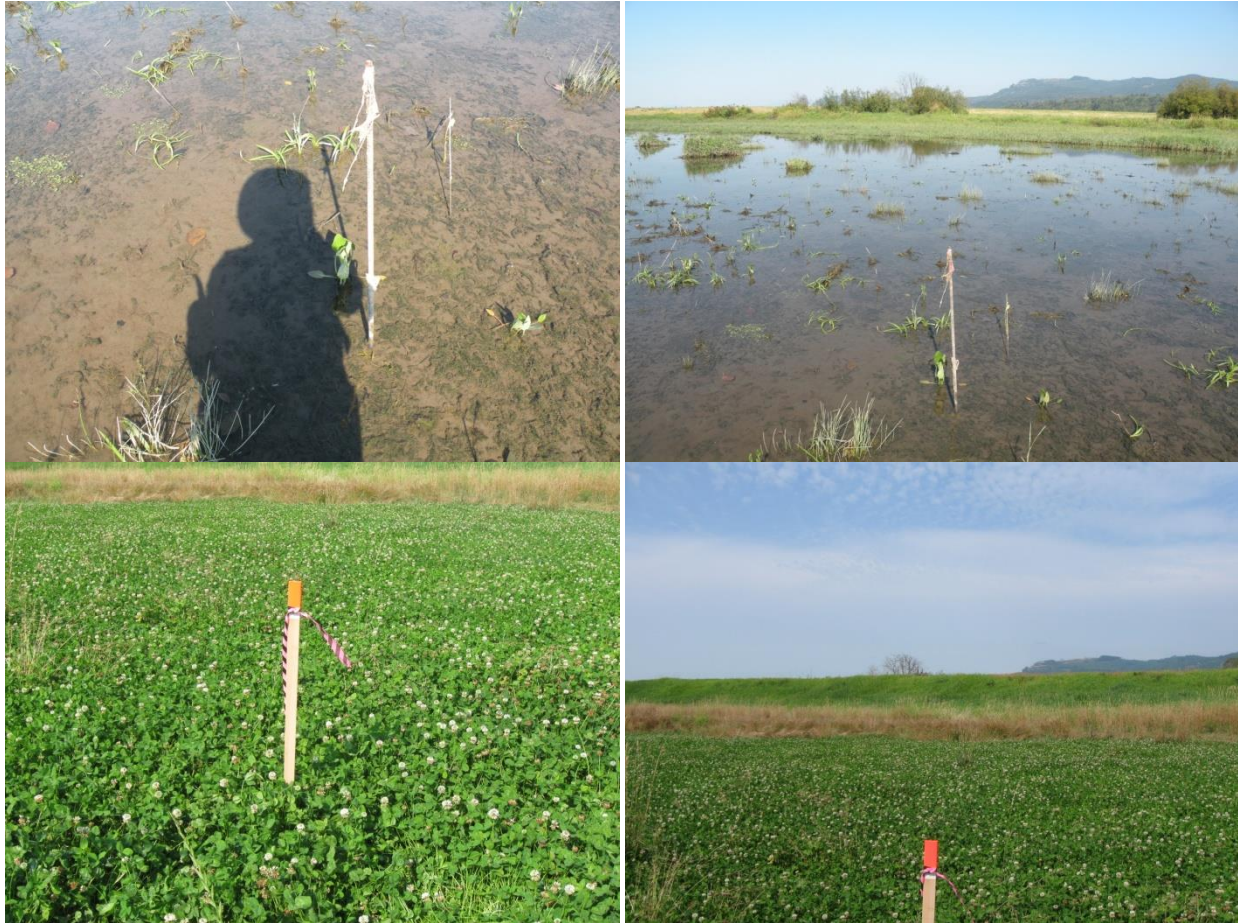


Figure 4-7a (plot-scale, left side), b (landscape-scale, right side) for 2012 (top) and 2010 (bottom). Note that the 2010 photos show a dike in the background (removed by 2012) that obscures view of shrub vegetation.

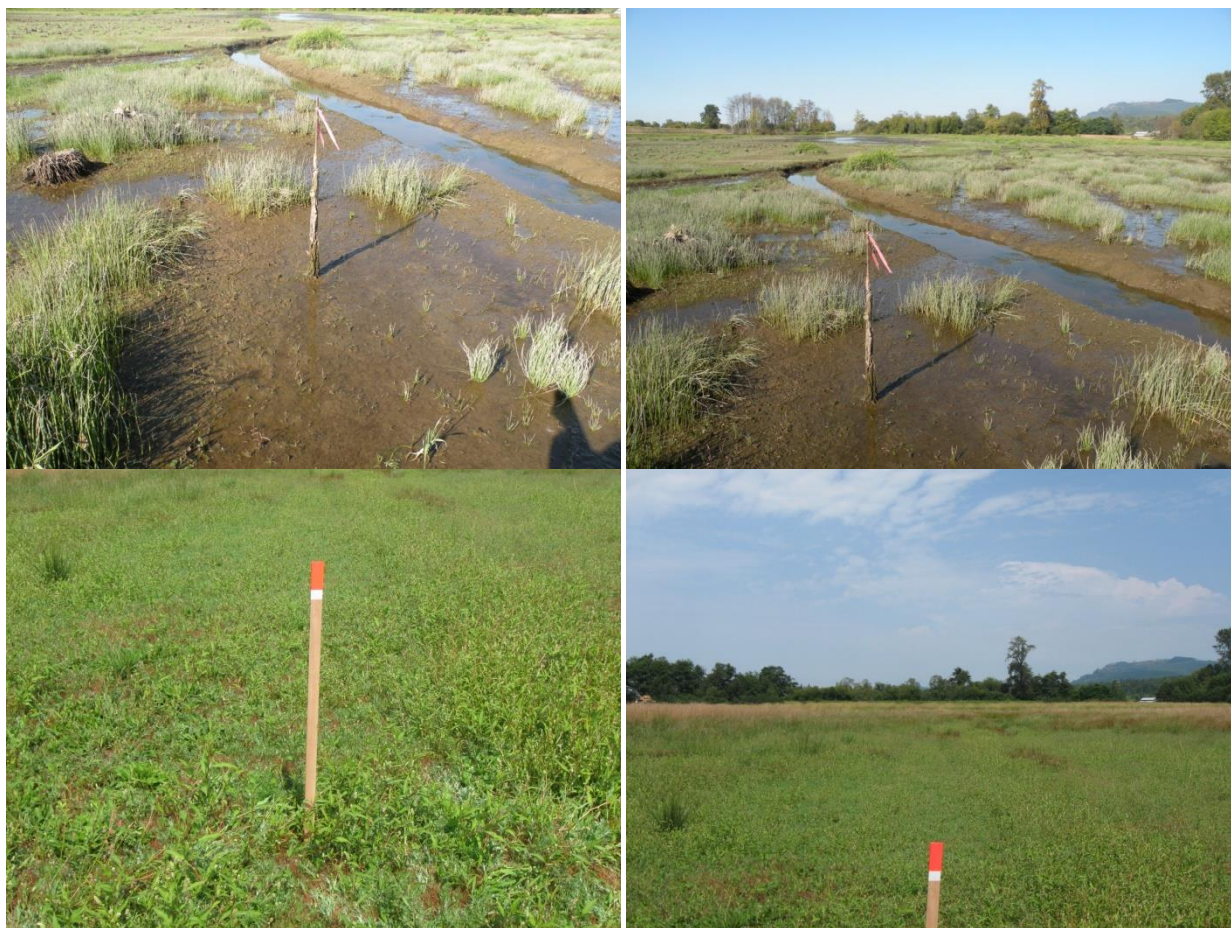


Figure 5-1a (plot-scale, left side), b (landscape-scale, right side) for 2012 (top) and 2010 (bottom).



Figure 5-9a (plot-scale, left side), b (landscape-scale, right side) for 2012 (top) and 2010 (bottom).

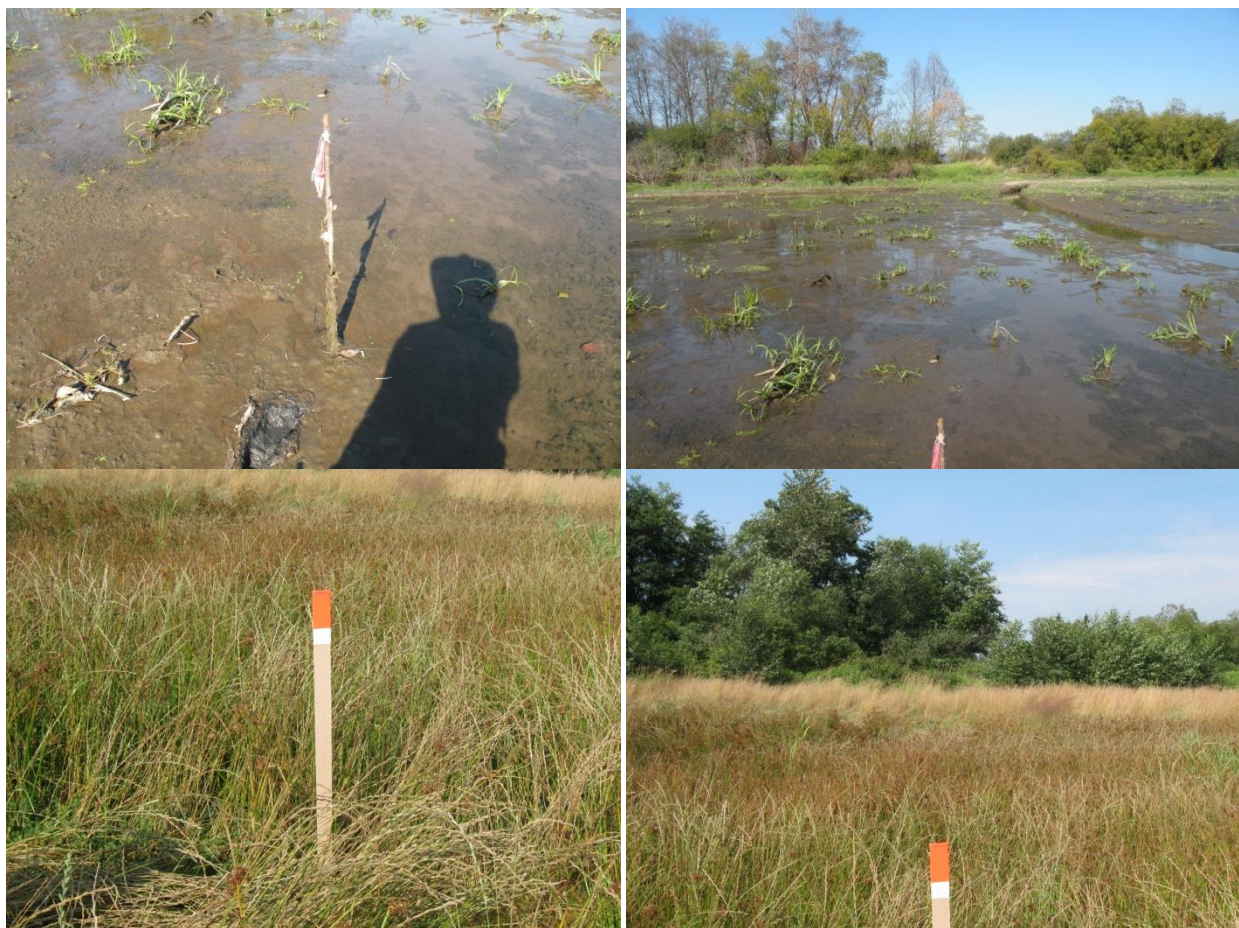


Figure 6-4a (plot-scale, left side), b (landscape-scale, right side) for 2012 (top) and 2010 (bottom).

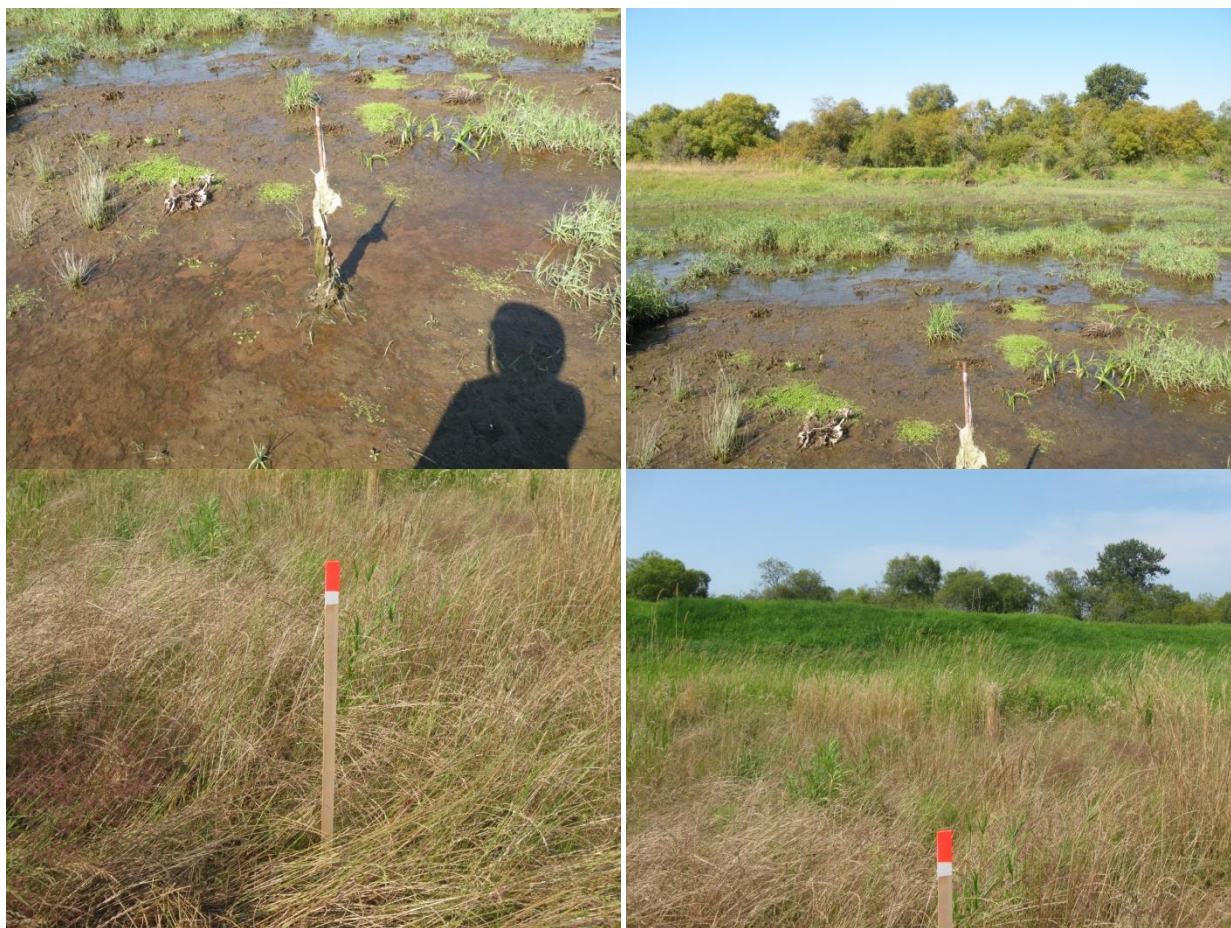


Figure 6-10a (plot-scale, left side), b (landscape-scale, right side) for 2012 (top) and 2010 (bottom). Note that the 2010 photos show a dike in the background (removed by 2012) that obscures view of shrub vegetation.



Figure 7-1a (plot-scale, left side), b (landscape-scale, right side) for 2012 (top) and 2010 (bottom).



Figure 7-3a (plot-scale, left side), b (landscape-scale, right side) for 2012 (top) and 2010 (bottom).

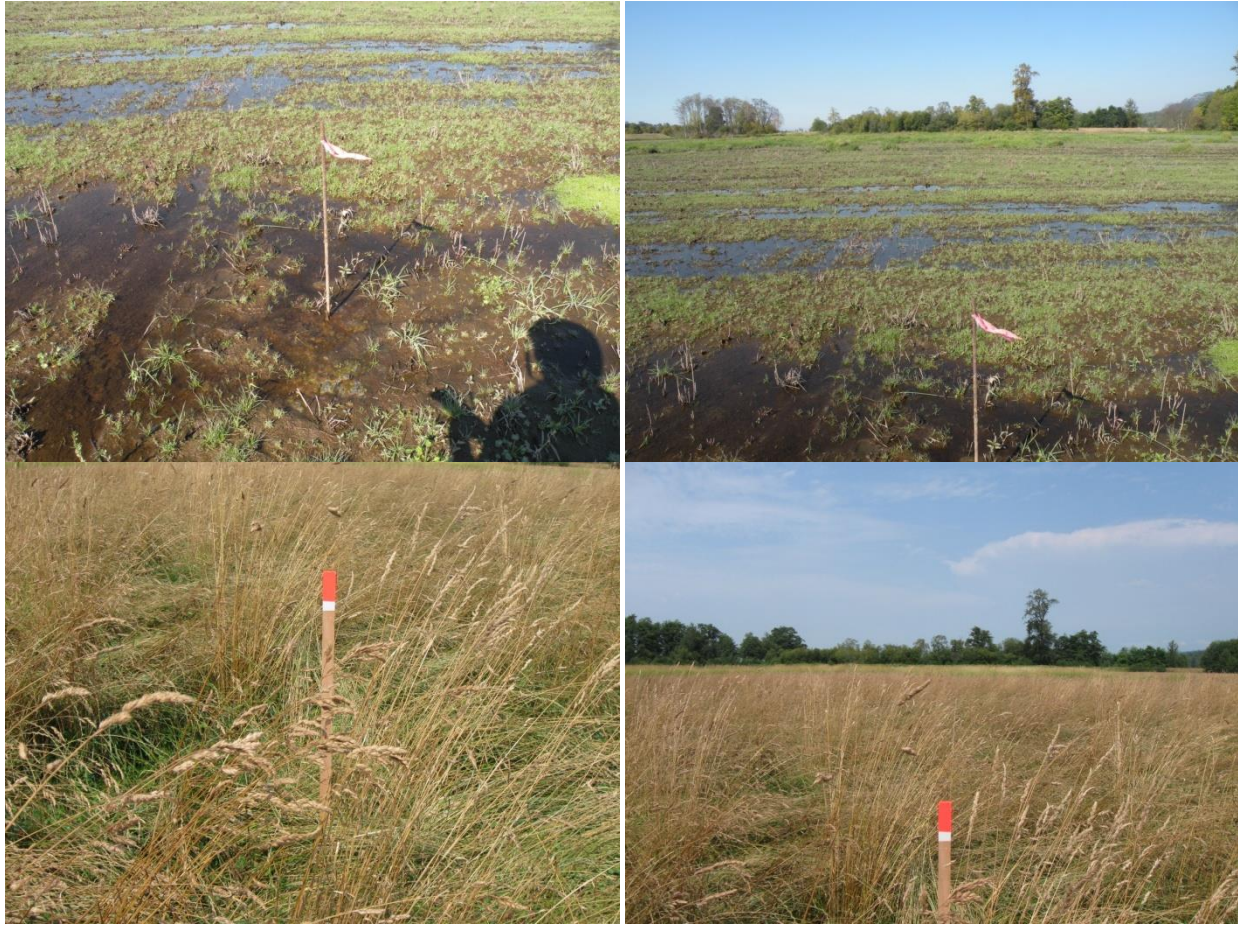


Figure 7-4a (plot-scale, left side), b (landscape-scale, right side) for 2012 (top) and 2010 (bottom).



Figure 9-2a (plot-scale, left side), b (landscape-scale, right side) for 2012 (top) and 2010 (bottom). Note that the 2010 photos show a dike in the background (removed by 2012) that obscures view of shrub vegetation; the vegetation in the foreground is reed canarygrass in 2010 and 2012.



Figure 9-8a (plot-scale, left side), b (landscape-scale, right side) for 2012 (top) and 2010 (bottom). Note that the 2010 photos show a dike in the background (removed by 2012) that obscures view of shrub vegetation.



Figure 10-3a (plot-scale, left side), b (landscape-scale, right side) for 2012 (top) and 2010 (bottom).



Figure 11-7a (plot-scale, left side), b (landscape-scale, right side) for 2012 (top) and 2010 (bottom).



Figure 13-7a (plot-scale, left side), b (landscape-scale, right side) for 2012 (top) and 2010 (bottom).



Figure 13-10a (plot-scale, left side), b (landscape-scale, right side) for 2012 (top) and 2010 (bottom). Note that the 2010 photos show a dike in the background (removed by 2012) that obscures view of shrub vegetation.

2.1.6 Hypothesis H6

Restoring a natural and more variable tidal regime will reduce the cover of reed canarygrass in areas where it occurs pre-project.

Table H6-1. Reed canarygrass (RCG) parameters.

Parameter	Before WY2009	WY2009 Condition	WY2010 Condition	WY2011 Condition	WY2012 Condition	Restoration Target
Total area of RCG, determined from vegetation mapping in aerial photographs.	Not measured	Not measured	There are approximately 19.30 acres of RCG in the project site.	Not measured	There are 3.0 ac of RCG in the restored tidal floodplain, 1.7 ac in the pre-restoration wetland, 7.8 ac in uplands: total of 12.5 ac.	Area mapped with RCG $\leq$ 19.30 acres by 2015.
Mean elevation of RCG on the site.	Not measured	Not measured	Mean RCG elevation in vegetation plots is 8.87 ft NAVD88: range is from 5.45 to 18.44 ft NAVD88.	Not measured	Not measured	Reduced RCG density at all elevation ranges.
Mean cover of RCG in vegetation plots.	RCG cover in the five vegetation treatment areas ranged from 10-70% cover in 2006.	Not measured	Mean percent RCG canopy cover in vegetation plots was 60%, ranging from 5-100%.	Not measured	Not measured	Percent cover of RCG in plots $\leq$ measured in 2010.

2.1.6.1 RCG area

Restoration target: Area mapped with RCG $\leq$ 19.30 acres by 2015.

Target met? Yes, the total area of RCG is 12.5 acres of which 4.7 acres are in the tidal floodplain.

2.1.6.2 RCG elevation

Restoration target: Reduced RCG density at all elevation ranges.

Target met? RCG density was not measured during this monitoring period.

Recommendation: The measurement parameter 'Mean elevation of RCG on the site' is inappropriately linked to the target 'Reduced RCG density at all elevation ranges'. One cannot infer density from measurement of elevation. Either the parameter or the goal should be changed.

2.1.6.3 RCG cover

Restoration target: Percent cover of RCG in plots $\leq$ measured in 2010.

Target met? Not measured.

Previous Monitoring: Reed canarygrass (RCG; *Phalaris arundinacea*) was sampled prior to site restoration in 2006 and 2010 and these results were reported in TNC 2011 and 2012, respectively. The 2006 sampling only measured the percent cover of RCG in sample plots (results ranged from 10%-70% coverage); it did not measure the extent of RCG occurrence over the project site. However, the 2011 baseline monitoring report did mention that RCG occurs in the riparian zone of the pre-restoration site (i.e., the islands within the channel and other low areas bordering the channel between the dikes) and that this area was measured in 2010 and amounted to 4.1 acres. The 2012 TNC report states that 19.3 acres of RCG were present. However, this includes areas of very high elevation (up to 18.4 ft NAVD88, well above MHHW or even maximum high water) and includes uplands such as dikes.

WY2012 Monitoring: The Fisher Slough Tidal Marsh Restoration Baseline Monitoring Report (TNC 2011) states that, “Reed canary grass occurs primarily in the existing Fisher Slough floodplain (or marsh plain) between the levees, in ditches adjacent to levees, along the levees, *and in the central and southeastern portion of Smith B*” [emphasis added]. It further states that, “Reed canary grass occurs in the riparian zone...” The RCG found on the site in October 2012 was found in the same locations in which it occurred prior to site restoration. This indicates that much, if not all, of the RCG onsite is not the result of new colonization; rather it results from the persistence of pre-existing patches.

The figures below (H6-1 & 2) depict the October 2012 locations of RCG superimposed on background air photos from autumn (October 25) and summer of 2011, post- and pre-restoration, respectively. The yellow points on the photos are GPS locations of individual patches (varying in size from ½ to 6 m in diameter), the start and end points of strips of RCG, and the edges of large patches of RCG. The total area of RCG coverage in the tidal floodplain amounts to 4.7 ac, with an additional 7.8 ac occurring on the eastern alluvial fan. In the 2012 monitoring period RCG was not mapped outside of the restored tidal floodplain, but qualitative observations indicated persistence of RCG coverage where it had been previously mapped in 2010. The upland, alluvial fan locations of RCG have been planted with willow stakes and other shrubs, but these are still too immature to displace the pre-existing RCG (e.g., Figures 7-1, 11-7). The average elevation at which RCG is found in the tidal floodplain is 7.6 ft NAVD88, with a range of 4.1 to 10.5 ft NAVD88. Occurrences observed at higher elevation were on dike remnants or the alluvial fan. Comparison of the pre- and post-restoration photos indicates that the long strips of RCG observed in this monitoring effort originally occurred along pre-restoration dikes and borrow ditches in Smith A field. Similar comparisons for Smith B field support the baseline monitoring report’s depiction of pre-existing RCG with persistence on the site one year after restoration. Interestingly, the GPS points were almost perfectly coincident (down to the scale of individual patches) with distinctive photo-signatures in the false-color infra-red air photo flown almost one year previously, on October 25, 2011. These photo signatures were light pink (lighter than the adjacent matrix field) and gave the impression of being taller than the adjacent matrix. This suggests that aerial photography, particularly color infra-red (CIR), may be useful to monitor RCG persistence or spread in future years. However, the utility of air photos will also depend on whether other species colonizing the site have a photo-signature that contrasts sufficiently with that of RCG. An autumnal photo (e.g., October) may be optimal since RCG tends to persist late in the growing season, while many other species have senesced.

In retrospect, it seems that pre-restoration treatment of RCG should have been attempted to minimize its ability to persist after restoration. This may be one “lesson learned” from this experience, although hopefully RCG coverage may shrink in Smith A and B fields with continued future inundation.



Figure H6-1. Blind Channel 1 (Smith A), with Reed Canary Grass (RCG) patches as green polygons; yellow dots are GPS locations of small RCG patches, the beginning and end of RCG strips, or the edges of large patches (2012 data). RCG distributions are overlaid on photos depicting post- and pre-restoration conditions (October 25, 2011, top frame; summer 2011, bottom frame) to illustrate the association of post-restoration RCG with the pre-restoration borrow ditches and dike margins. For comparison, 2010 RCG distributions are shown as yellow stippling in the top frame.

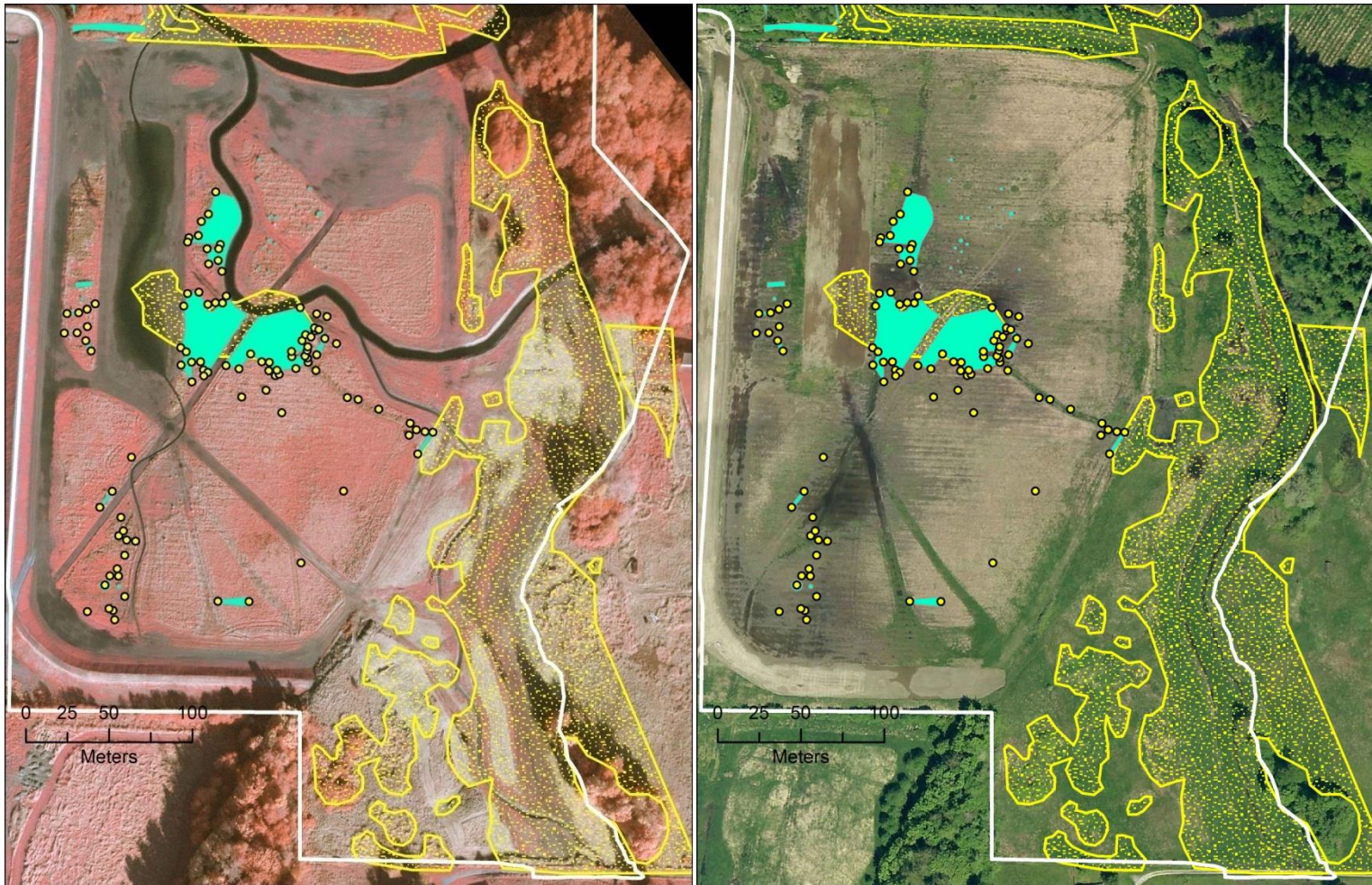


Figure H6-2. Blind Channel 2 (Smith B), with Reed Canary Grass patches as green polygons; yellow dots are GPS locations of small RCG patches, the beginning and end of RCG strips, or the edges of large patches (2012 data); project boundary (white outline). The background photo on the left is post-project construction (October 25, 2011) and the one on the right is pre-project construction (summer 2011). For comparison, 2010 RCG distributions are shown as yellow stippling. RCG monitoring in 2012 was focused primarily on the tidal floodplain, though some qualitative observations were made in the uplands that indicated significant coverage of RCG.

2.1.7 Hypothesis H7

Restored tidal exchange will reintroduce sediment transport and scouring of tidal channels on the project site, resulting in the creation of greater overall channel area and a more complex channel network compared to pre-project conditions.

Pre-restoration conditions (WY2009) were re-evaluated by characterization from historical aerial photos, because previous estimates of channel surface area did not make sense relative to post-restoration characterization of channel area, i.e., they indicated no change in tidal channel surface area even though significant channel excavation occurred as part of restoration. The updated characterizations represent an “apples-to-apples” comparison of pre- and post-restoration channel geometry exclusively within the tidal floodplain.

Table H7-1. Fisher Slough channel metrics. Items in red are new this year.

Parameter	WY2009 Condition	WY2011 Condition	WY2012 Condition	Allometric prediction (90% Confidence limits)	Restoration Target
Channel area (total channel area estimated from aerial photographs and elevations using GIS).	3.4 ac of channel	3.7 acres of channel area	4.8 acres total	1.48 acres (0.48 – 4.8)	Total channel area and length will increase by 2015
Channel cross sections and longitudinal profiles (estimate area).	Not measured	Not measured	14.2 ft ² for Blind Channel 1 25.5 ft ² for Blind Channel 2	Not measured	
Total length of channel network (estimated from aerial photographs using GIS).	4,858 ft	5000 ft excavated or remnant after rerouting Fisher Slough	9,664 ft total	12,136 ft (3,840 – 38,400)	After Project Element 3 is complete, the total length of channel network will be at least 9664 feet.
Channel density (total length divided by project area).	0.0114	0.0117 length per unit area (i.e., 5000 ft/9.8 ac)	0.0040	0.0051 (0.0016 – 0.016)	
Distance upstream to head of blind tidal channel.	Not measured	Not measured	1397 ft for longest channel	Not measured	
Number of tidal channels	3	4	6	13 (5 – 32)	

2.1.7.1 Channel area

Restoration target: Total channel area and length will increase by 2015.

Target met? Yes, total tidal channel area of the Fisher Slough Project site was increased by tidal channel excavation and re-routing. However, this is a short-term measurement. Long-term adjustments in the tidal channels may occur that either reduce or increase tidal channel size, depending on tidal prism, flooding, and sediment supply.

Comparison of pre- and post-restoration tidal channel planform, using GIS analysis of aerial photos, shows that tidal channel area and length were increased significantly through tidal channel excavation and re-routing in the tidal floodplain (Figure H7-1). Channel density for excavated tidal channels was based on a tidal floodplain area of 55.7 acres (Table H7-1; see also Figure H3-1).

For the sake of context, the amount of tidal channel area, length, and outlet count within the intertidal portion of the restoration site was compared to the amount of tidal channel typical of reference marshes in the South Fork Skagit River delta as described by an allometric model of channel geometry (Hood 2007). The total amount of tidal channel area and length in the 55.7-acre restored tidal plain is comparable to that predicted by the allometric relationships describing channel geometry in reference South Fork Skagit River marsh islands (Table H7-1), although channel outlet count (the number of channel connections to the mainstem of Fisher Slough) was low relative to model predictions. However, there are important nuances to the comparison that should be considered. The South Fork allometric relationship describes blind tidal channels, while the excavated channels include re-routed stream channels that convey significant upland discharge in addition to tidal prism. Additionally, the Fisher Slough restoration site likely experiences muted tidal prism relative to the South Fork Skagit River tidal marshes because Fisher Slough is located further upstream than the reference marshes and because the Fisher Slough floodgate mutes tidal exchange. While direct comparisons of Fisher Slough and the reference Skagit River marshes are problematic for the aforementioned reasons, they nevertheless suggest there is scope for the restored tidal plain to develop greater channel length; channel area on the other hand is already quite high and may decline slightly in the future as portions of Fisher Slough that were once part of the mainstem, but are now by-passed blind channels, shoal and narrow to adjust to reduced discharge. Additionally, one of the new blind tidal channels was over-excavated during construction, made pond-like in its mid-length, and this area may also narrow over time.

Recommendation: Future monitoring should involve a combination of aerial photo analysis of channel planforms and RTK-GPS surveys of channel cross-sections and profiles, including locating areas of active channel head-cutting. LiDAR surveying will likely be problematic for channel measurement because LiDAR does not penetrate water well.

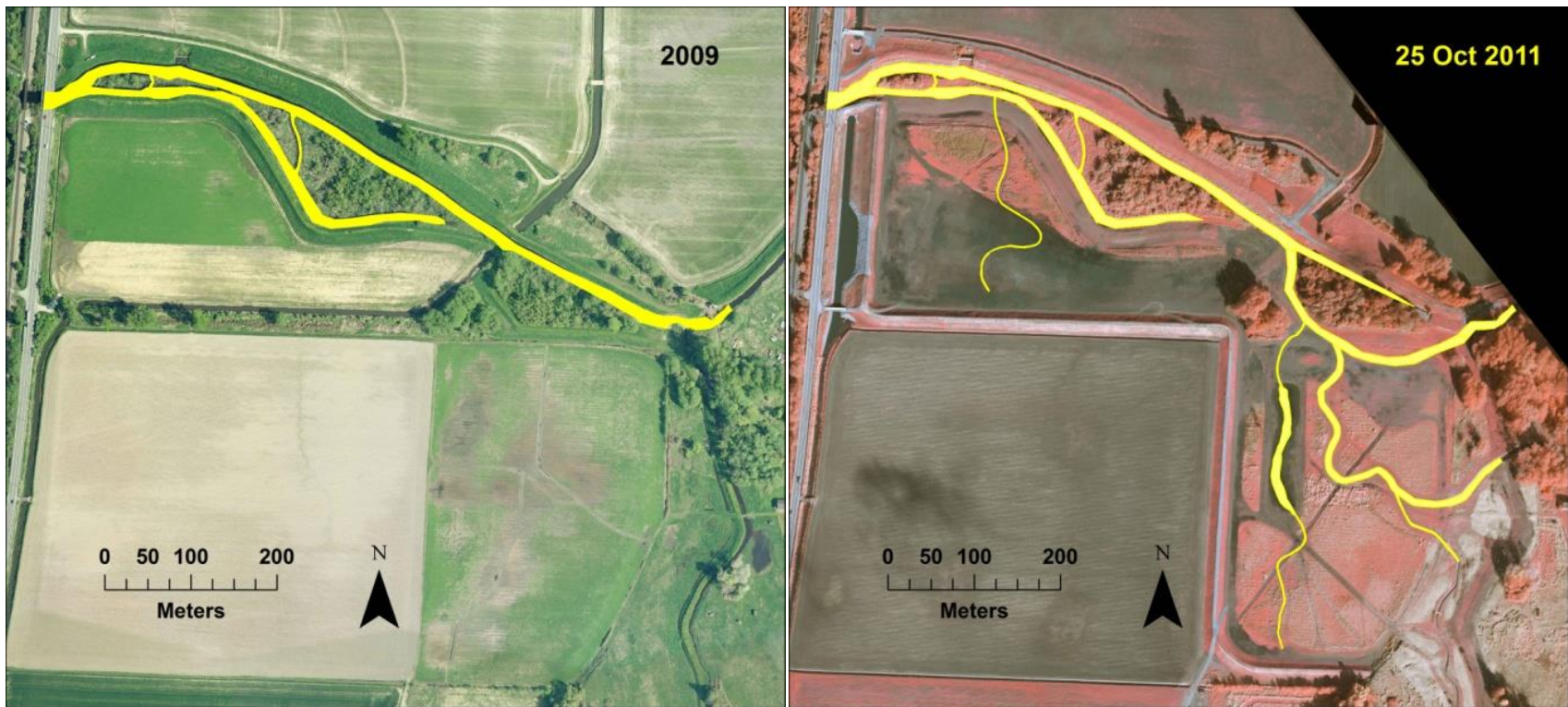


Figure H7-1. Location of pre-restoration (2009, left frame) and post-restoration (Oct 2011, right frame) tidal channels (yellow polygons) in the farmland/tidal floodplain portion of the project site. Note: stream channels that climb out of the floodplain onto the alluvial fan are not shown.

2.2 Objective 2

Restore and improve freshwater tidal rearing habitat for Chinook salmon (*Oncorhynchus tshawytscha*).

2.2.1 Hypothesis H8

Chinook salmon abundances (0+ year class) will be similar above and below the floodgates (post replacement) during the majority of the migration curve (Feb 1 through August 15).

Table H8-1. Summary of Fisher Slough juvenile Chinook salmon density as a function of floodgate replacement.

Parameter	Before WY2009	WY2009 Condition	WY2010 Condition	WY2011 Condition	WY2012 Condition	Restoration Target
Juvenile Chinook salmon: Seasonal density up and downstream of floodgate and at reference sites	Not measured	There was no significant difference in log transformed mean wild juvenile Chinook density between sites up- and downstream of the floodgates from February to August 2009 (Beamer et al. 2010).	Log transformed mean density of wild juvenile Chinook salmon was significantly higher downstream of the floodgate than upstream in 2010 (Beamer et al. 2011).	There was no significant difference in the log transformed mean wild juvenile Chinook density between sites up- and downstream of the floodgates from February to June 2011 (Beamer et al. 2013a).	There was no significant difference in the log transformed mean wild juvenile Chinook density between sites up- and downstream of the floodgates from February to July 2012 but overall abundance was much higher (Beamer et al. 2013b).	By 2015, trends suggest higher relative density of age-0+ Chinook above floodgates compared to pre-2010 conditions ¹ .

Restoration target: By 2015, trends suggest higher relative density of age 0+ Chinook above floodgates compared to pre-2010 conditions.

Target met? Yes. Juvenile Chinook salmon responded as hypothesized to dike setback restoration (along with the new floodgate) in 2012. Dike setback restoration was hypothesized to increase fish carrying capacity through increasing available habitat. Expanded juvenile Chinook salmon density results measured in 2012 suggest that dike setback increased Chinook salmon abundance upstream of the floodgate, even with a poorer floodgate operation indicator result for 2012 than in other years. However, the restoration target is meant to be achieved by 2015; presumably multiple years of results can demonstrate a consistent response of juvenile Chinook salmon to the restored area and floodgate operation.

Dike setback increased tidal habitat area upstream of the floodgate in Fisher Slough. The first year when juvenile salmon and other fish could occupy this new tidal habitat was 2012. Fish monitoring results collected in 2012 are reported in Beamer et al. (2013b). Wild juvenile

¹ The intent of this hypothesis is that the floodgate and its operation have no negative effect on fish passage.

Chinook salmon abundance and carrying capacity results for before (pre-2010) and after restoration (2012) are summarized in Table H8-2. In summary, the additional juvenile Chinook smolt carrying capacity that is a result of the Fisher Slough restoration project is 21,823 as of 2012. However this estimate only takes into consideration one year of post-restoration results and is subject to change as more information becomes available from future years of fish monitoring. The results could change based on: 1) how fish find the area each year (i.e., fluctuations in habitat connectivity) and 2) how channel/impounded areas change over time within the restoration project area.

Table H8-2. Summary of Fisher Slough juvenile Chinook salmon abundance and carrying capacity estimates. 'US of FG' is upstream of floodgate.

Monitoring Year or Source of estimate	Juvenile Chinook monitoring results			Juvenile Chinook salmon Carrying Capacity and production estimates			Juvenile Chinook salmon Carrying Capacity model inputs			
	Skagit River juvenile Chinook outmigration Level (% of carrying capacity of Skagit estuary)	Wild juvenile Chinook population size US of FG		Wild juvenile Chinook carrying capacity US of FG		Estimate of new smolt production due to restoration (smolts annually)	Landscape Connectivity		Tidal Channel area US of FG	
		Point Estimate (smolts annually)	% of best carrying capacity estimate	High Estimate (smolts annually)	Low Estimate (smolts annually)		High	Low	Total Tidal Channel Habitat (ha)	New Tidal Channel Habitat
Skagit Chinook Recovery Plan						16,431	0.423		2.186	0.81 hectares estimated to be restored
2009 ¹	54%	8,236	48%	27,459	16,950	No new fish	0.0416	0.0258	1.376	No new habitat
2012	88%	37,999	98%	38,773	23,935	21,823 ²	0.0416	0.0258	1.943	0.567 hectares actually restored

¹The carrying capacity estimates for 2009 were re-calculated from what was reported in the 2009 fish report (Beamer et al. 2010) based on updated estimates of tidal channel area upstream of the floodgate.

² The additional smolt production is the result of subtracting the low carrying capacity estimate in 2009 from the high carrying capacity estimate in 2012 which most closely matches the observed fish monitoring results in both years.

Our model for estimating carrying capacity for juvenile Chinook salmon is based on landscape connectivity and tidal channel area. The Skagit Chinook Plan estimate of juvenile Chinook carrying capacity for the conceptual Fisher Slough Restoration project used a different estimate for landscape connectivity (0.0423) than actual (either 0.0416 or 0.0258, depending on pathway). Also, the Recovery Plan assumed 0.81 hectares of new tidal channel habitat would be created at Fisher Slough whereas the actual amount of habitat is less (0.567 hectares of new tidal channel, see results for Hypothesis 7 in this report).

These two higher-than-actual values resulted in the 16,431-fish estimate found in the Chinook Recovery Plan of new juvenile Chinook to be produced by the Fisher Slough restoration project. This fish estimate is higher than the value that is now predicted by subtracting the before/after restoration estimates for carrying capacity presented in our two fish reports (Beamer et al. 2010 and 2013b). Estimates of increased juvenile Chinook salmon carrying capacity between 2009 and 2012 (before and after restoration) are 6,445 fish (38,773 minus 32,328 for the estimates based on high landscape connectivity) or 3,979 fish (23,935 minus 19,956 for the estimates based on low landscape connectivity). Both estimates are much lower than the original estimate of 16,431 fish. The 2012 fish report (Beamer et al. 2013b) concluded the best estimate of increased carrying capacity as a result of Fisher Slough restoration is 21,823 juvenile Chinook salmon annually, which is derived from the high carrying capacity estimate post-restoration (38,773 fish) minus the low carrying capacity estimate before restoration (16,950 fish).

The best estimate of changed carrying capacity is based on fish monitoring data and looking for consistency in the percentage of carrying capacity between the Skagit estuary and Fisher Slough for a given year. The percentage of carrying capacity is monitored fish population size divided by carrying capacity estimate. We believe this is a good approach because it considers how fish actually use the site in a given year.

Recommendation: Continue fish monitoring along with floodgate operation monitoring for several years without any additional restoration treatments to determine whether patterns observed in 2012 are consistent or spurious.

2.2.2 Hypothesis H9

Juvenile Chinook salmon will utilize restored channels and marshes at densities similar to other Skagit freshwater tidal marshes, adjusted for landscape connectivity.

Table H9-1. Summary of Fisher Slough juvenile Chinook salmon density results as a function of landscape connectivity within the Skagit River delta.

Parameter	Before WY2009	WY2009 Condition	WY2010 Condition	WY2011 Condition	WY2012 Condition	Restoration Target
Juvenile Chinook salmon: Seasonal density up- and downstream of floodgate and at reference sites	Not measured	Nine out of ten Fisher Slough monitoring sites were within the scatterplot of seasonal fish density and landscape connectivity for long-term Skagit delta monitoring sites (Beamer et al. 2010).	Three out of ten Fisher Slough monitoring sites were within the scatterplot of seasonal fish density and landscape connectivity for long-term Skagit delta monitoring sites (Beamer et al. 2011).	All but one Fisher Slough monitoring site located upstream of the floodgate fell outside (lower) the scatterplot of seasonal fish density and landscape connectivity for long-term Skagit delta monitoring sites (Beamer et al. 2013a).	All Fisher Slough monitoring sites were within the scatterplot of seasonal fish density and landscape connectivity for long-term Skagit delta monitoring sites (Beamer et al. 2013b).	Seasonal juvenile Chinook salmon densities within the Fisher Slough Restoration Project are not lower than seasonal juvenile Chinook salmon densities of other Skagit River tidal delta systems when adjusted for landscape connectivity.

Restoration target: Seasonal juvenile Chinook salmon densities within the Fisher Slough Restoration Project are not lower than seasonal juvenile Chinook salmon densities of other Skagit River tidal delta systems when adjusted for landscape connectivity.

Target met? Yes. The restoration target for Hypothesis 9 was achieved for sites upstream of the floodgate in 2012.

Landscape connectivity, or large-scale connectivity, refers to the relative distances and pathways that salmon must travel to find habitat over a very large area. As this concept is applied in the Skagit River delta, landscape connectivity is a function of both the distance and complexity of the pathway that salmon must follow to specific habitat areas (e.g., sites within Fisher Slough). Connectivity decreases as the complexity of the route the fish must swim increases and the distance the fish must swim increases. Within the delta, the complexity of the route fish must take to find habitat is measured by the distributary bifurcation order and distance traveled. Habitat that is less connected to the source of fish has lower densities of fish. By determining landscape connectivity to various sites, comparisons of juvenile Chinook salmon usage results from Fisher Slough with that of other sites throughout the Skagit River tidal delta can be made in order to determine whether Fisher Slough is functioning consistently with the rest of the Skagit River delta.

There is a positive relationship between seasonal wild juvenile Chinook salmon density and landscape connectivity for the long term monitoring sites throughout the Skagit River delta for

each of the four years when Fisher Slough monitoring has occurred (Figure H9-1). This positive relationship is expected and is useful to help determine whether juvenile Chinook salmon use of habitat in Fisher Slough is consistent with natural tidal habitat located throughout the Skagit delta.

Before floodgate replacement (year 2009) the Fisher Slough monitoring sites generally clustered within the scatter of the Skagit River long term monitoring sites. In both years after floodgate replacement, most Fisher Slough sites located upstream of the floodgate fell outside (lower) of the scatter of the Skagit River long term monitoring sites. In contrast, the Fisher Slough sites located downstream of the floodgate are clustered within the scatter of the Skagit River long term monitoring sites. Figure H9-1 graphically displays the weight of evidence from the long-term Skagit River delta monitoring sites, suggesting juvenile Chinook salmon use of Fisher Slough upstream of the floodgate was disrupted from the normal pattern observed at all other Skagit sites after the floodgate was replaced and before dike setback occurred. In contrast, scatter plot results from 2012 (Figure H9-1, panel D) show that Fisher Slough sites (both up- and downstream of the floodgate) are within the norm of the Skagit landscape connectivity function, suggesting there was no disruption at the site of the floodgate in 2012 after completion of dike setback restoration.

Recommendation: Continue fish monitoring along with floodgate operation monitoring for several years without any additional restoration treatments to determine whether patterns observed in 2012 are consistent or spurious.

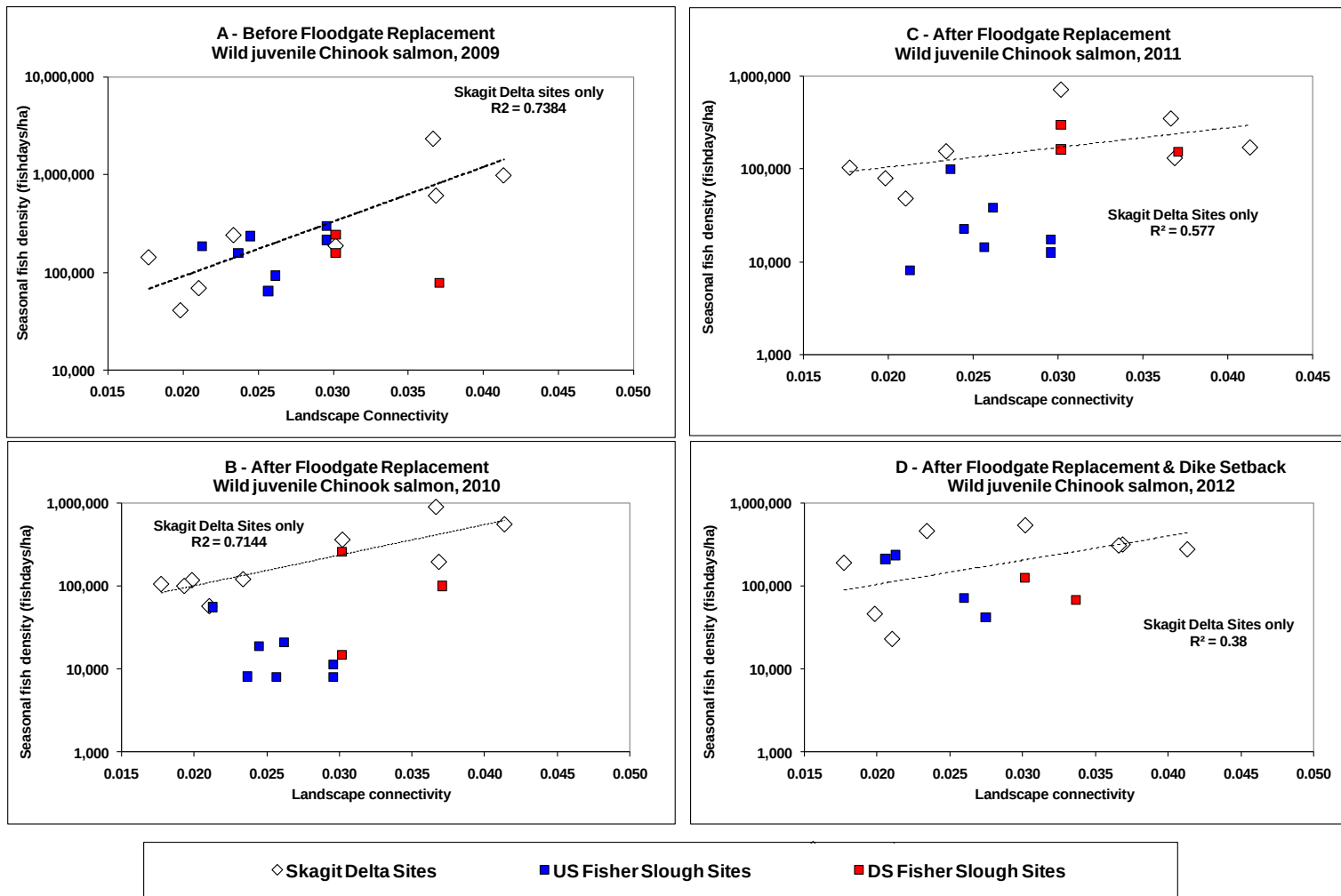


Figure H9-1. Relationship between landscape connectivity and seasonal Chinook salmon density for Skagit River delta long-term monitoring sites and Fisher Slough monitoring sites, 2009 through 2012. All panels show connectivity calculated to Fisher Slough sites based on fish migration pathways using the downstream end of Tom Moore Slough (avoiding the current log jam at the north end of Tom Moore).

2.3 Objective 3

Restore passage for coho and chum salmon spawning access.

2.3.1 Hypothesis H10

Floodgate operation will improve fish passage opportunity for coho and chum compared to pre-project conditions.

Table H10-1. Floodgate operation metrics.

Parameter	Before WY2009	WY2009 Condition	WY2010 Condition	WY2011 Condition	WY2012 Condition	Restoration Target
Number of days floodgates are open from October 1 to February 28 or 29.	Gates were open f34% of the time during the fall of 2006 (Tetra Tech 2008).	Not measured	Not measured	At least one of three floodgate doors was open on 143 of 151 days (Oct 1-Feb 28).	At least one of three floodgate doors was open on 121 of 121 days Nov 1, 2011 to Feb 29, 2012 when no restoration construction was occurring.	After floodgate replacement, gates open at least once per day October to February 28 or 29.

Hypothesis 10 is related to improving upstream passage of adult coho and chum salmon during fall and winter to spawning areas located in tributaries upstream of the Fisher Slough Restoration Project. We used floodgate door opening data to test this hypothesis (Table H10-1). The floodgate had been disengaged during all of October 2011 due to the completion of the restoration construction and did not open for twenty days that month. Otherwise, the restoration target for Hypothesis 10 was met.

Restoration target: Gates open at least once per day October to February 28 or 29.

Target met? Yes. During the time period when there was no restoration construction occurring and the floodgate operated normally, the doors were open at least once per day. The floodgate was disengaged from October 1 through October 30 for the completion of restoration construction. During that time, the doors were open eleven days.

2.3.2 Hypothesis H11

Removal of the passage barrier at Big Ditch will result in more natural channel profile through this area.

Table H11-1. Big Ditch channel metrics.

Parameter	Before WY2009	WY2009 Condition	WY2010 Condition	WY2011 Condition	WY2012 Condition	Restoration Target
Longitudinal channel profile of Fisher Slough at Big Ditch crossing.	Not measured	Not measured	Not measured; assumed the same as 'before removal' RTK GPS survey of 2011.	'Before removal' RTK GPS survey found mean sill height was 1.5 ft higher than upstream and downstream streambed.	Sill no longer present; some mild channel aggradation upstream and downstream.	By 2015, passage barrier (sill) at Big Ditch can no longer be seen in channel profile.
Mean water depth of Fisher Slough at Big Ditch crossing.	Not measured	Not measured	Average 2.05 ft deep during adult coho and chum upstream migration period (Oct 1 – Dec 31, 2009).	Average 1.81 ft deep during adult coho and chum upstream migration period (Oct 1 – Dec 31, 2010).	Average 2.83 ft deep during adult coho and chum upstream migration period (Oct 1 – Dec 31, 2011).	Mean water depth at crossing increases after passage barrier at Big Ditch is removed.

Hypothesis 11 is related to improving upstream passage of adult coho and chum salmon to spawning areas located in tributaries upstream of the Fisher Slough Restoration Project. Two metrics (stream bed elevation and water depth) were identified in the MAMP (Parametrix 2010) to test this hypothesis (Table H11-1).

2.3.2.1 Longitudinal channel profile at Big Ditch Crossing

Restoration target: By 2015, passage barrier (sill) at Big Ditch can no longer be seen in channel profile.

Target met? Yes. The passage barrier has been removed.

Part of the restoration project involved removing the siphon that allowed Big Ditch to cross under Fisher Slough. This siphon formed a sill in the Fisher Slough channel that was considered a fish passage barrier. A longitudinal channel profile was measured in 2011 and 2012, before and after the sill was removed, using an RTK-GPS (Figure H11-1). In 2011, survey point spacing averaged 1.0 ft on top of the sill and 2.3 ft for areas up and downstream of the sill. In 2012, survey point spacing averaged 3.1 ft throughout the surveyed profile. The survey line followed the thalweg of the channel in both years, except where the thalweg was indistinguishable, in which case the channel center line was surveyed. The gap in survey points immediately downstream of the sill was a continuation of a scour hole (part of which can be seen in Figure H11-2) that exceeded the depth of the instrument's pole and therefore was not surveyed.

In 2011, average elevation of the sill before removal was 5.51 ft NAVD88. The highest point on the sill was 5.82 ft NAVD88 (Figure H11-2). Average streambed elevation (not including scour hole and points surveyed near the scour hole) upstream and downstream of the sill was 3.9 and 4.2 ft NAVD88, respectively. After sill removal the Fisher Slough profile deepened significantly (up to 2.3 ft) where the

siphon was removed. In 2012, average elevation of the channel where the sill was removed was 3.72 ft NAVD88, while the highest point was 4.23 ft NAVD88. However, upstream and downstream of the removed siphon the channel shoaled by an average of 0.26 ft and 0.39 ft, respectively (two-sample t-test, $p < 0.0001$ for both locations). The deep hole immediately downstream of the siphon remains, but was better characterized this year due to greater accessibility as a result of lower river levels. Nevertheless, a portion of this hole was still too deep to survey with the RTK-GPS.

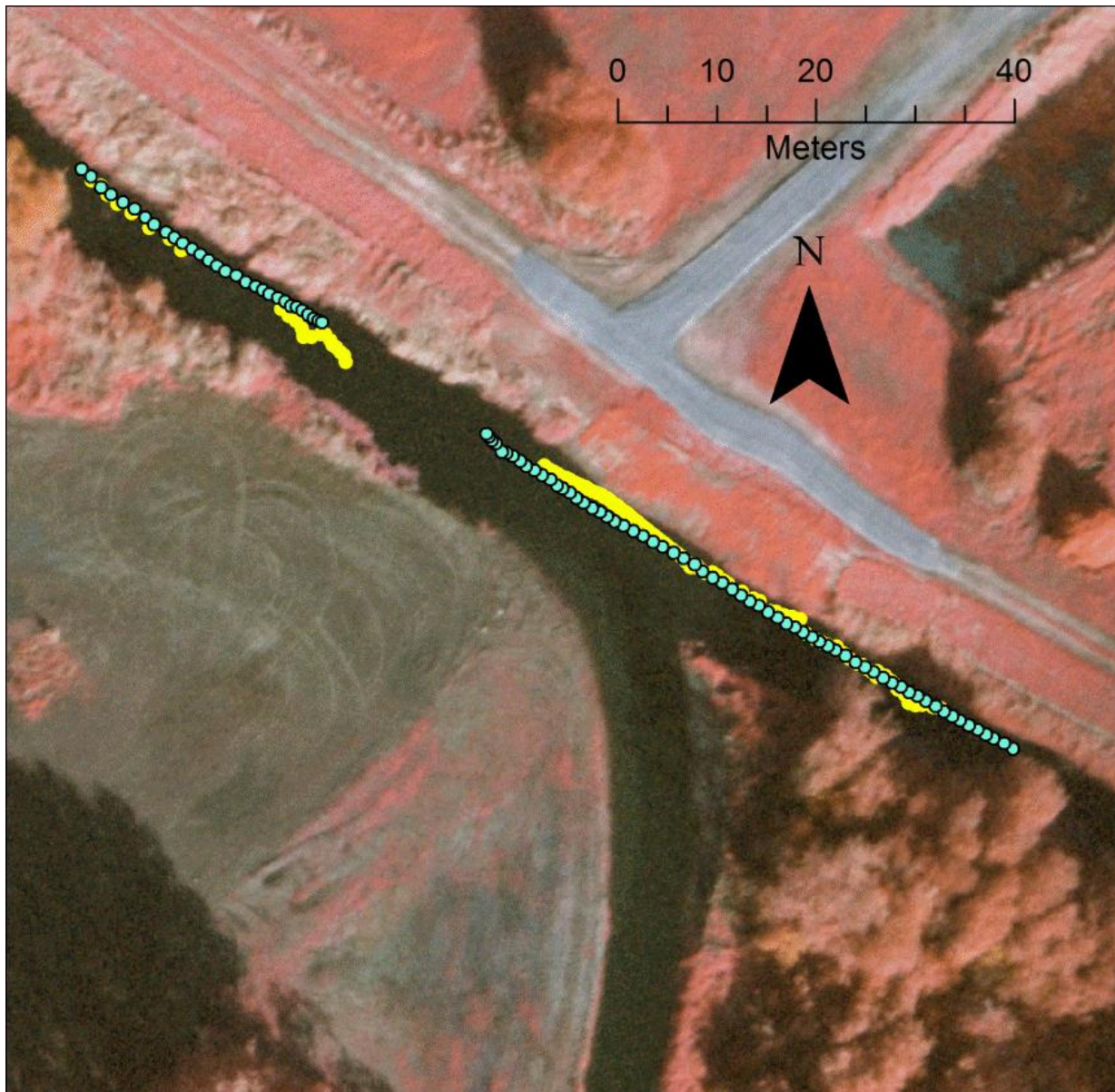


Figure H11-1. Location of 2011 (yellow points) and 2012 (blue points) profiles in Fisher Slough in the area of the old Big Ditch siphon. Surveys were conducted with an RTK-GPS Rover. The gaps in points in the middle of the surveys represent areas where the channel was too deep to survey.

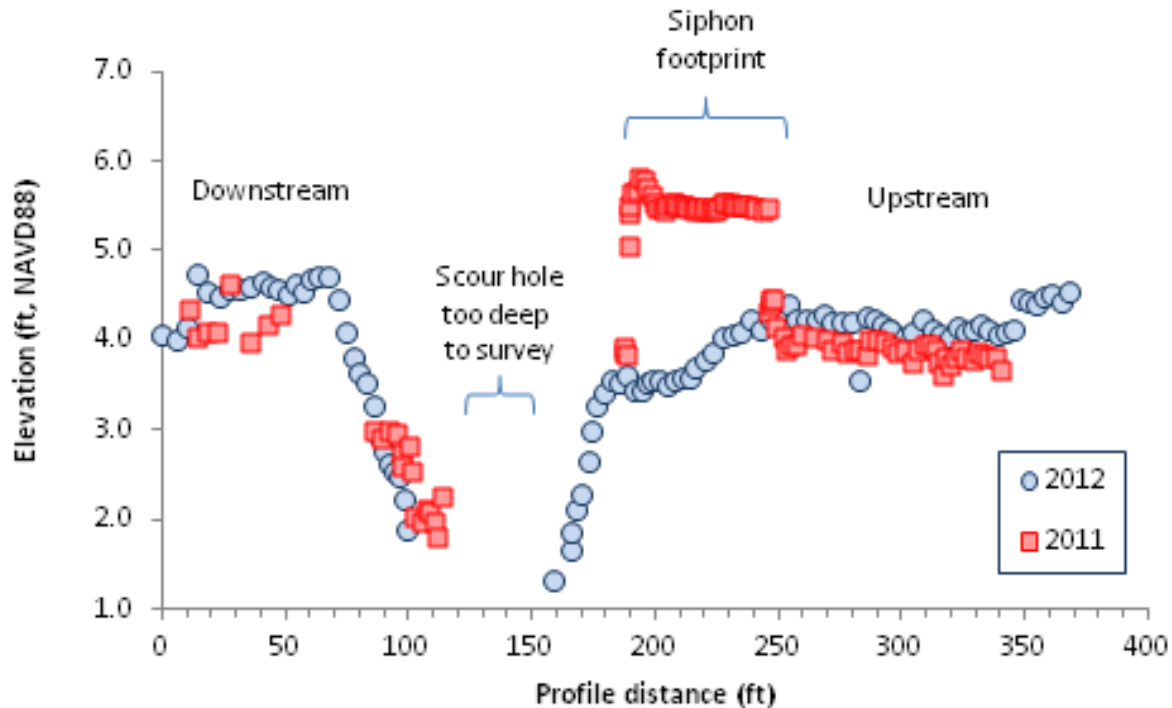


Figure H11-2. Fisher Slough profile in 2011 vs. 2012, before and after siphon removal. Note: a deep scour hole is present during both years, while the high sill is absent in 2012.

2.3.2.2 Mean water depth at Big Ditch Crossing

Before Concrete Sill Removal - We previously calculated water depth by subtracting maximum sill elevation from WSE results collected by the Solinst logger located just upstream of the old siphon. The highest streambed elevation (5.82 ft NAVD88) before the concrete sill was removed was located on the downstream end of the sill (Figure H11-2). Average WSE from the Solinst data logger for this area of Fisher Slough during the time when adult coho and chum salmon migrate upstream (October 1 through December 31) was 7.87 and 7.63 ft NAVD88 in WY2010 and WY2011, respectively. Therefore, average water depth in the shallowest location of the long profile was 2.05 and 1.81 ft before concrete sill removal, depending on year (Figure H11-3). In WY2012, following siphon removal, the highest stream bed elevation in the footprint of the former sill was 4.23 ft NAVD88, while the mean WSE from October 1 through December 31, 2011 was 7.06 ft NAVD88. Thus, the mean water depth above the highest point in the footprint of the removed siphon was 2.83 ft.

Restoration target: Mean water depth at crossing increases after passage barrier at Big Ditch is removed.

Target met? Yes, mean water depth in WY2012 increased by 0.78 ft relative to WY2010 and 1.02 ft relative to WY2011. For each water year, water depth was measured relative to the highest points on the channel profile over the sill location, because they represented the maximum potential for fish migration barriers during low flow.

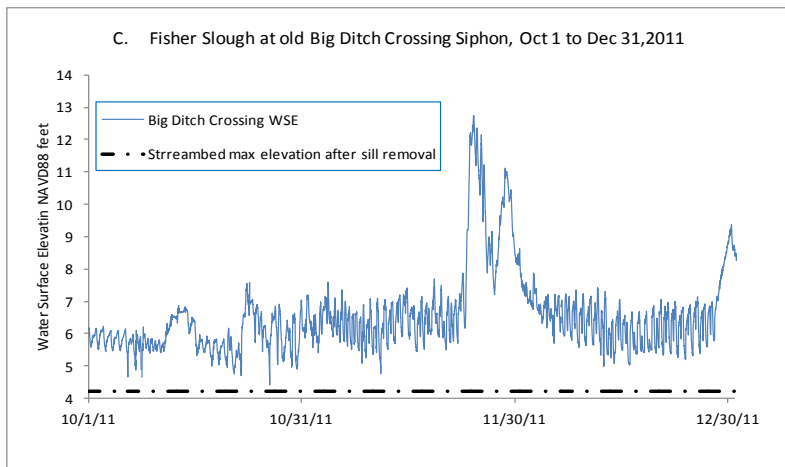
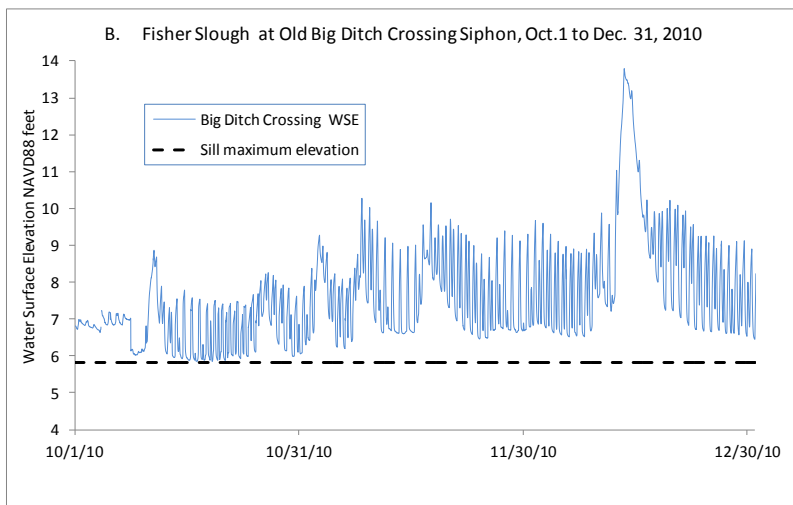
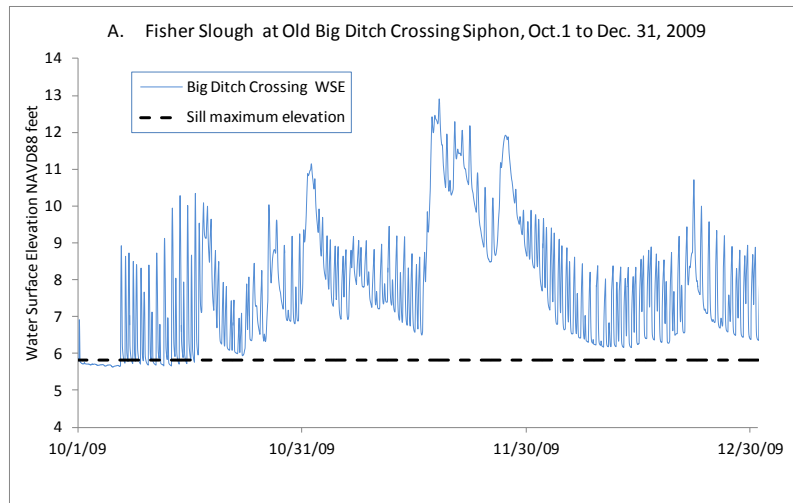


Figure H11-3. Maximum streambed elevation at the Big Ditch inverted siphon (dashed line) plotted against WSE from Oct. 1 through Dec. 31, 2009 (WY2010, panel A) and the same period in 2010 (WY2011, panel B). Maximum streambed elevation at the former Big Ditch inverted siphon following siphon removal is plotted against WSE from Oct. 1 through Dec. 31, 2011 (WY2012, panel C).

2.4 Objective 4

Improve flood storage and protect adjacent farm uses.

2.4.1 Hypothesis H12

Levee setback and restoration of tidal exchange will result in 310 acre-feet available for flood water storage (i.e., greater floodplain and channel area) during high flows.

Table H12-1. Flood storage metrics.

Parameter	Before WY2009	WY2009 Condition	WY2010 Condition	WY2011 Condition	WY2012 Condition	Restoration Target
Change in flood storage capacity	64 acre-feet of storage (Tetra Tech 2009a).	64 acre-feet of storage (Tetra Tech 2009a).	Under construction, not measured.	309 acre-feet of storage* (PSE 2011).	309 acre-feet of storage (PSE 2011).	At least 247 acre-feet of new flood storage (about 310 acre-feet total).

*The calculation of 2011 flood storage was made in November 2011, following the completion of construction. Though construction was completed at the start of WY2012 and thus the increased flood storage area was not available in WY2011, we include it in the WY2011 Condition because the calculation is a required deliverable for 2011 reporting.

New surveys were not done for this hypothesis in 2012, even though the calculation for WY2011 conditions was done in November 2011 (technically a part of WY2012). This metric will not be reassessed in the future, so these results are final. The text below is reported from the 2011 monitoring report (Beamer et al. 2012).

Prior to any restoration work at Fisher Slough, the existing channels and marshes had a flood storage capacity of approximately 64 acre-feet (Figure H12-1). The original, pre-project flood storage volume was calculated starting at the muted tidal peak (MHHW) elevation of 8.8 feet up to the spillway elevation of 14.0 feet. Flooding is a concern for adjacent landowners during the heavy rain months in winter and during snow melt in spring and early summer.

Restoration Target: At least 247 acre-feet of new flood storage (about 310 acre-feet total). Adjustments to the project design after the original restoration target was calculated revised this target by approximately 2 acre-feet (down to 245).

Target Met? Based on the post-restoration as-built diagram with elevation TIN, the flood storage available between 8.8 feet and 14 feet elevation is estimated at 309.1 acre-feet of water storage at the restored site. This is a 245 acre-feet increase in flood storage capacity compared to the pre-project storage of 64 acre-feet – almost a four-fold increase (Figure H12-1). Water storage is in created channels and excavated marsh areas of the floodplain. Project design changes implemented after the restoration target was calculated resulted in a decrease of final flood storage area by 2 acre-feet compared to the predicted outcome. The adjusted restoration target was met.

Section 3: Recommendations

This section lists recommendations that are deviations, modifications, or clarifications from the current monitoring plan.

Hypothesis 2 Recommendations

2.1.2.1. Dissolved oxygen: Protective cages should be installed around the standpipes housing the DO probes to help keep floating green algae and detritus away from the probes. This should be done at the Upper Main Channel site and in the three blind channel lobes. The DO sites Upstream Floodgate and Downstream Floodgate did not have major problems and will not need the protective cages. Desiccant packs should be added to each DO logger housing in order to help prevent moisture damage to the data control box. All four loggers should be calibrated by INW prior to deployment in 2013. We recommend continuing comparison of DO levels measured during SRSC's fish monitoring to DO levels recorded by the continuous-reading loggers.

Hypothesis 3 Recommendations

2.1.3.2. Water level elevations: This target is related to vegetation and is covered under Hypothesis 5, and should be removed as a target under Hypothesis 3.

2.1.3.4. Number of days or percent period project is inundated: The recommendation is to make one of two possible changes:

1) We suggest this restoration target, as written, is not quantitative and is covered by the remaining three targets for this Hypothesis, and therefore should be removed,

or

2) We suggest changing the language of this restoration target to use data recorded by the water elevation loggers deployed in the blind channel areas to calculate the inundation time period when the WSE is greater than or equal to 9.5 feet NAVD88.

Hypothesis 6 Recommendations

2.1.6.2. RCG elevation: The measurement parameter 'Mean elevation of RCG on the site' is inappropriately linked to the target 'Reduced RCG density at all elevation ranges'. One cannot infer density from measurement of elevation. Either the parameter or the goal should be changed.

Hypothesis 7 Recommendations

2.1.7.1. Channel area: Future monitoring should involve a combination of aerial photo analysis of channel planforms and RTK-GPS surveys of channel cross-sections and profiles, including locating areas of active channel head-cutting. LiDAR surveying will likely be problematic for channel measurement because LiDAR does not penetrate water well.

Hypothesis 8 Recommendations

2.2.1.1 Juvenile Chinook salmon density as a function of floodgate replacement: Continue fish monitoring along with floodgate operation monitoring for several years without any additional restoration treatments to determine whether patterns observed in 2012 are consistent or spurious.

Hypothesis 9 Recommendations

2.2.2.1 Juvenile Chinook salmon density as a function of landscape connectivity: Continue fish monitoring along with floodgate operation monitoring for several years without any additional restoration treatments to determine whether patterns observed in 2012 are consistent or spurious.

Appendix A Recommendations

Groundwater: When the logger at GW1-Smith has been removed from the groundwater well for data downloads there has been a varnished color observed on the logger either from iron or tannins in the water. This logger is more discolored than the other two loggers. It is possible the contacts on this logger are fouled, thereby providing inaccurate data, and the logger needs replacing. Comparisons of spot measurements to data logger-recorded elevations at this site have been off by more than two feet in both WY2011 (Beamer et al. 2012) and WY2012. It is suggested this logger be replaced with a new logger.

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Appendix A – Groundwater Data

Groundwater elevations are not related to project objectives and hypotheses, but there is an interest in tracking groundwater elevations at several locations before, during and after the restoration project due to concerns about effects on neighboring farmland. Groundwater elevations are plotted over time and are used as a descriptive indicator to identify whether there is a need in the future for additional groundwater monitoring. Determining what factors groundwater elevations are responding to would require more extensive sampling than is currently planned.

The water elevation at groundwater wells was monitored at three locations within the Fisher Slough restoration area (Figure A1). Data from these loggers were downloaded on a bi-monthly schedule in WY2012 (October 2011, December 2011, February 2012, April 2012, June 2012, and August 2012). The installation and download methods are detailed in Parametrix (2010).

The groundwater elevation data for Water Year 2012 are plotted by the floodgate management periods in Figures A2 through A4 and by the month in Figures A5 through A16. The monthly average, maximum and minimum groundwater elevations are given in Table A1.

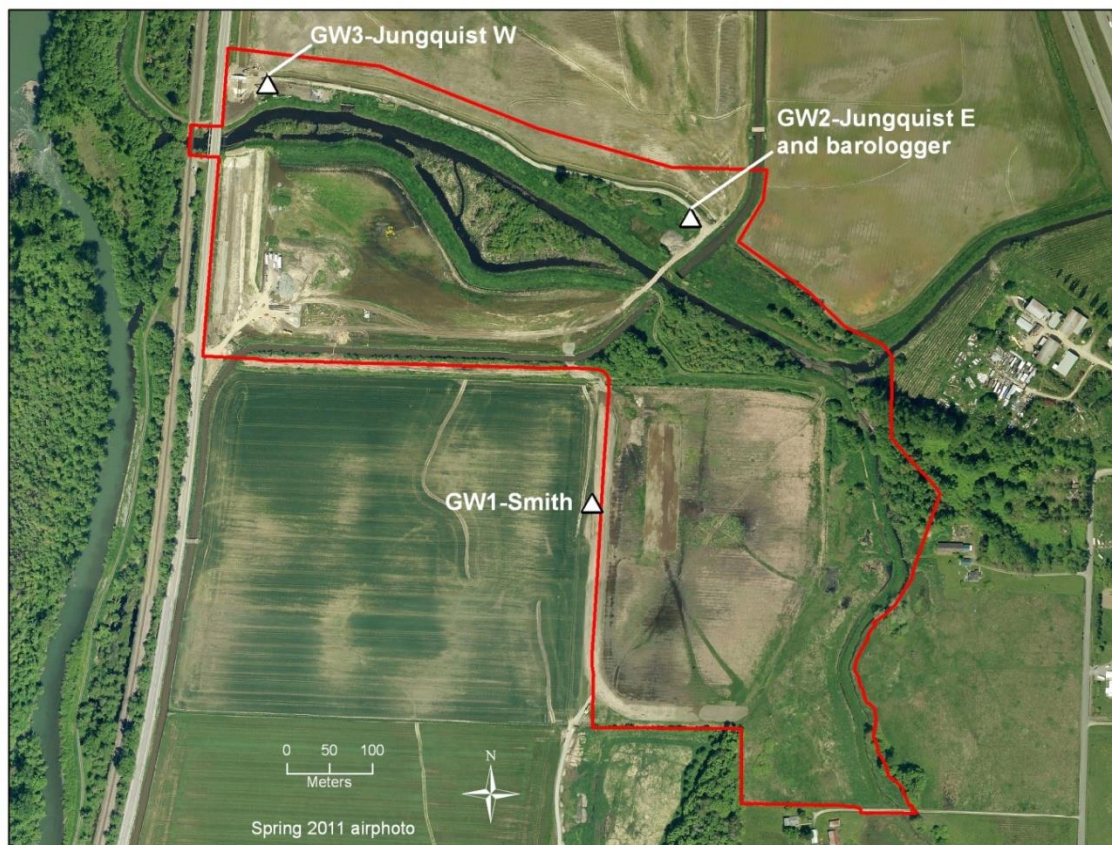


Figure A1. Location of groundwater wells and barometric pressure logger (barologger) at the Fisher Slough restoration area. Project area is outlined in red.

General Observations

The restoration construction for Project Element 3 ended in October 2011. The water level at GW1-Smith was low and varied from 0.7 to 4 feet NAVD88 during the month. The water levels at GW2-Jungquist E and GW3-Jungquist W varied from 2 and 5 feet NAVD88 (Figure A6). Once the floodgate was engaged at the end of the construction project and the area filled up with water, the groundwater level at increased. All three sites had increases in ground water level starting October 22. In November the water level increased to around 5 to 6 feet NAVD88 at all three sites by the end of the month (Figure A6). The level at GW3-Jungquist W was about one foot lower than the levels at the other two sites for most of the remainder of the year.

The top of the well cases at GW1-Smith and GW3-Jungquist W are at elevations of 7.25 and 7.3 feet NAVD88, respectively. During the third week of November 2011, and in January and February 2012, the groundwater at these two sites was almost to the surface of the ground (Figure A2). The well case at GW2-Jungquist E was slightly higher at 8.38 feet NAVD88 and the groundwater never reached the surface there.

A decrease in the ground water levels was seen starting in March 2012 at all sites. By the end of September the groundwater level varied from 2 to 4 feet NAVD88 at all sites (Figure A3).

Table A1. Monthly average, maximum and minimum of groundwater elevations at the three well sites at Fisher Slough in WY2012.

Date	GW1-Smith			GW2-Jungquist E			GW3-Jungquist W		
	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
Oct-11	2.23	0.65	4.28	3.81	2.40	5.24	3.38	1.89	4.98
Nov-11	5.10	2.44	7.81	5.19	3.04	7.91	4.60	2.49	6.73
Dec-11	5.29	4.03	6.27	4.94	3.71	5.92	4.34	3.11	5.35
Jan-12	5.87	5.27	6.98	5.45	4.73	7.00	4.81	4.25	5.90
Feb-12	6.07	5.43	7.21	5.87	5.08	7.48	5.05	4.32	6.30
Mar-12	6.15	5.51	6.99	6.19	5.48	7.22	5.01	4.47	5.92
Apr-12	5.89	5.34	6.72	5.60	5.10	6.17	4.72	4.09	5.24
May-12	5.98	5.47	6.70	5.40	4.81	6.55	4.61	3.94	5.41
Jun-12	6.19	5.53	6.93	5.05	4.70	5.63	4.66	4.13	5.24
Jul-12	6.19	5.25	6.97	5.11	4.59	5.69	4.54	3.76	5.23
Aug-12	4.64	4.22	5.35	4.22	3.77	4.73	3.39	3.12	3.89
Sep-12	3.90	3.57	4.37	3.11	2.62	3.83	2.61	1.96	3.33

Spot Measurements and Surveys

Spot measurements of the groundwater level were made during the data download of the loggers using a Solinst Water Level Meter Model 101. The distance from the top of the well casing to the water level inside the well was measured and compared to the level recorded by the submerged data logger.

At GW2-Jungquist E the difference between the data logger and the spot measurements varied from 0.07 to 0.99 feet, while at GW3-Jungquist W the difference varied from 0.04 to 0.40 feet. These values are shown in Table A2.

The data logger at GW1-Smith varied with the spot measurements more than did the other two loggers. On December 6, 2011 the field-measured water level varied by just over two feet from the level recorded by the logger. During the other five spot measurements, the difference varied from 0.14 to 1.79 feet.

The greatest difference between the data logger and the spot measured groundwater elevations occurred at all three sites on December 6, 2011. The weather that day was cold with localized surface

water ice observed in the new blind channel area near the historic Big Ditch area. It is unknown if this weather phenomenon lead to problems in the data values of the loggers.

Recommendation: When the logger at GW1-Smith has been removed from the groundwater well for data downloads there has been a varnished color observed on the logger either from iron or tannins in the water. This logger is more discolored than the other two loggers. It is possible the contacts on this logger are fouled, thereby providing inaccurate data, and the logger needs replacing. Comparisons of spot measurements to data logger-recorded elevations at this site have been off by more than two feet in both WY2011 (Beamer et al. 2012) and WY2012.

It is suggested this logger be replaced with a new logger.

Table A2. Groundwater elevation determined by spot measurements versus data logger-recorded elevations at Fisher Slough in WY2012.

Site	Date	Time	WSE NAVD88 feet (logger)	WSE NAVD88 feet (spot measurement)	difference (feet)
GW1-Smith	10/6/11	10:15	2.04	1.53	0.51
GW1-Smith	12/6/11	13:30	4.85	2.73	2.12
GW1-Smith	2/2/12	13:45	6.07	4.28	1.79
GW1-Smith	4/2/12	13:30	5.83	4.58	1.25
GW1-Smith	6/6/12	6:15	6.05	4.81	1.24
GW1-Smith	8/7/12	14:00	4.94	5.08	-0.14
GW2-JungquistE	10/6/11	11:15	3.76	3.29	0.47
GW2-JungquistE	12/6/11	14:45	4.42	5.41	-0.99
GW2-JungquistE	2/2/12	15:00	5.93	5.71	0.22
GW2-JungquistE	4/2/12	12:45	5.93	5.81	0.12
GW2-JungquistE	6/6/12	7:15	4.98	4.90	0.07
GW2-JungquistE	8/7/12	16:00	4.27	4.20	0.07
GW3-JungquistW	10/6/11	10:30	3.16	3.20	-0.04
GW3-JungquistW	12/6/11	14:15	3.98	4.38	-0.40
GW3-JungquistW	2/2/12	14:15	5.10	5.30	-0.20
GW3-JungquistW	4/2/12	12:15	4.81	5.00	-0.19
GW3-JungquistW	6/6/12	7:45	4.35	4.29	0.06
GW3-JungquistW	8/7/12	13:30	3.55	3.57	-0.02

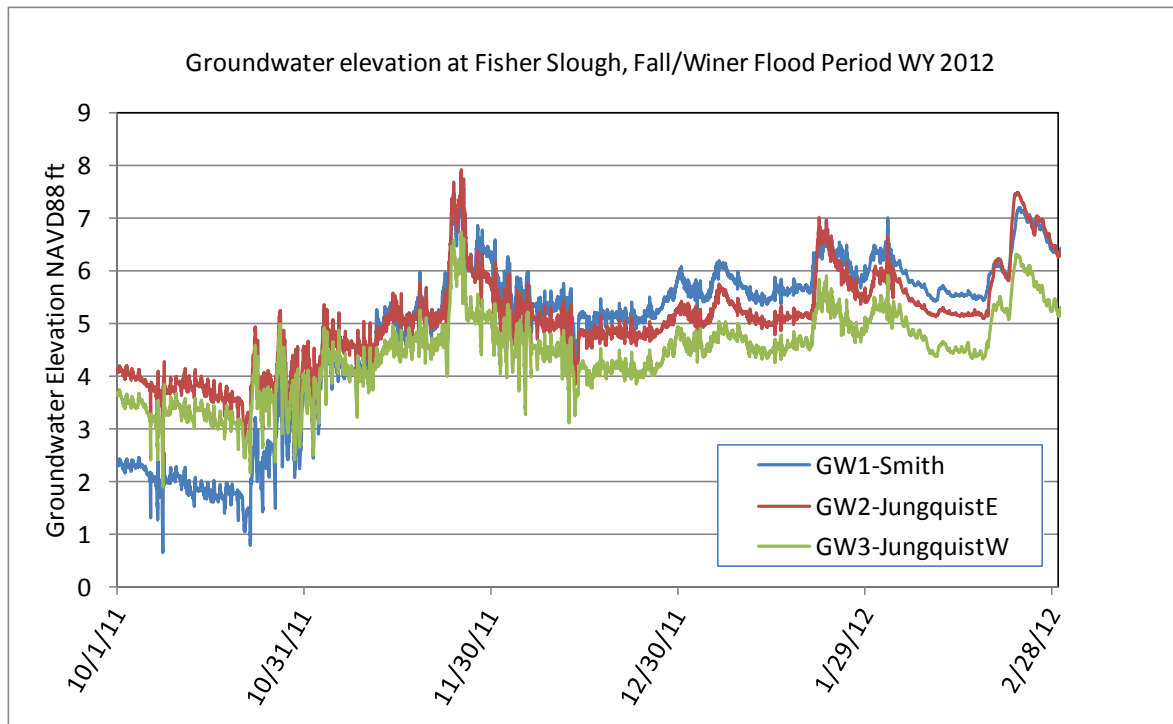


Figure A2. Groundwater elevation graph for the Fall/Winter Flood Period of WY2012.

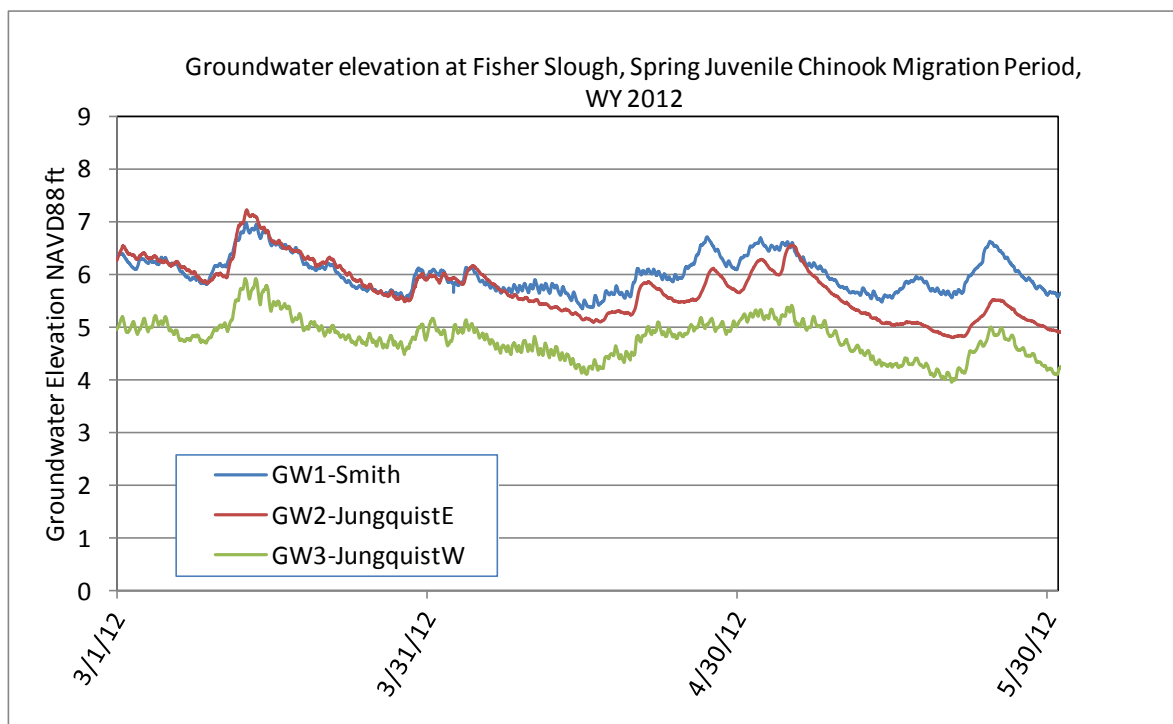


Figure A3: Groundwater elevation graph for the Spring Juvenile Chinook Migration Period of WY2012.

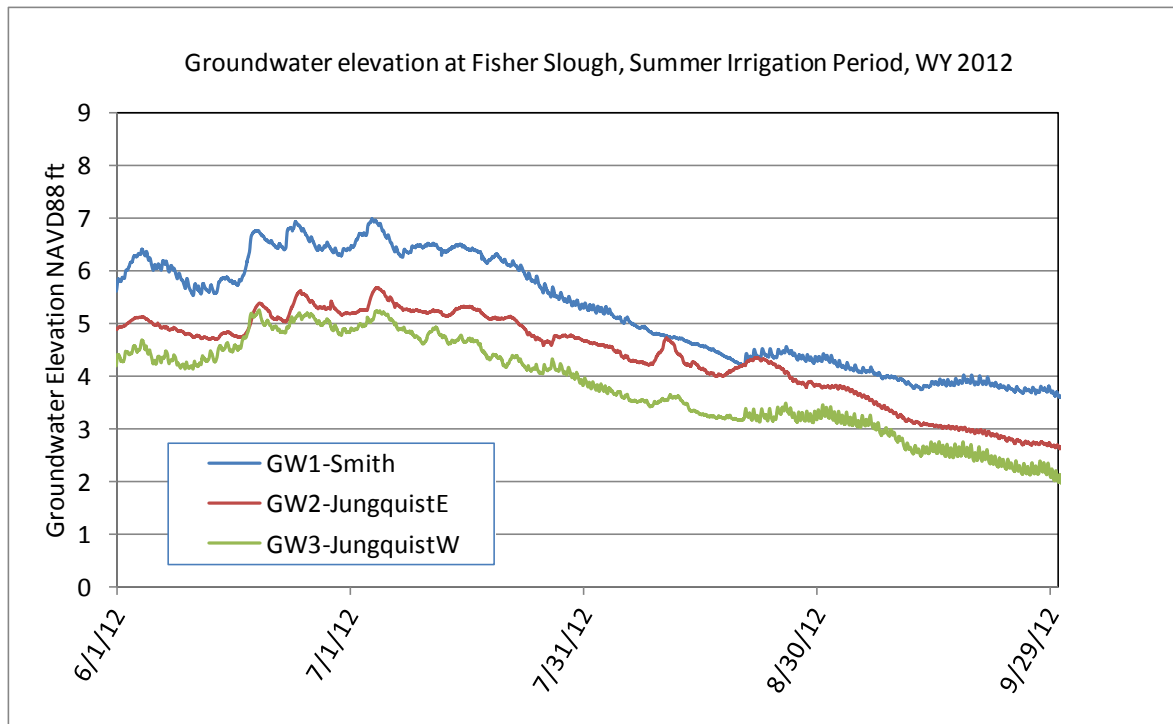


Figure A4: Groundwater elevation graph for the Summer Irrigation Period of WY2012.

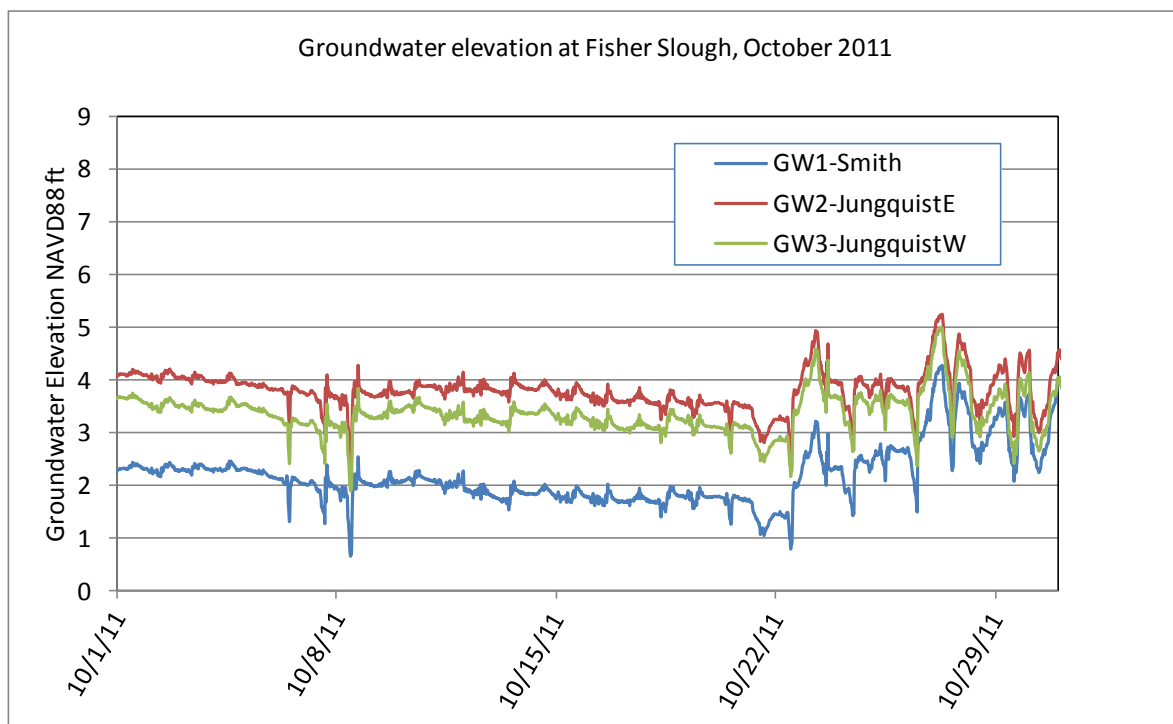


Figure A5. Groundwater elevation graph for October 2011.

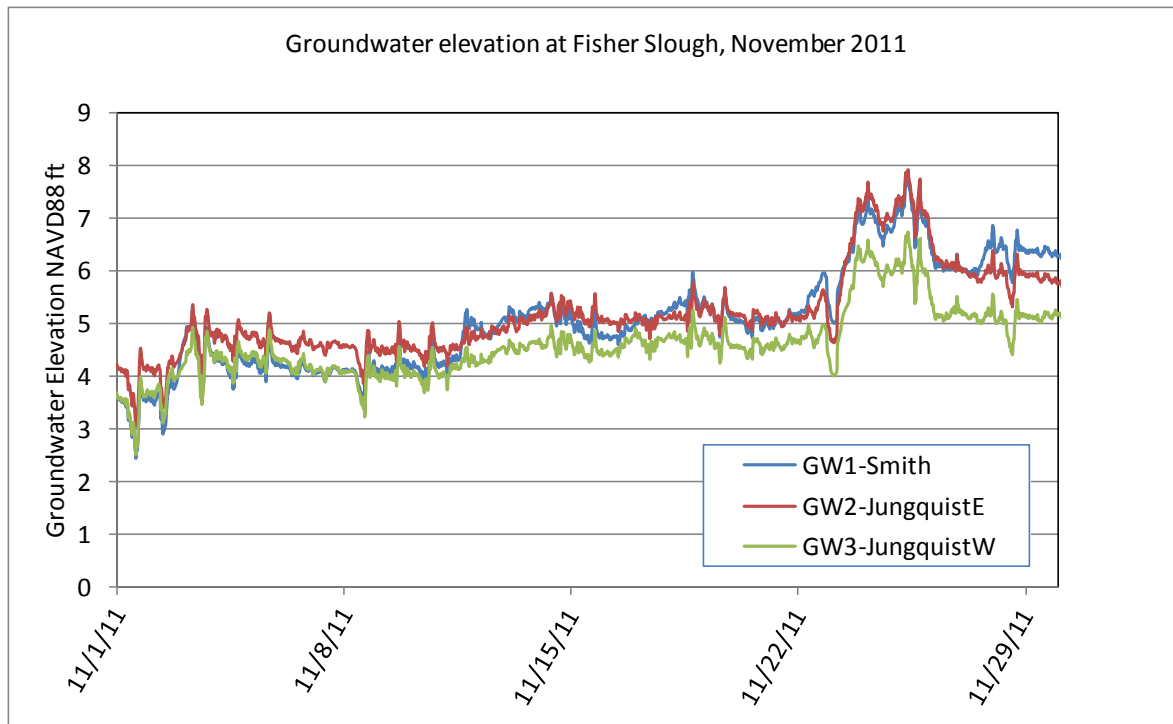


Figure A6. Groundwater elevation graph for November 2011.

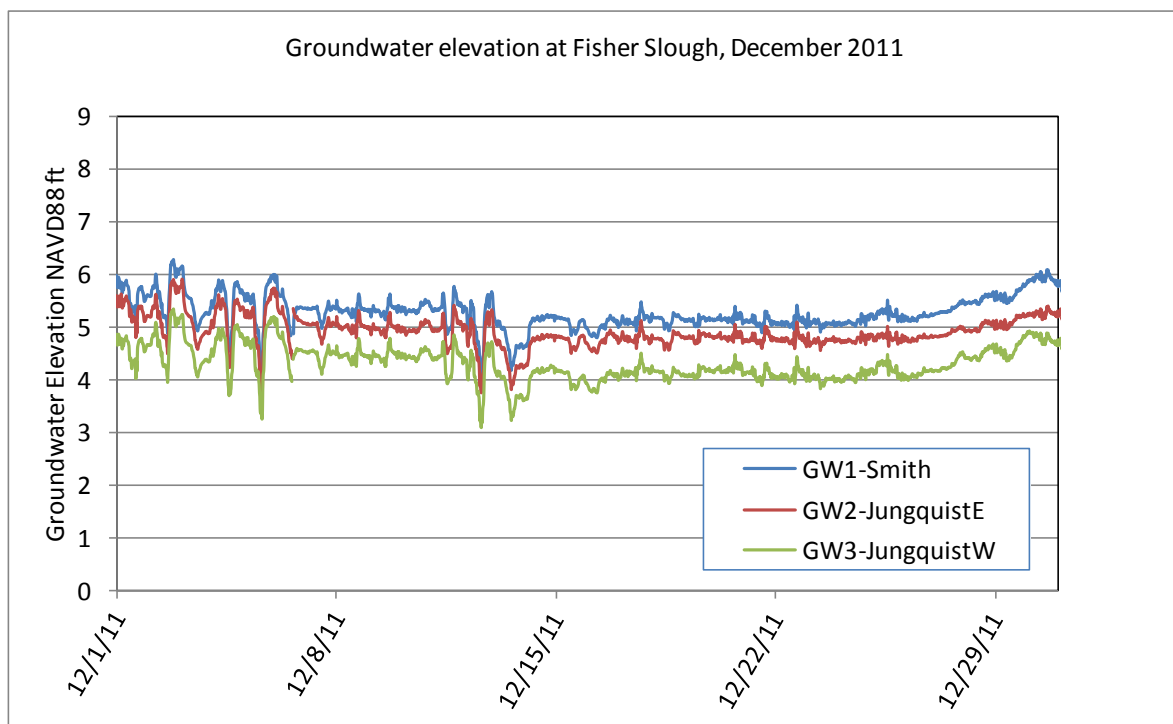


Figure A7. Groundwater elevation graph for December 2011.

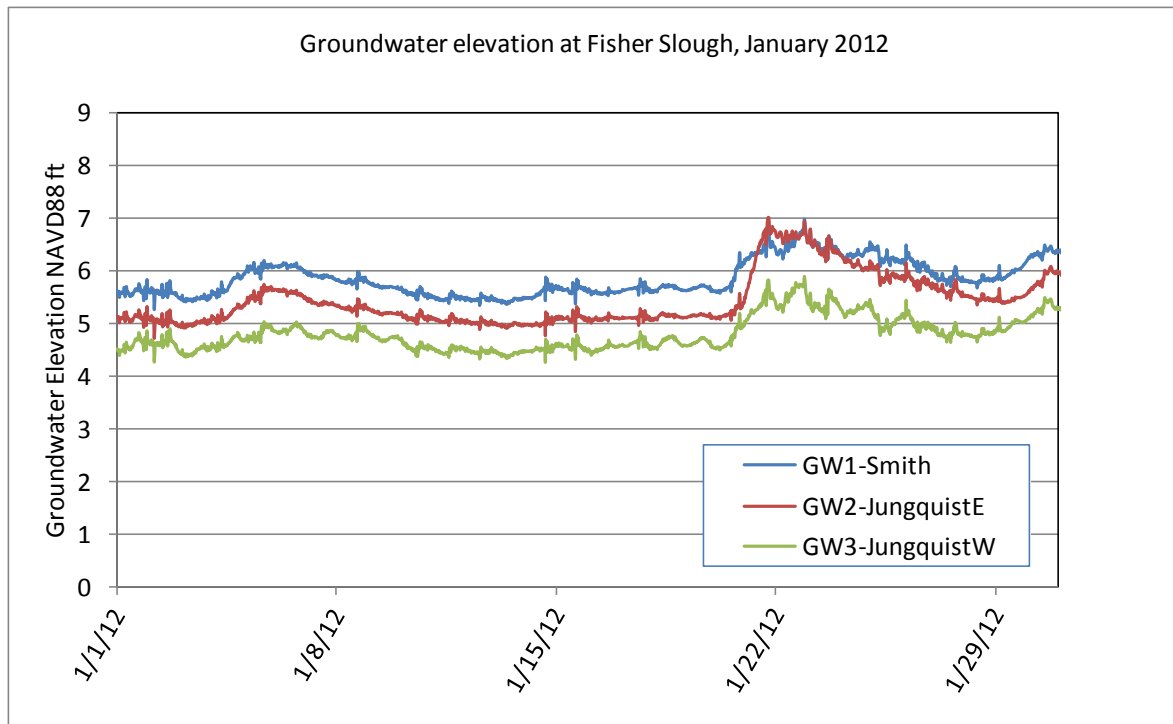


Figure A8. Groundwater elevation graph for January 2012.

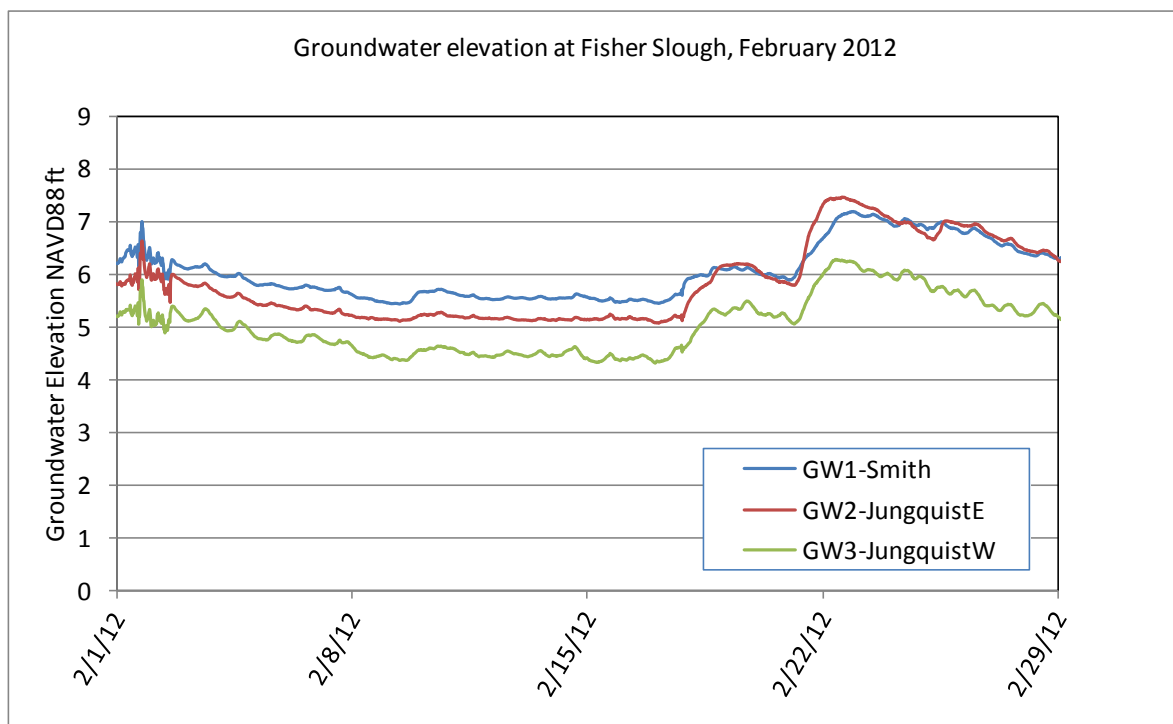


Figure A9. Groundwater elevation graph for February 2012.

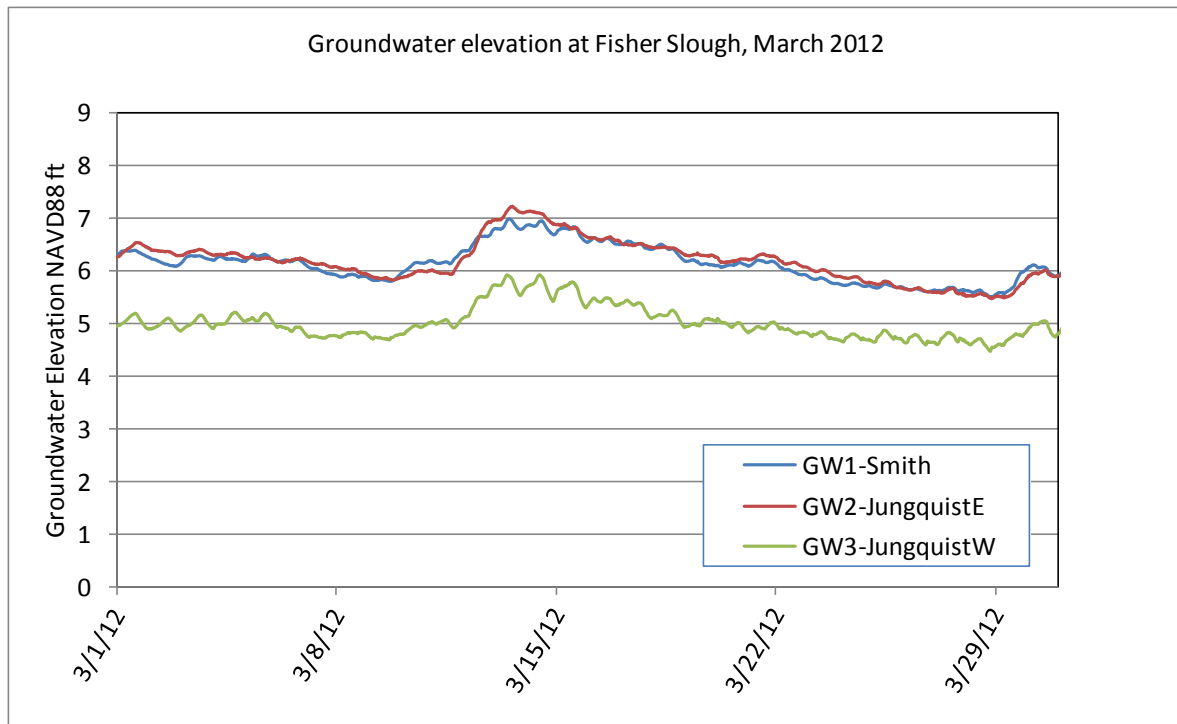


Figure A10. Groundwater elevation graph for March 2012.

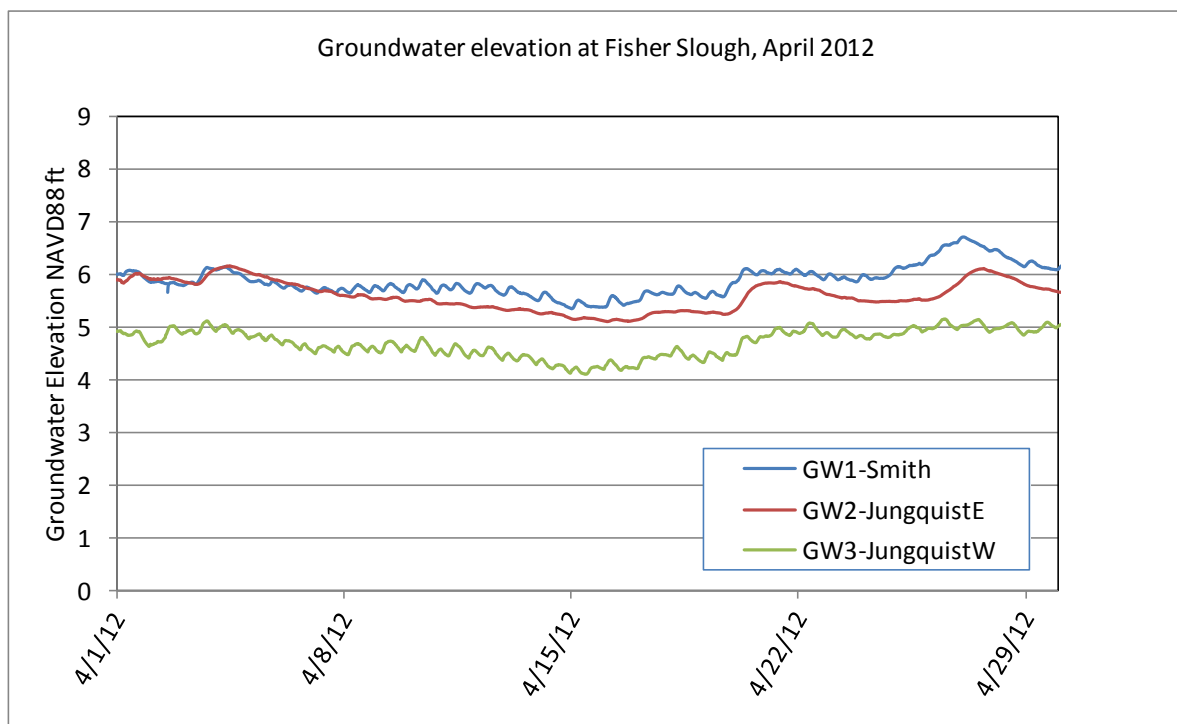


Figure A11. Groundwater elevation graphs for April 2012.

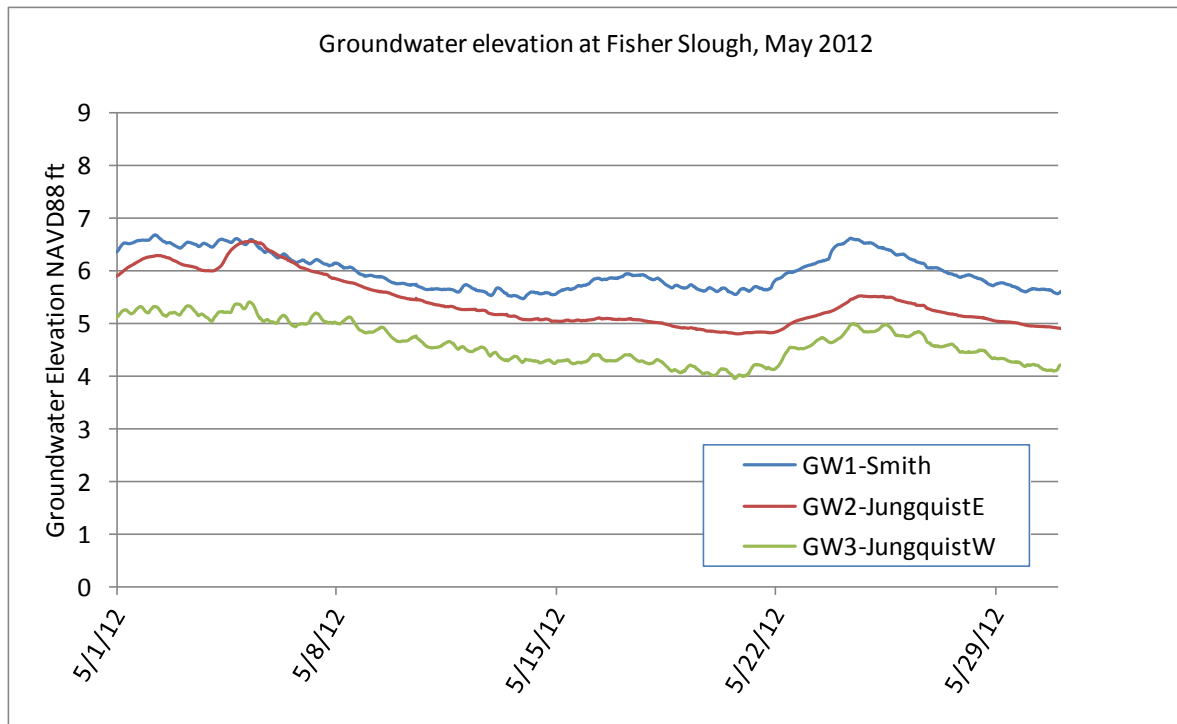


Figure A12. Groundwater elevation graph for May 2012.

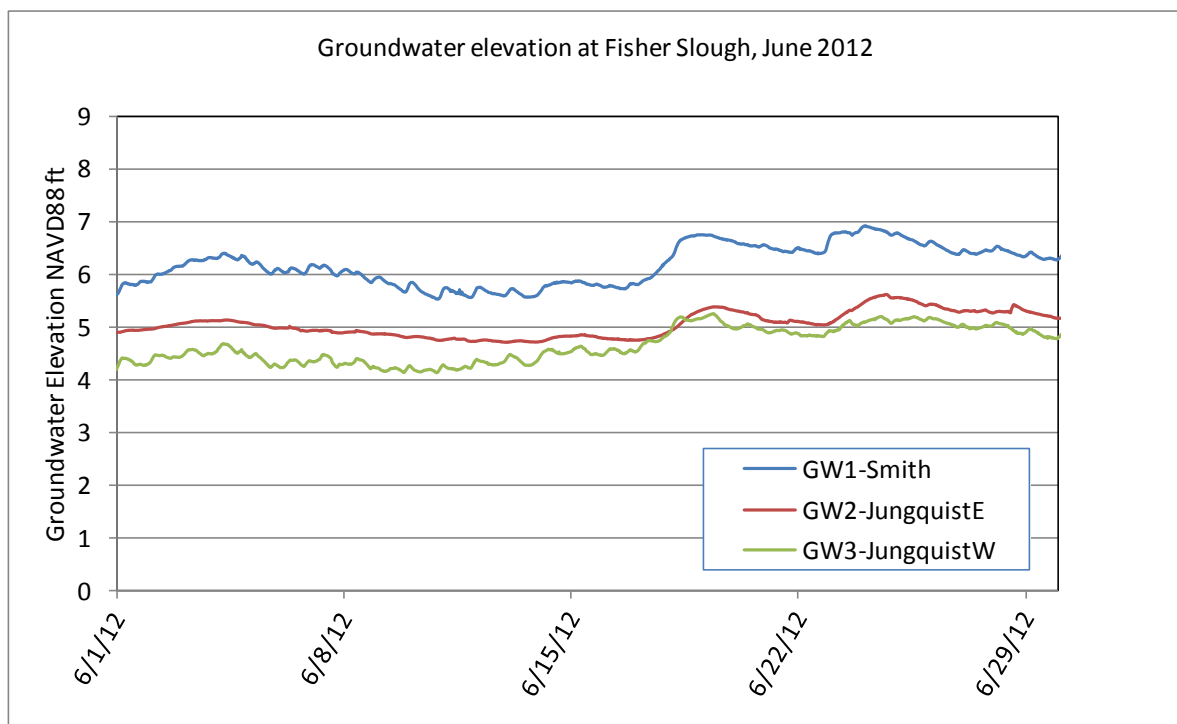


Figure A13. Groundwater elevation graph for June 2012.

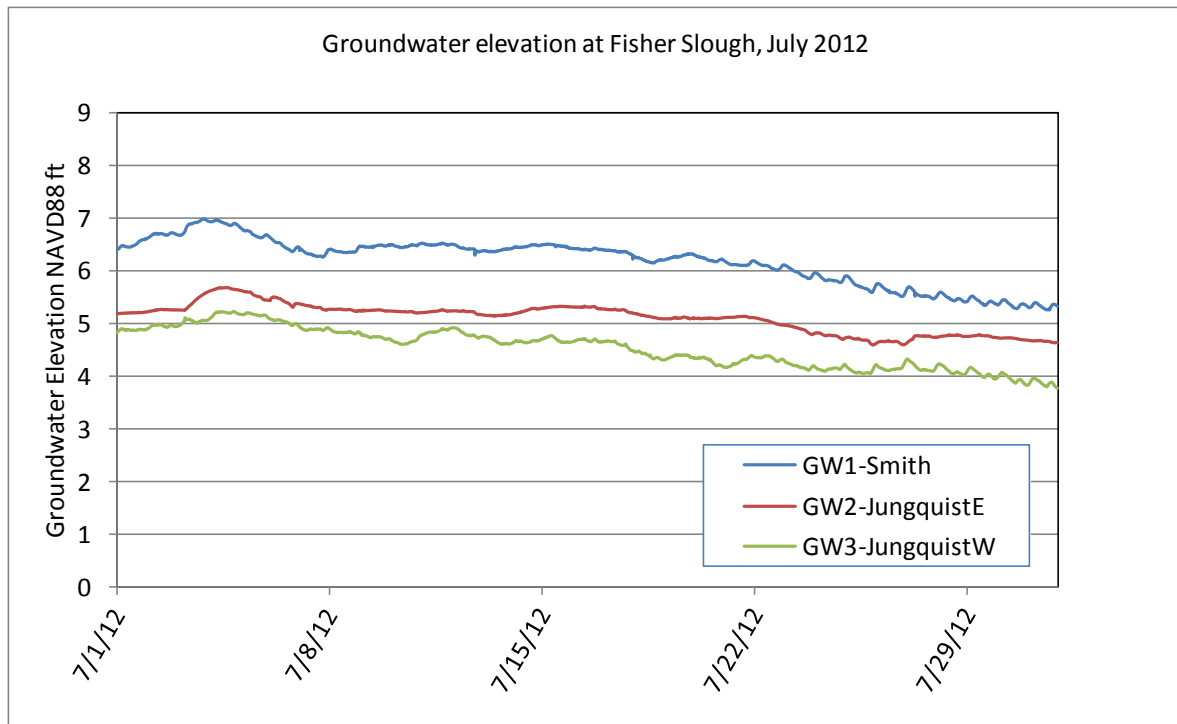


Figure A14. Groundwater elevation graph for July 2012.

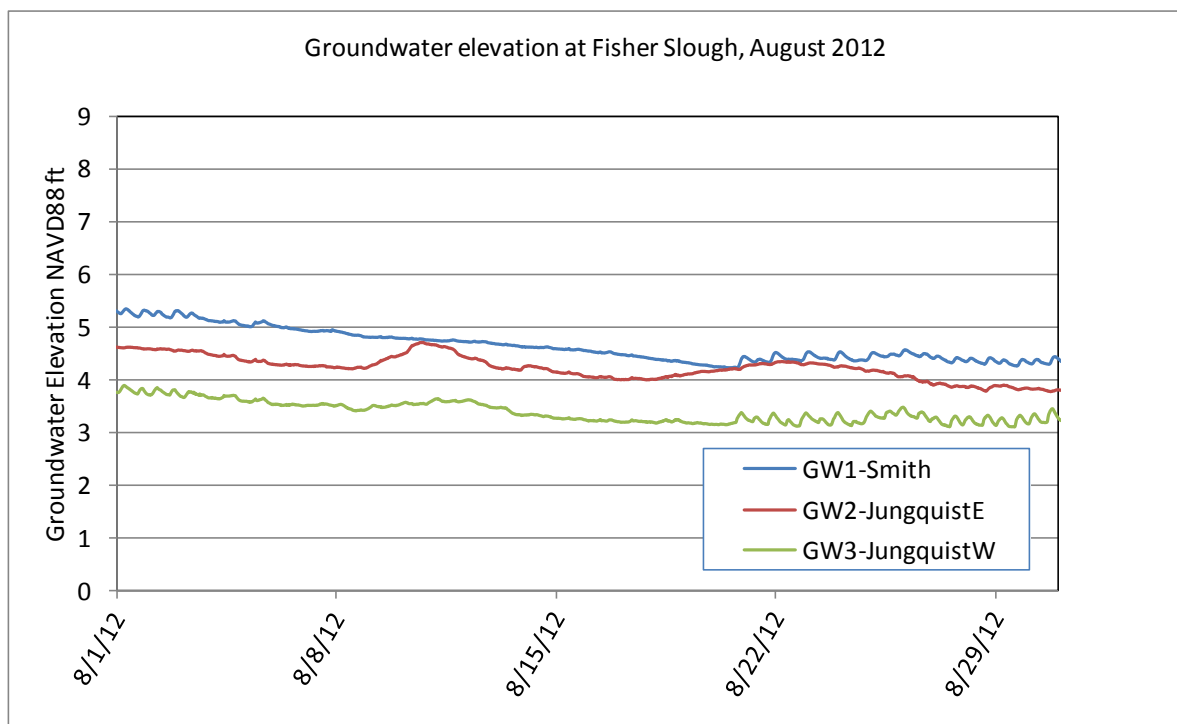


Figure A15. Groundwater elevation graph for August 2012.

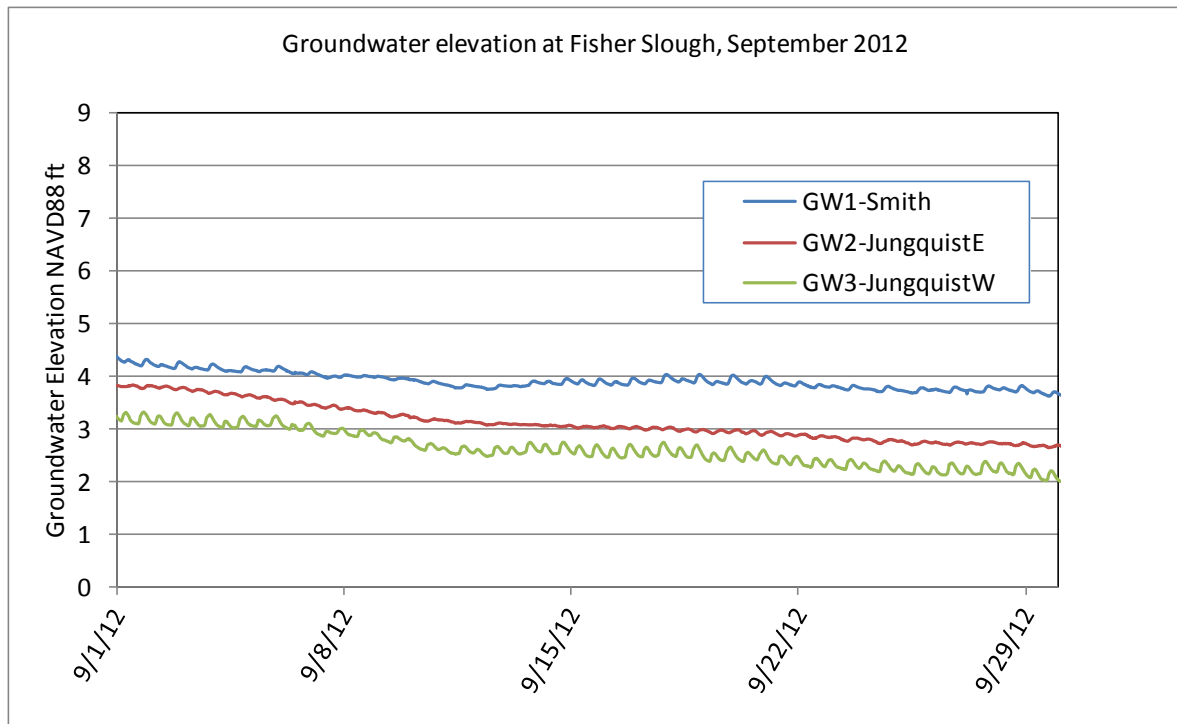


Figure A16. Groundwater elevation graph for September 2012.

Appendix B – Surface Water Data

Data presented below show the seasonal variations from water surface elevations taken from five Solinst dataloggers and one AquiStar® model PS9805 data logger, which is located on the upstream face of the floodgate headwall. Two of the Solinst loggers, one downstream of the floodgate and one near the historic Big Ditch Crossing (now called Blind Ch 3) have been in place since 2009. Three Solinst loggers were added in March 2012 at sites created during the dike setback and channel relocation of Project Element 3 at Upper Main Channel, Blind Ch 1 and Blind Ch 2. The AquiStar data logger has been in place since January 2010. Data were taken at 15-minute intervals. The floodgates were disengaged during October 2011 for the completion of Project Element 3, the dike setback and channel relocation phase of the construction. They were engaged on October 31, 2011 and operated under normal conditions until the middle of the summer. Programming problems with the Solinst logger occurred at the Upper Main Channel site, resulting in intermittent data until May 10, 2012. The floodgates were disengaged from August 3 to August 20 to help facilitate low water for a Dike District 3 maintenance project in Hill Ditch located upstream of the Fisher Slough restoration area (Figures B3 and B14). The standpipe housing the logger at Downstream Floodgate became unsecured from the headwall, resulting in the logger dangling freely from September 18 to September 20, 2012 (Figures B3 and B15).

Figures B1 through B3 represent data by management period; Figures B4 through B15 show the data by month with data from the main channels shown in the top panel and data from the blind channels shown in the bottom panel.

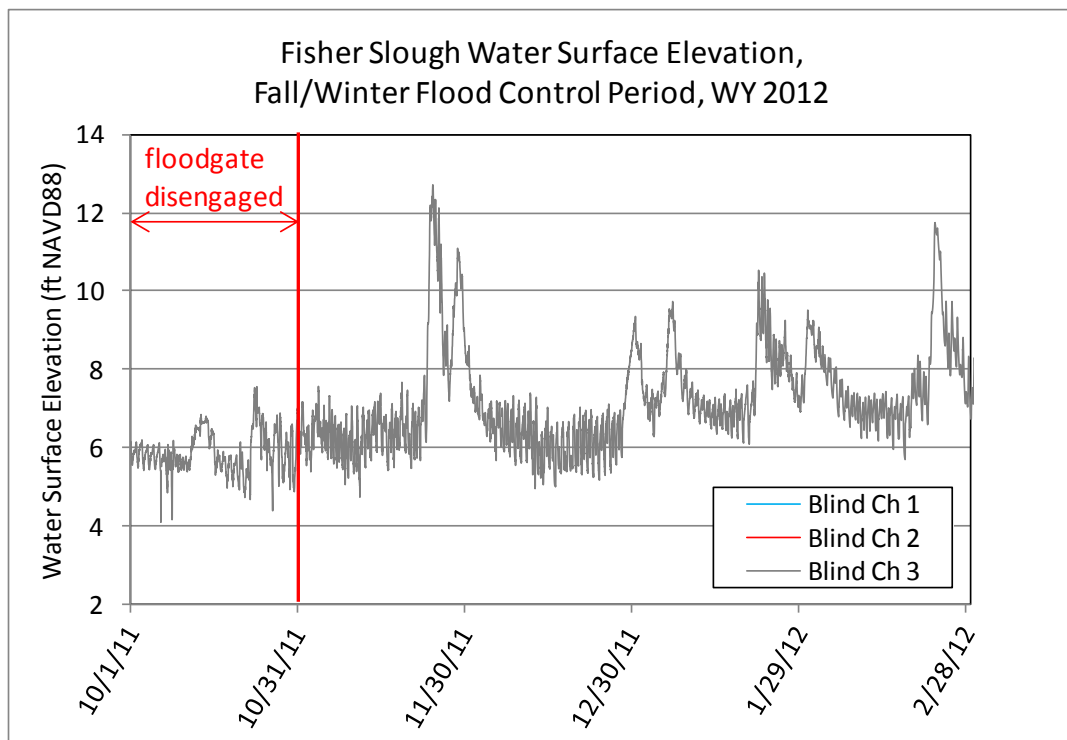
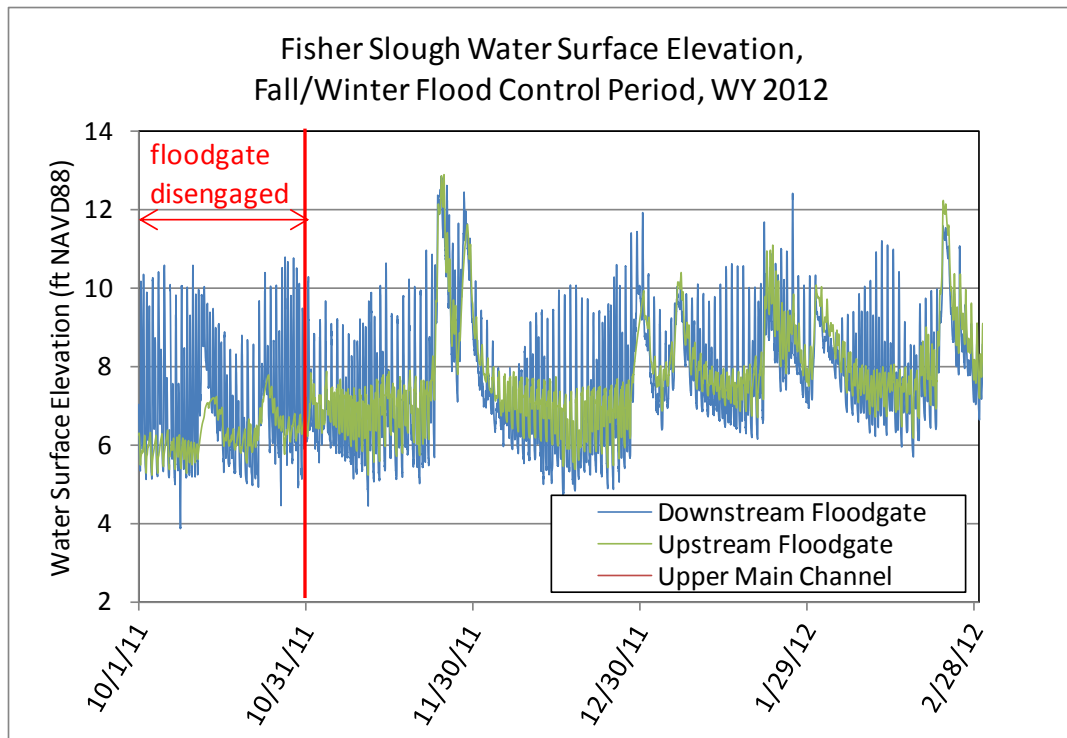


Figure B1. Water surface elevation graphs for the Fall/Winter Flood Control Period of WY2012. The floodgate was disengaged during October for restoration construction relating to Project Element 3. The logger at Upper Main Channel was installed on March 23, 2012. Loggers at Blind Ch1 and 2 were installed on March 5, 2012.

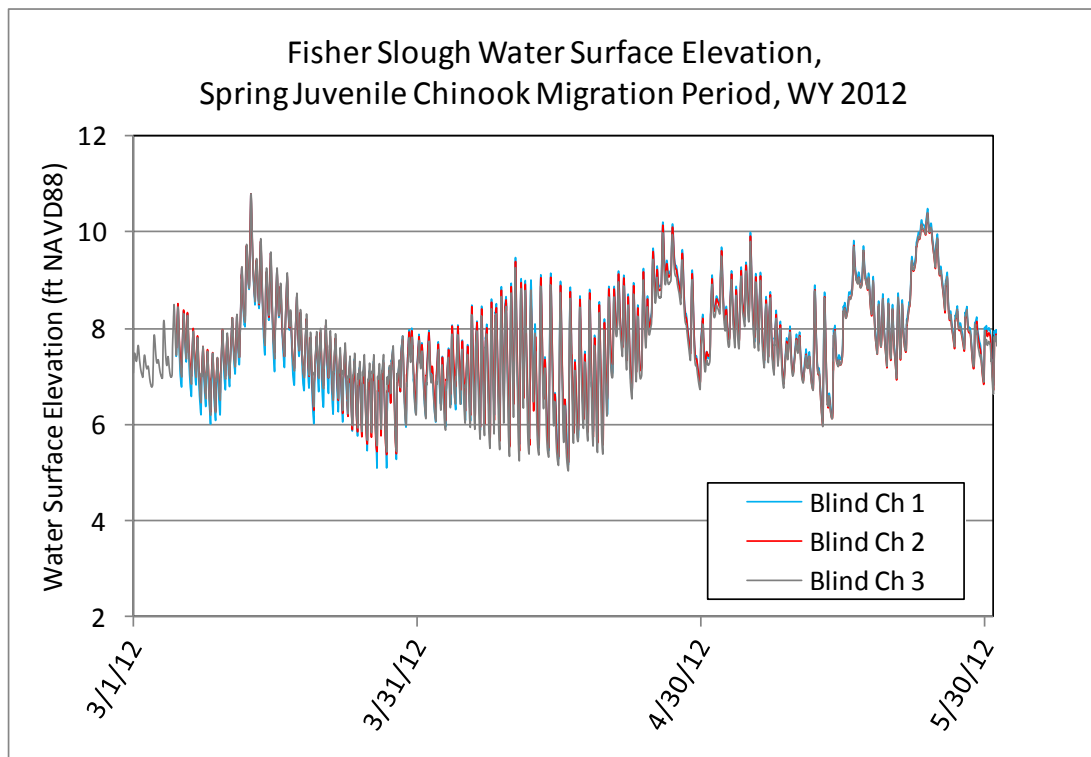
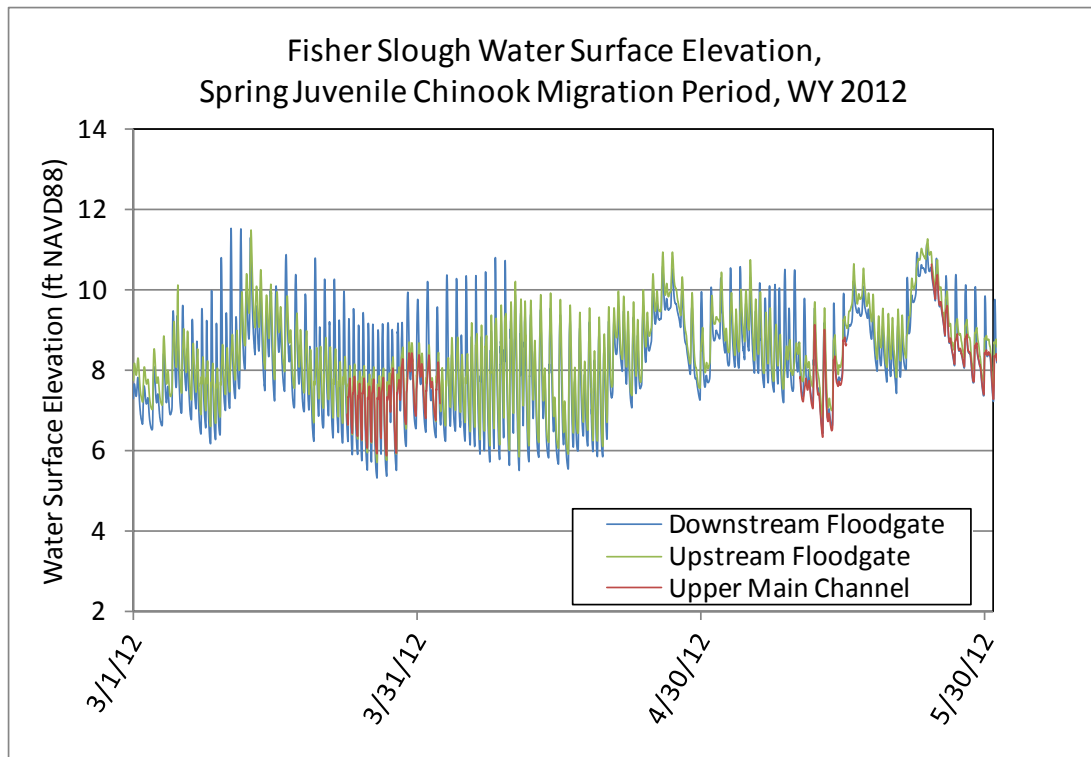


Figure B2. Water surface elevation graphs for the Spring Juvenile Chinook Migration Period of WY2012. Logger at Upper Main Channel was installed on March 23, 2012. Loggers at Blind Ch1 and 2 were installed on March 5, 2012

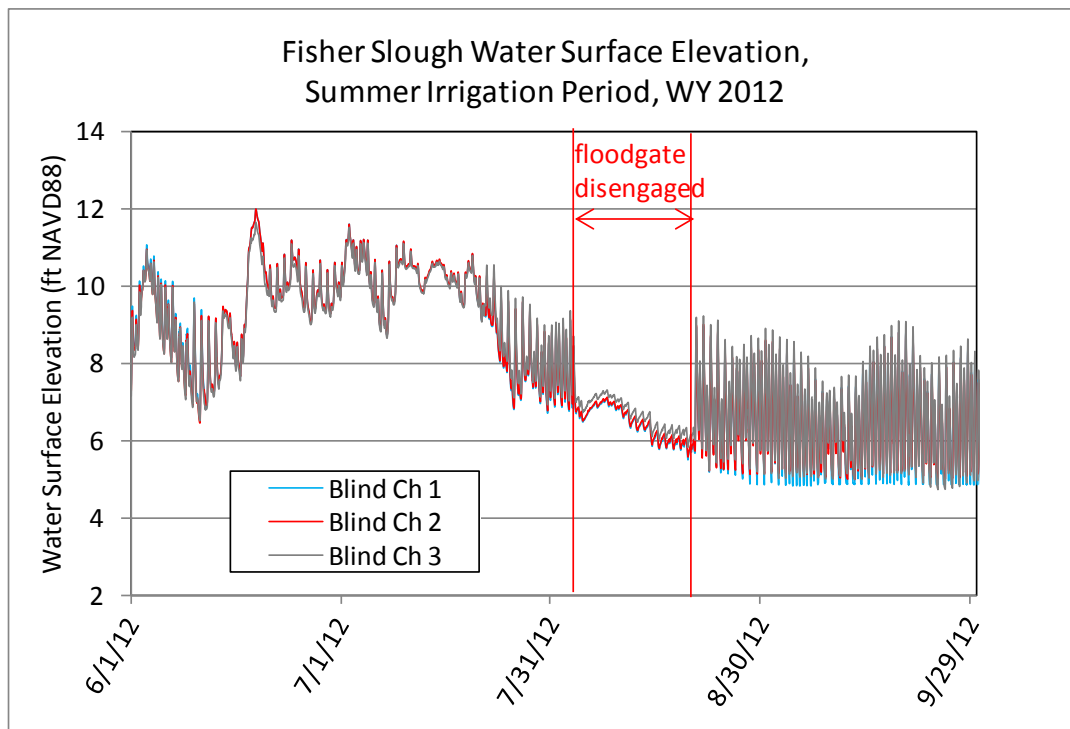
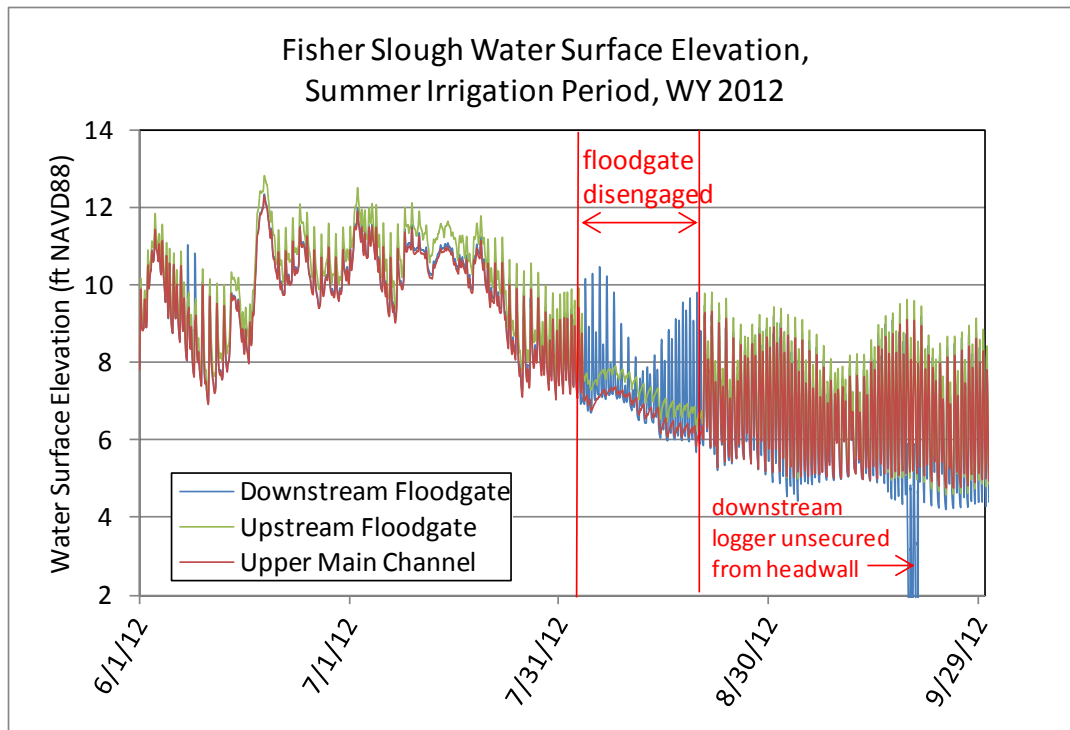


Figure B3. Water surface elevation graphs for the Summer Irrigation Period of WY2012. Floodgates were disengaged from August 3 to August 20, 2012 to help facilitate a Dike District 3 maintenance project in Hill Ditch upstream of the Fisher Slough Project area. The logger at Downstream Floodgate was unsecured from the headwall of the floodgate and dangled freely from September 18 through September 20, 2012

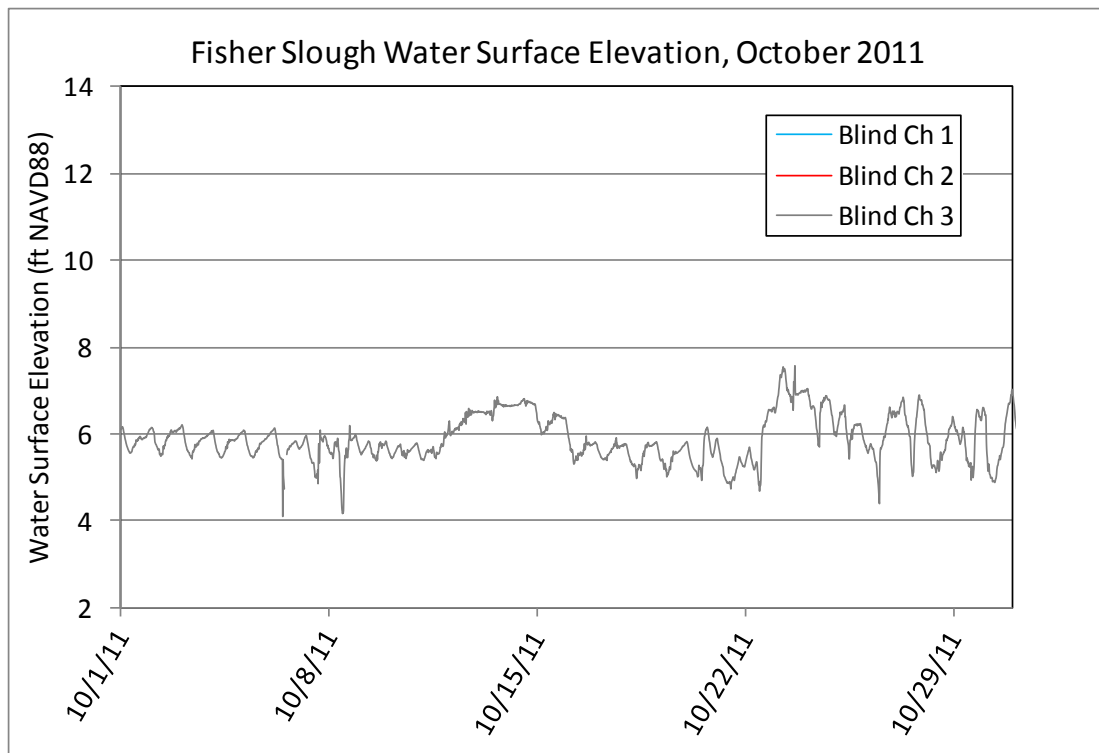
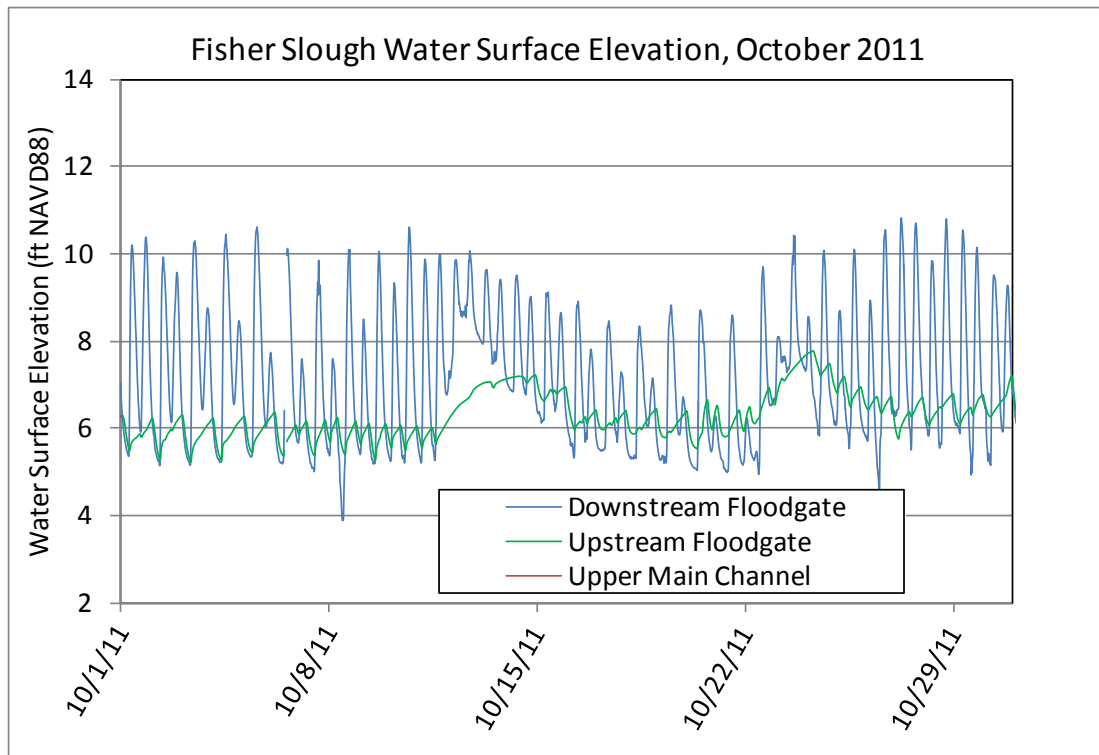


Figure B4. Water surface elevation graphs for October 2011. Logger at Upper Main Channel was installed on March 23, 2012. Loggers at Blind Ch1 and 2 were installed on March 5, 2012.

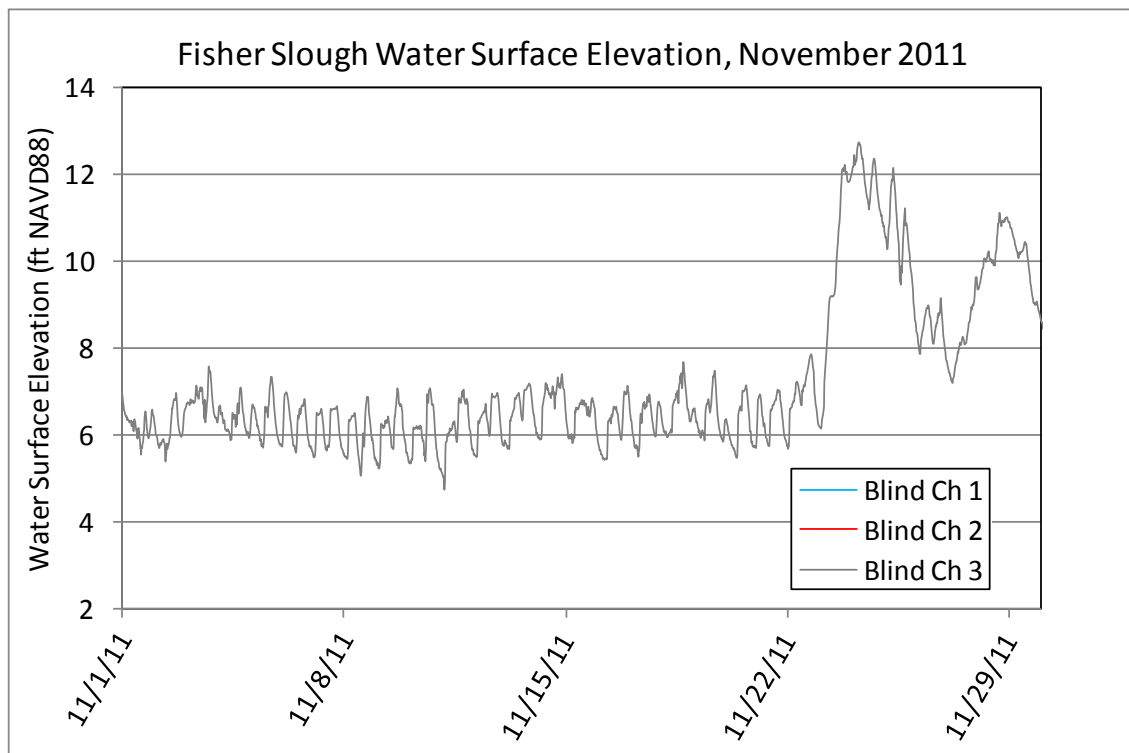
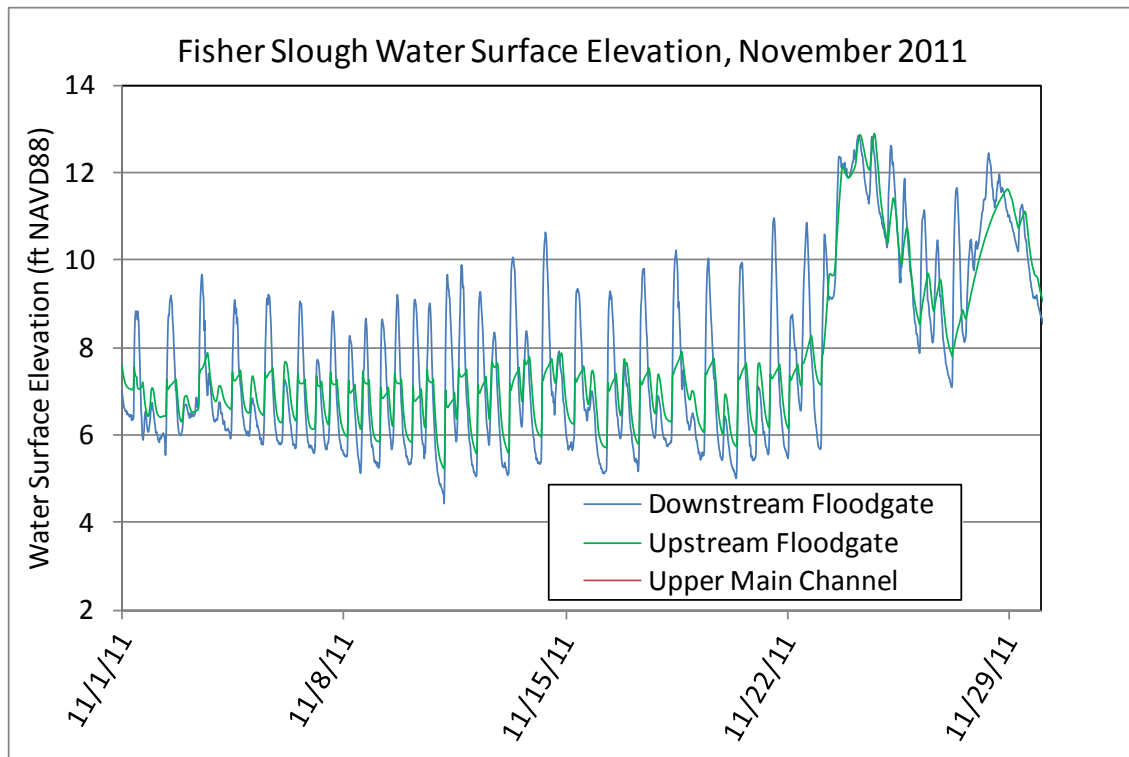


Figure B5. Water surface elevation graphs for November 2011. Logger at Upper Main Channel was installed on March 23, 2012. Loggers at Blind Ch1 and 2 were installed on March 5, 2012.

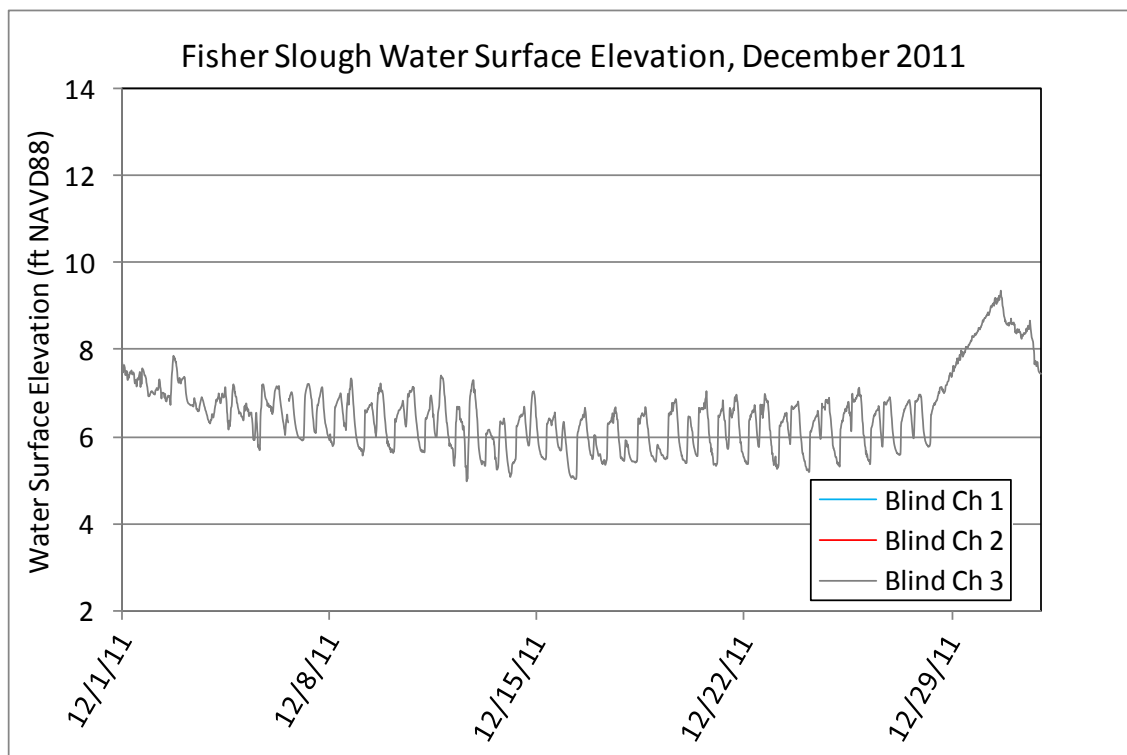
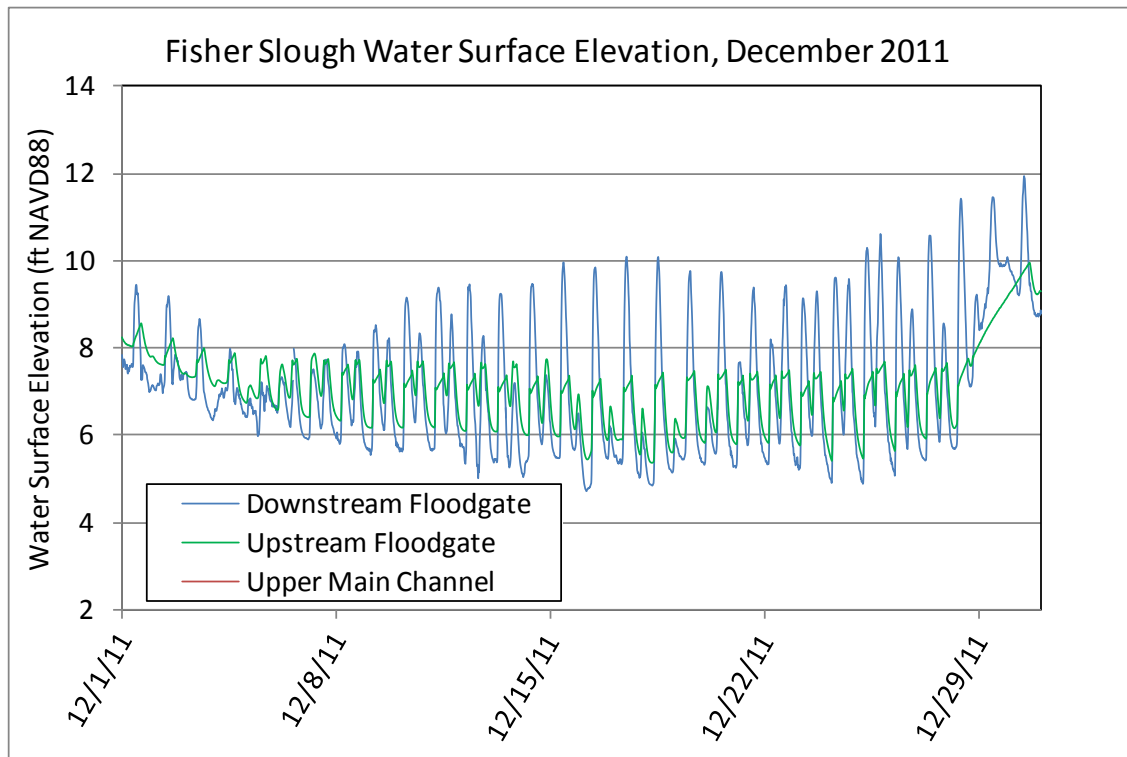


Figure B6. Water surface elevation graphs for December 2011. Logger at Upper Main Channel was installed on March 23, 2012. Loggers at Blind Ch1 and 2 were installed on March 5, 2012

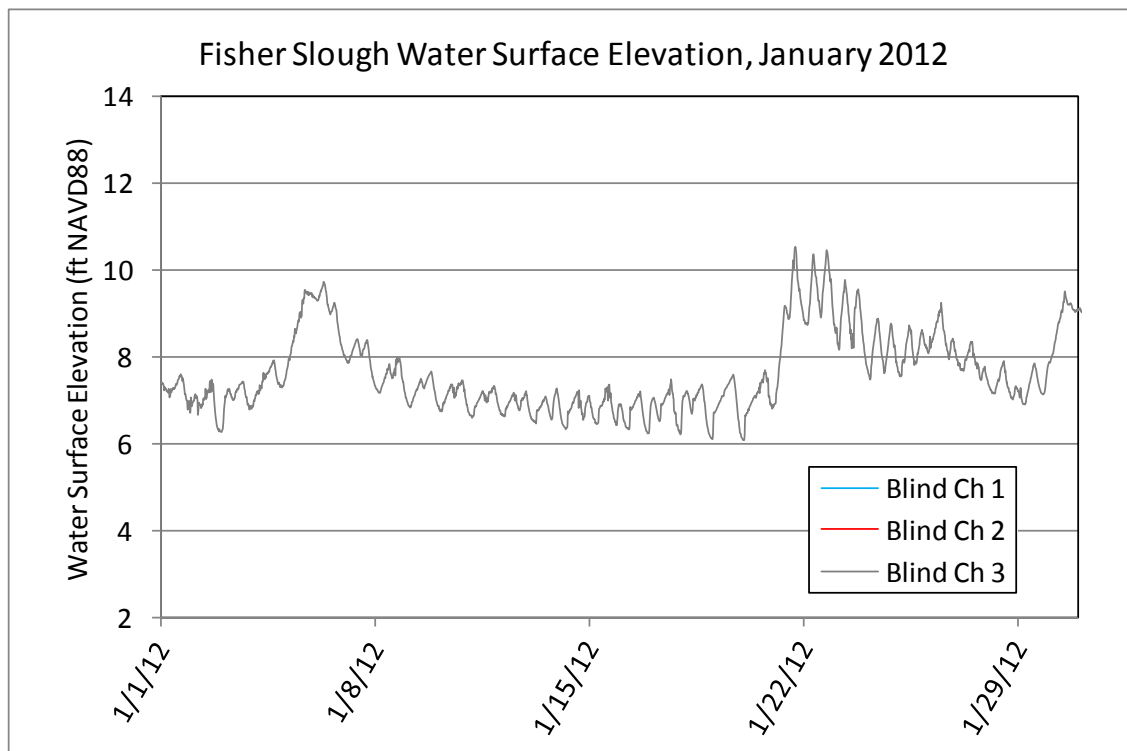
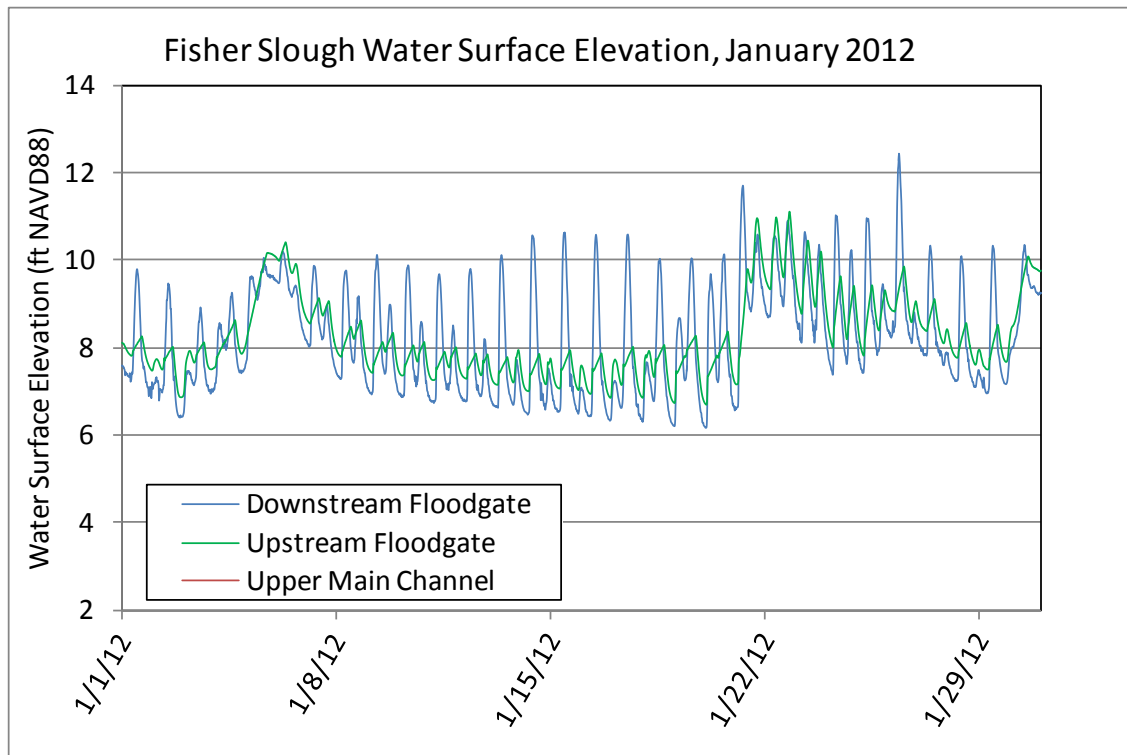


Figure B7. Water surface elevation graphs for January 2012. Logger at Upper Main Channel was installed on March 23, 2012. Loggers at Blind Ch1 and 2 were installed on March 5, 2012.

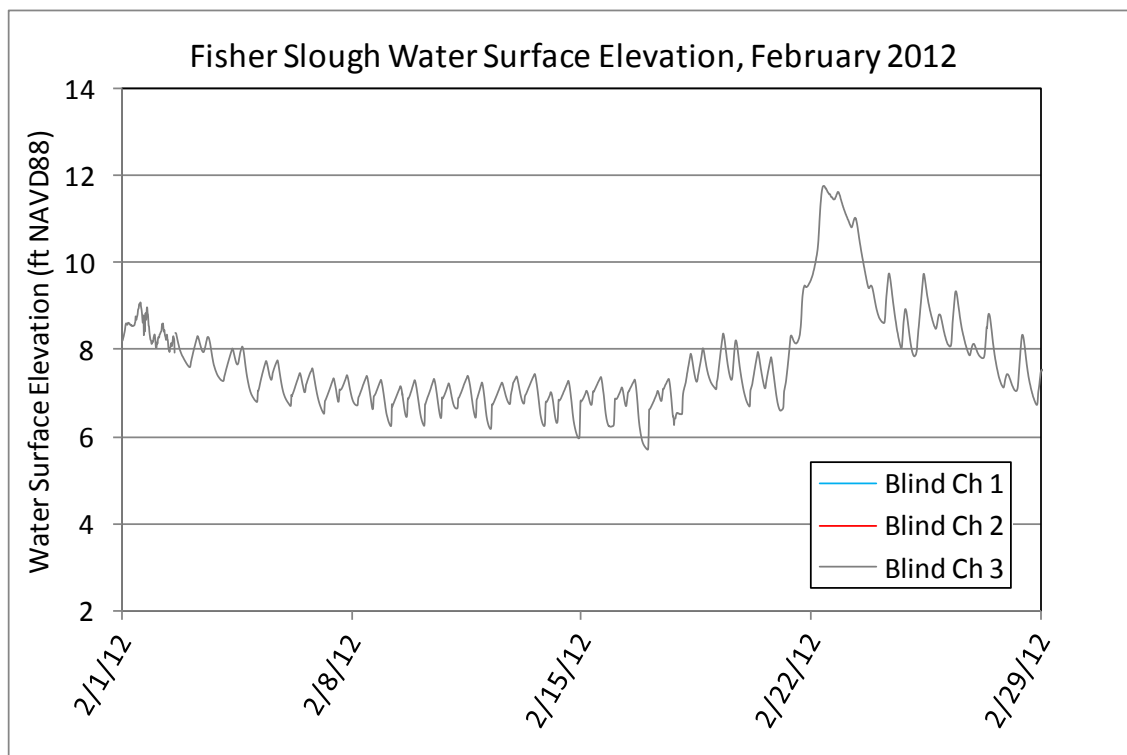
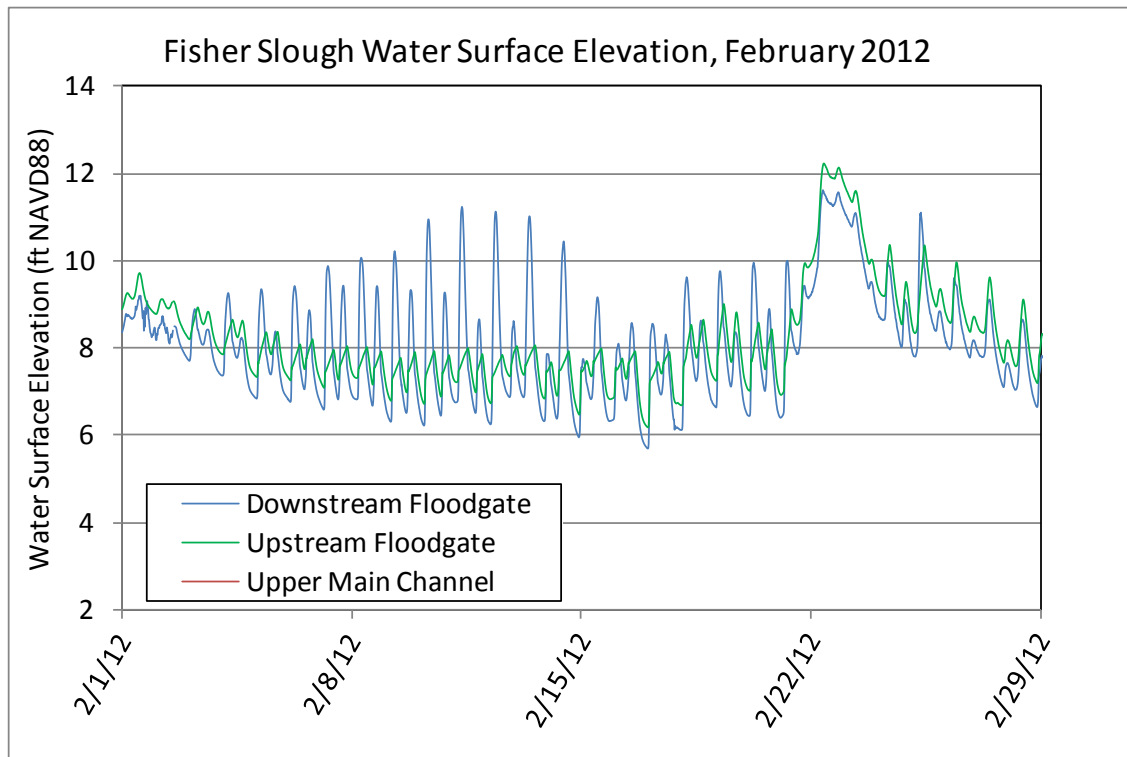


Figure B8. Water surface elevation graphs for February 2012. Logger at Upper Main Channel was installed on March 23, 2012. Loggers at Blind Ch1 and 2 were installed on March 5, 2012.

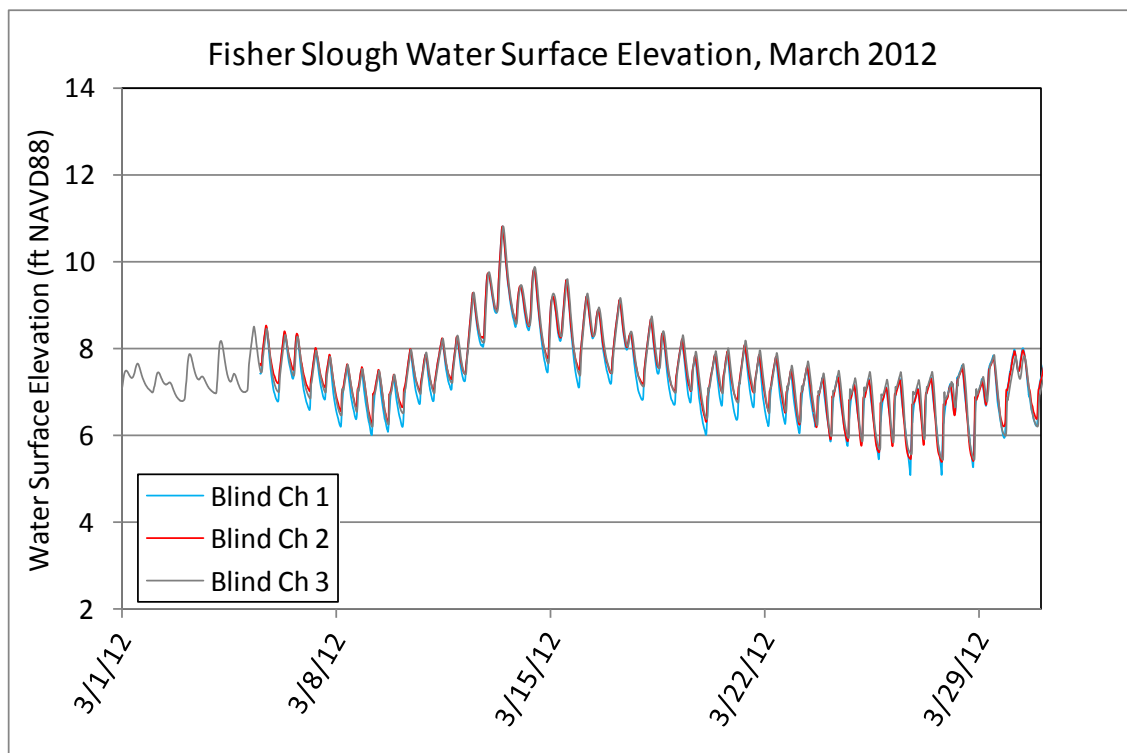
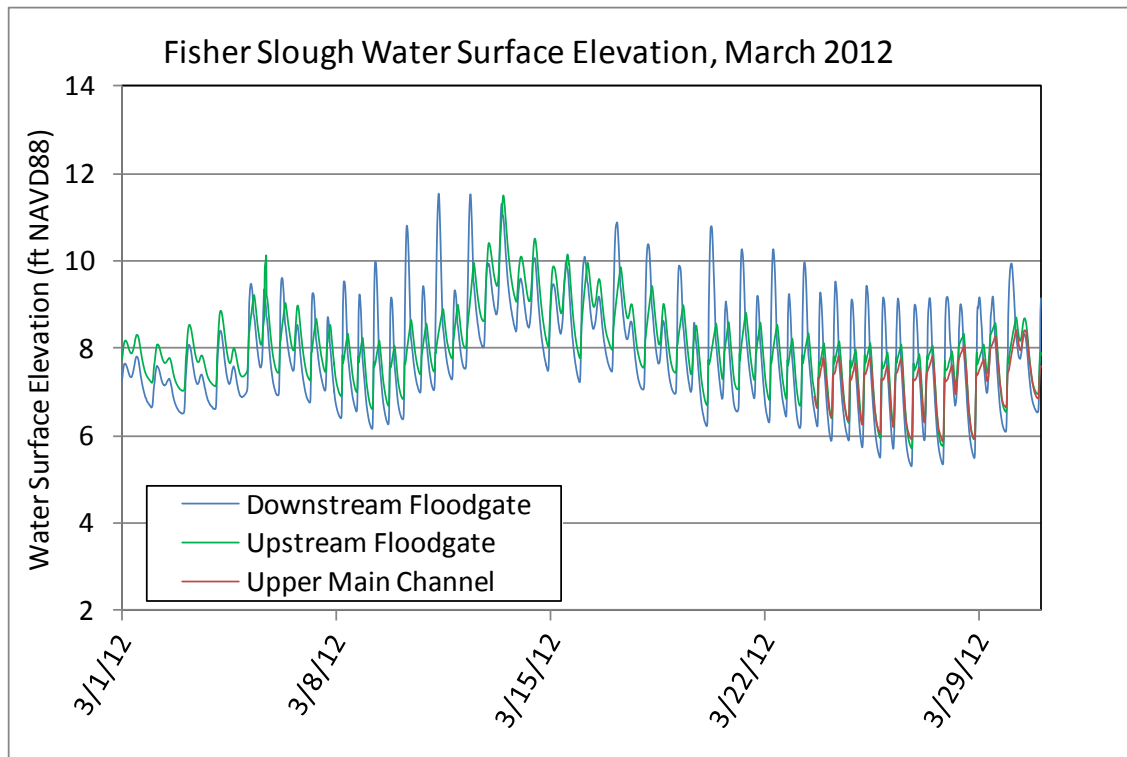


Figure B9. Water surface elevation graphs for March 2012. Logger at Upper Main Channel was installed on March 23, 2012. Loggers at Blind Ch1 and 2 were installed on March 5, 2012.

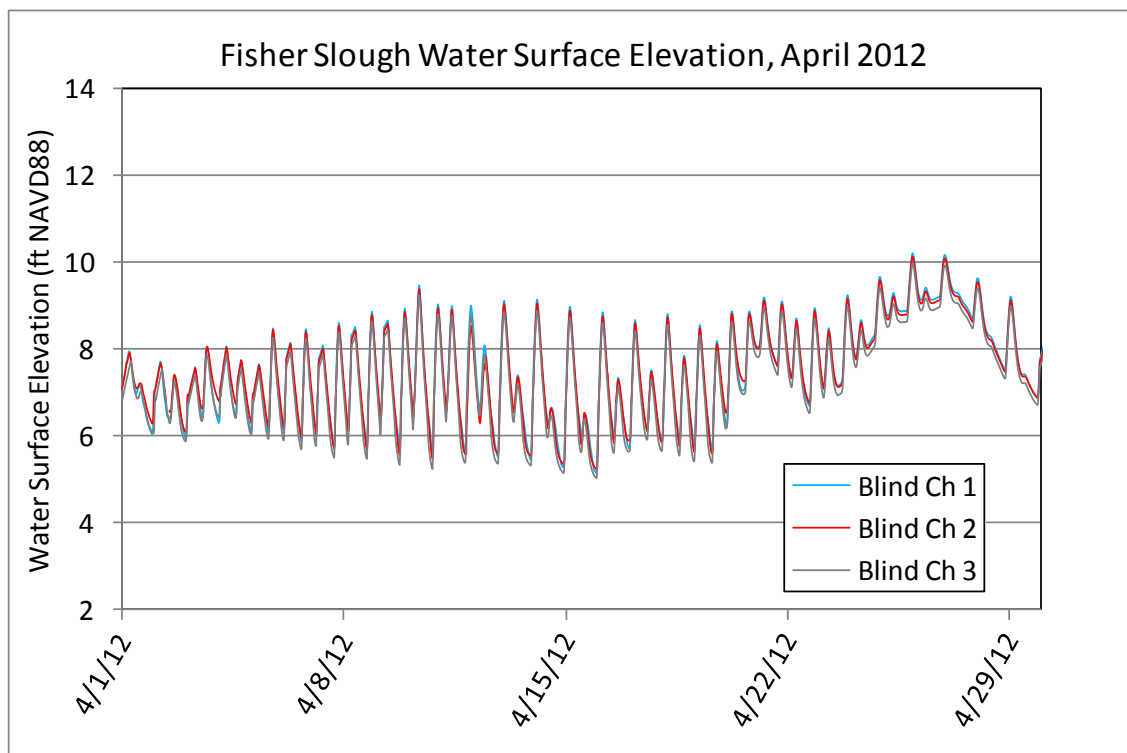
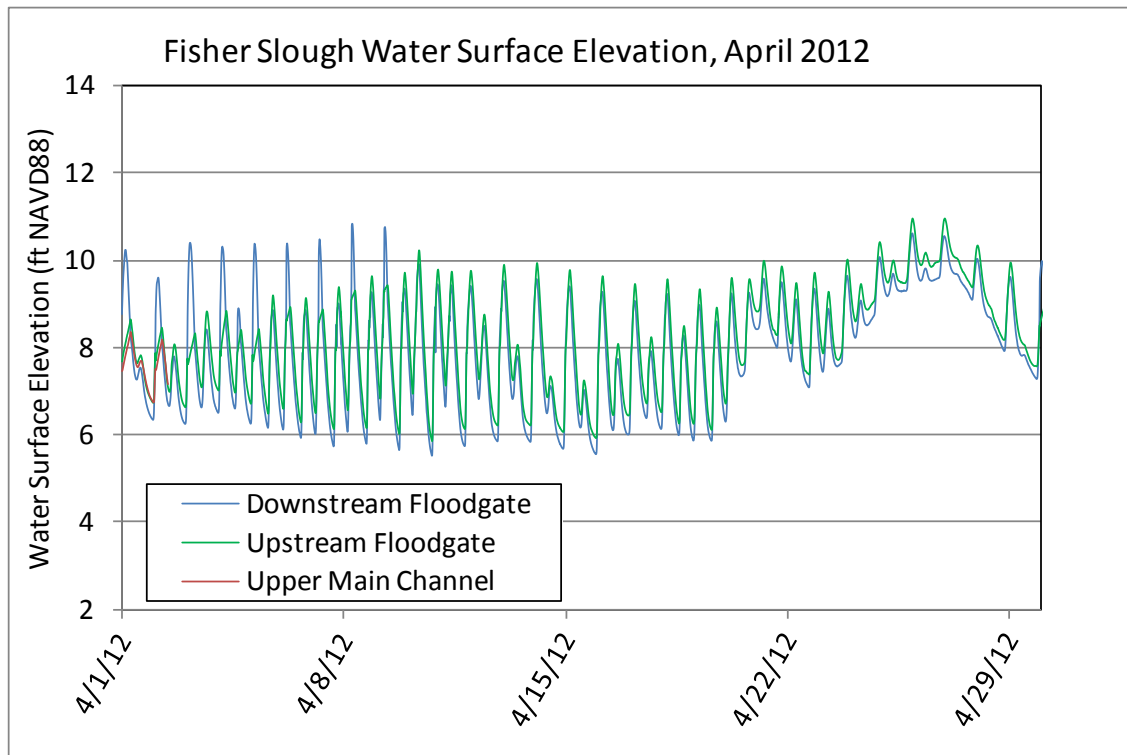


Figure B10. Water surface elevation graphs for April 2012. The logger at Upper Main Channel did not record data from April 2 to May 10, 2012.

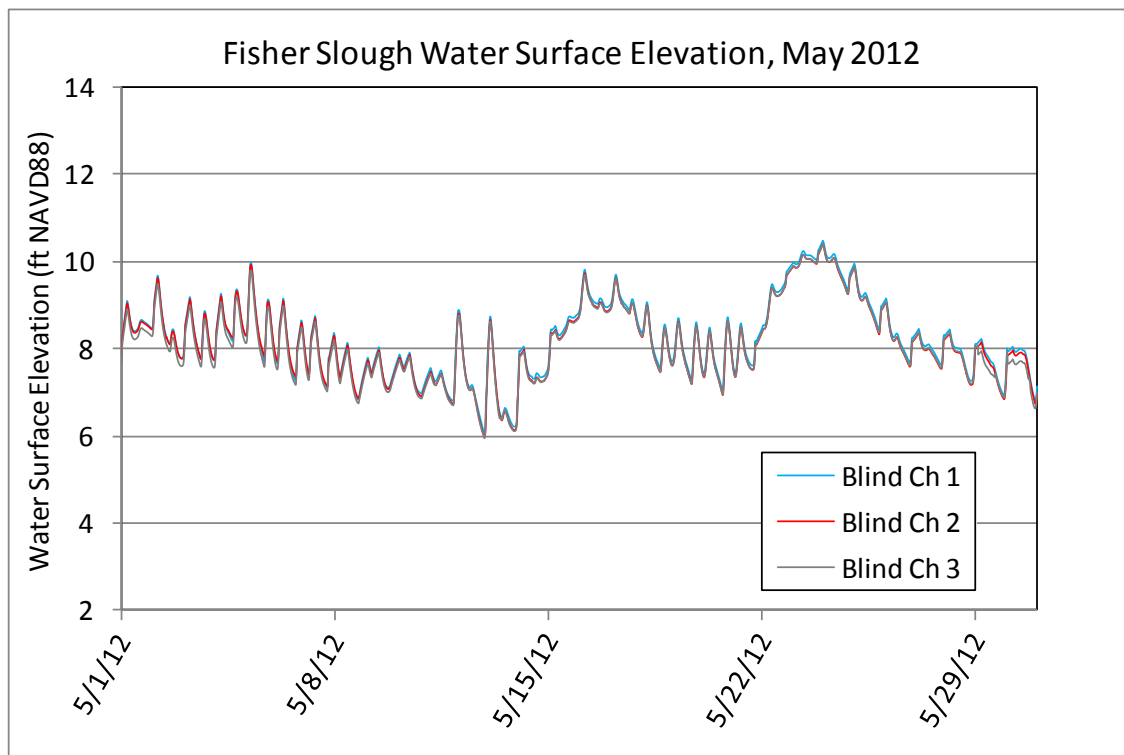
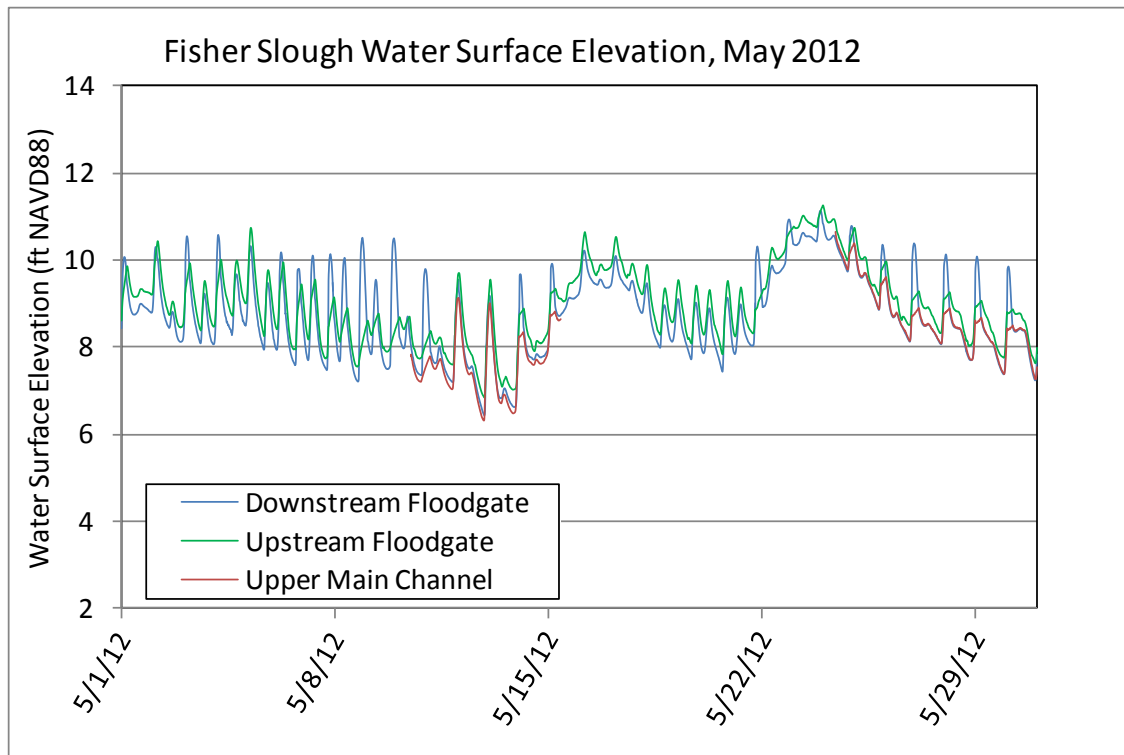


Figure B11. Water surface elevation graphs for May 2012. The logger at Upper Main Channel did not record data from April 2 to May 10, 2012.

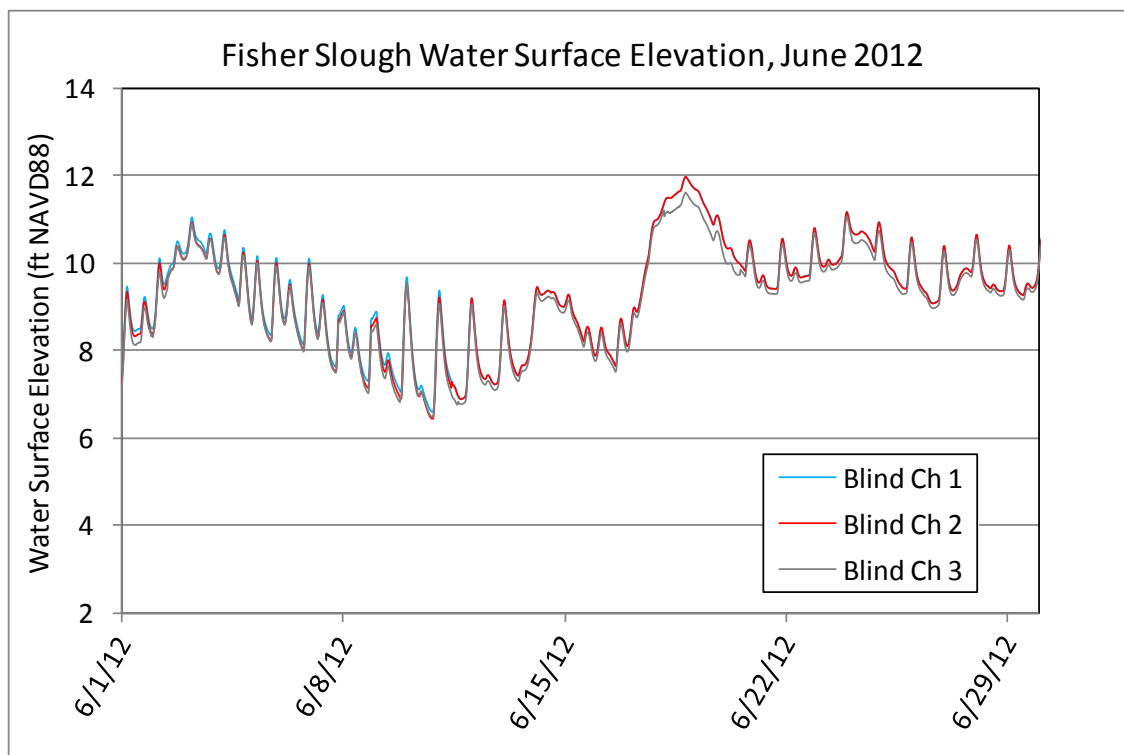
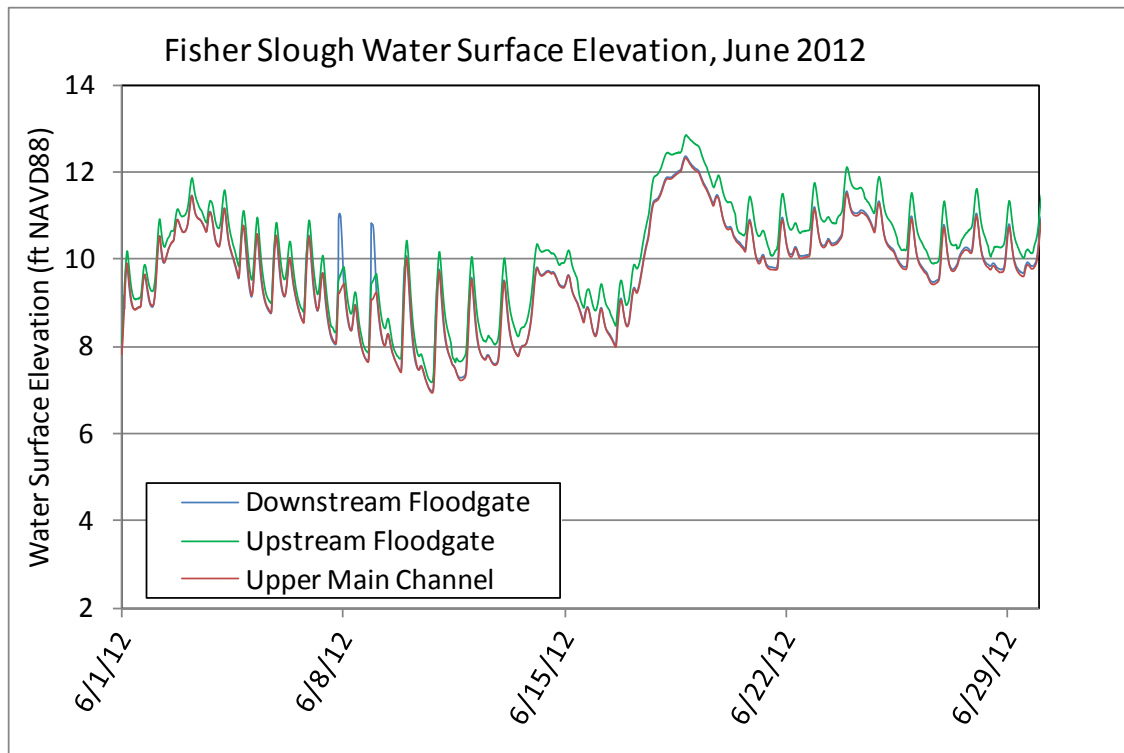


Figure B12. Water surface elevation graphs for June 2012.

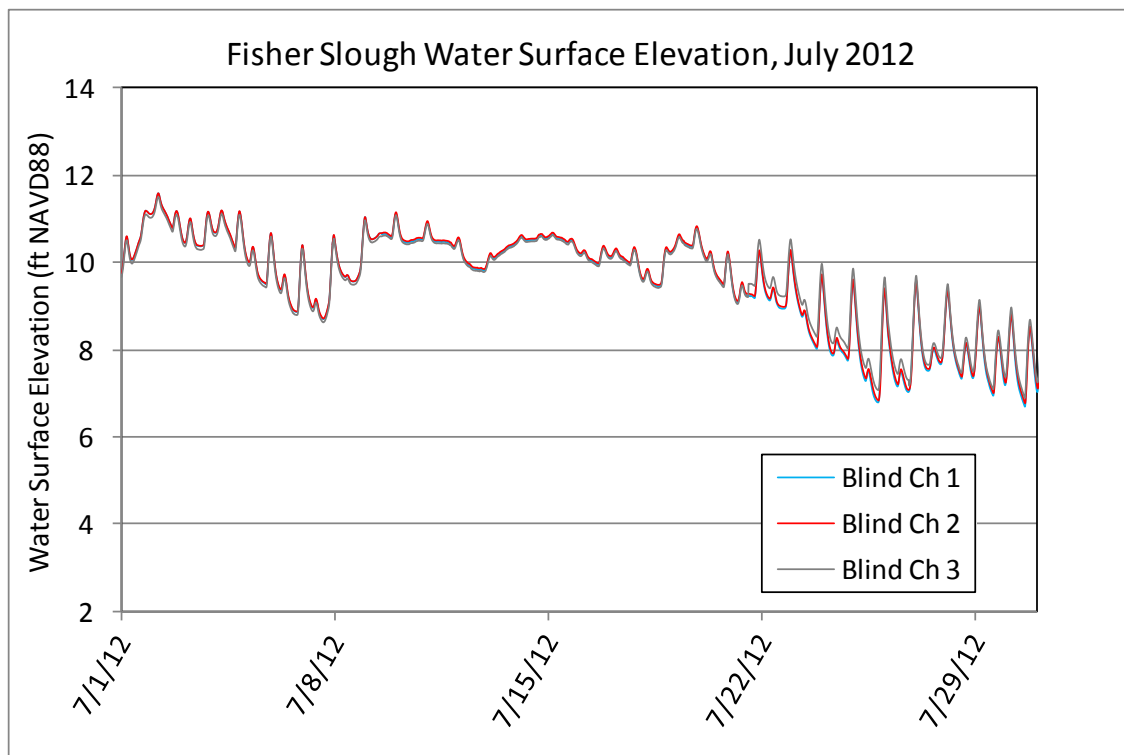
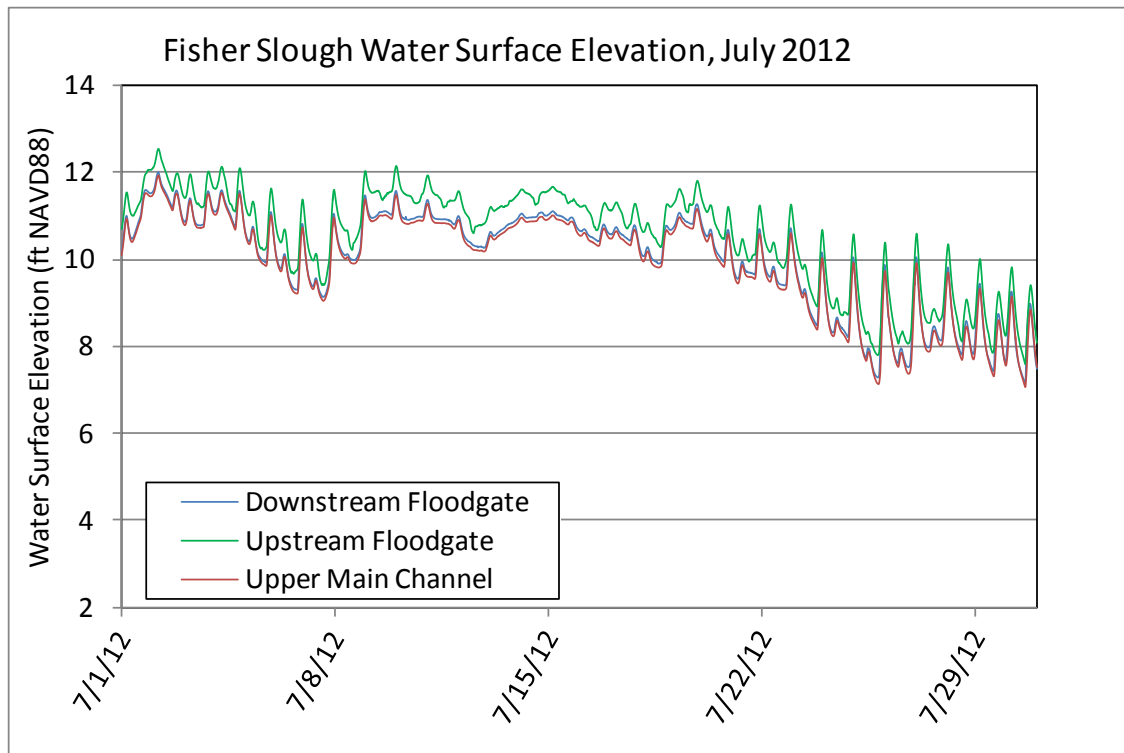


Figure B13. Water surface elevation graphs for July 2012.

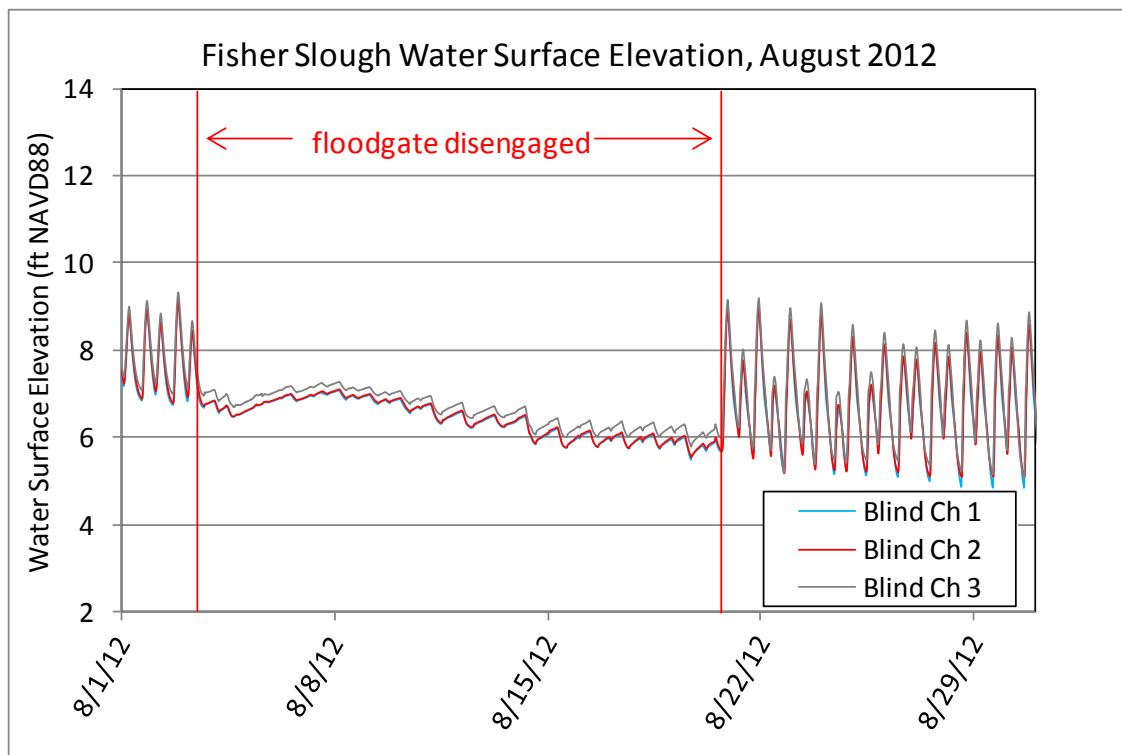
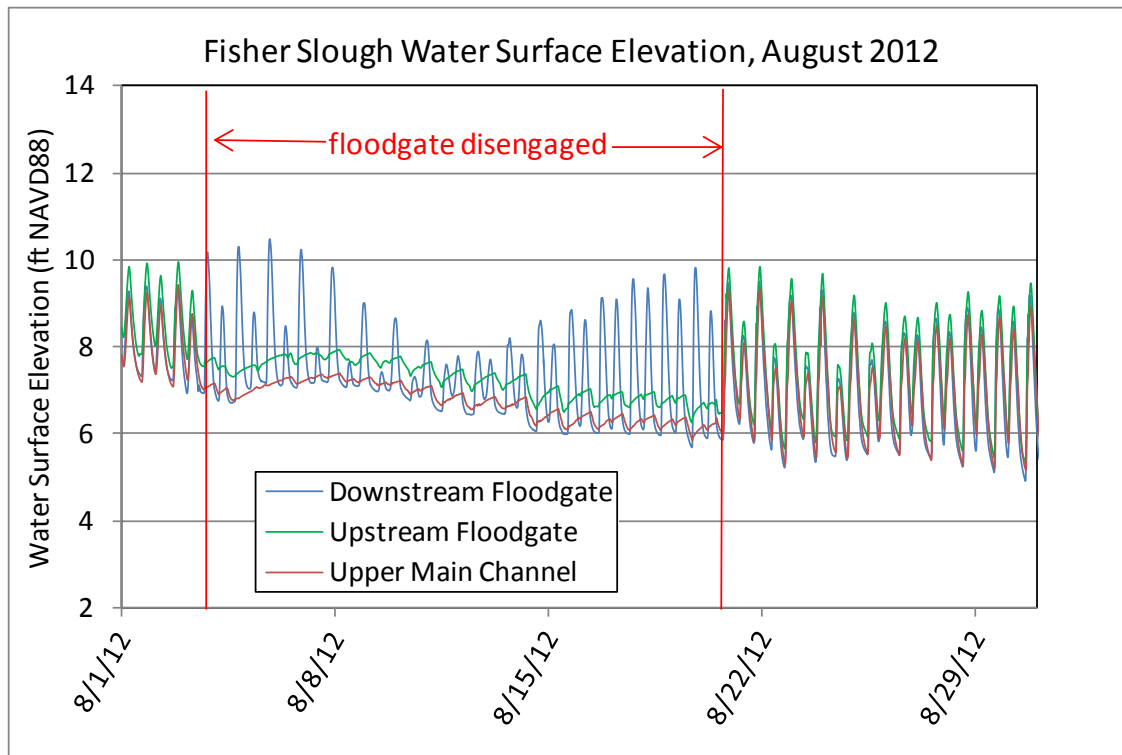


Figure B14. Water surface elevation graphs for August 2012. Floodgates were disengaged from August 3 to August 20, 2012 to help facilitate a Dike District 3 maintenance project in Hill Ditch upstream of the Fisher Slough Project area.

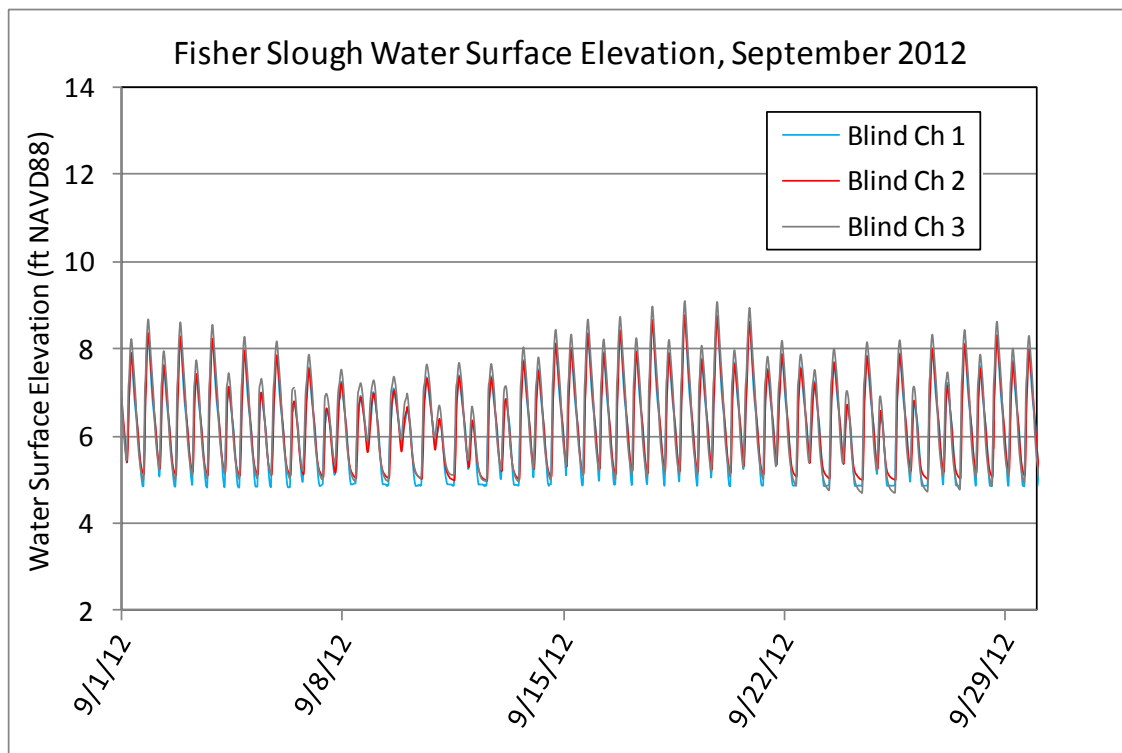
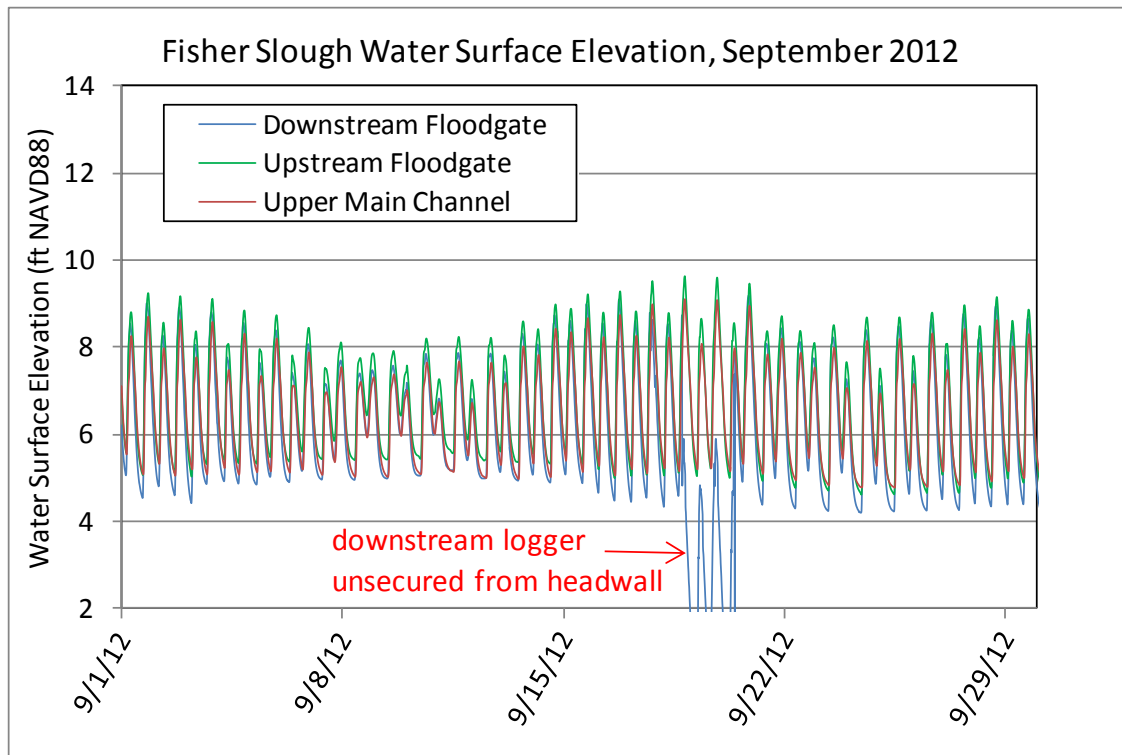


Figure B15. Water surface elevation graphs for September 2012. The data logger at Downstream Floodgate was unsecured from the headwall of the floodgate and dangled freely from September 18 through September 20, 2012.

Appendix C – Water Quality Data

Dissolved Oxygen

This section shows dissolved oxygen data relevant to Hypothesis H2, parameter 1.

Data in Table C1 is from continual-read Aquistar Smart Sensor DO loggers deployed at Downstream Floodgate, Upstream Floodgate and a new site at Upper Main Channel, upstream of the old inverted siphon. A fourth DO logger was rotated on an approximate two-week schedule between the new blind channel areas. The logger probe is located at the bottom of the water column. Data were recorded at 15-minute intervals. The table summarizes the average for each day. The floodgates were disengaged from August 3 to August 20 to help facilitate low water for a Dike District 3 maintenance project in Hill Ditch located upstream of the Fisher Slough restoration area.

Tables C2 and C3 show DO readings for the water surface and the water bottom taken during SRSC's fish monitoring at Fisher Slough in 2012. Readings were taken with a YSI Professional Plus DO meter. Data is averaged for sites within the sampling areas upstream and downstream of the floodgate.

Table C1. Daily average Dissolved Oxygen levels in mg/L from Aquistar® data loggers deployed at Fisher Slough in 2012. Data highlighted in bold indicate values lower than the restoration target of 8.0 mg/L. Data highlighted in yellow shows suspect data due to the logger recording negative numbers. Negative valued numbers recorded by the DO logger were removed from the data set prior to computing the daily average.

Date	Downstream Floodgate	Upstream Floodgate	Upper Main Channel	Blind Ch 1	Blind Ch 2	Blind Ch 3	Management Period
29-Mar	9.79		9.47			9.93	Spring juvenile Chinook Migration Period
30-Mar	9.53		9.40			9.73	
31-Mar	9.48		9.60			9.59	
1-Apr	9.47		9.79			10.40	
2-Apr	9.73		9.90			10.76	
3-Apr	9.77		9.51			10.18	
4-Apr	9.94		9.90			10.35	
5-Apr	9.91	9.54	9.89			10.33	
6-Apr	9.97	9.43	9.98				
7-Apr	9.92	9.41	10.03				
8-Apr	9.87	9.27	9.83				
9-Apr	9.74	9.16	9.60				
10-Apr	9.46	8.81	9.40				
11-Apr	9.13	8.56	9.06				
12-Apr	9.15	8.75	9.55		11.36		
13-Apr	8.93	9.06			10.98		
14-Apr	8.72	9.04			10.88		
15-Apr	8.83	8.98			10.79		
16-Apr	9.30	8.98			10.42		
17-Apr	9.27	9.24	9.36		10.73		
18-Apr	9.43	9.40	9.91		11.17		
19-Apr	9.36	9.25	9.78		10.78		
20-Apr	9.38	8.81	9.11		10.25		
21-Apr	9.34	8.94	9.50		10.65		
22-Apr	9.18	8.93	9.35		10.34		
23-Apr	9.07	8.73	8.99		9.99		
24-Apr	8.76	8.27	8.01		9.32		
25-Apr	8.51	8.54	9.13		9.70		
26-Apr	8.46	8.09	7.95		9.55		
27-Apr	8.02	8.19	8.32	10.43	9.97		
28-Apr	8.08	8.67	9.06	10.29			
29-Apr	8.08	8.50	9.17	9.77			
30-Apr	8.34	8.24	8.94	9.11			
1-May	8.62	8.32	8.75	9.09			
2-May	8.43	8.65	9.12	8.83			

Date	Downstream Floodgate	Upstream Floodgate	Upper Main Channel	Blind Ch 1	Blind Ch 2	Blind Ch 3	Management Period
3-May	8.52	8.52	8.83	8.83			Spring Juvenile Chinook Migration Period
4-May	8.75	8.45	8.78	8.61			
5-May	8.94	8.59	9.15	9.16			
6-May	9.08	8.82	9.09	9.34			
7-May	9.03	8.67	9.10	8.73			
8-May	7.70	8.09	9.05	6.76			
9-May	8.17	8.33	9.57	5.14			
10-May	8.35	8.53	9.77	0.38		9.97	
11-May	8.75	8.81	10.13			10.25	
12-May	9.02	8.90	10.13			10.69	
13-May	8.77	8.31	9.86			10.48	
14-May	8.65	7.79	10.38			10.42	
15-May	8.92	7.94	10.49			10.35	
16-May	8.70	7.94	11.08			9.51	
17-May	8.65	8.23	10.40			8.67	
18-May	8.61	8.27	9.60			9.06	
19-May	9.00	8.75	10.60			9.73	
20-May	8.95	8.62	9.73			8.98	
21-May	8.91	8.48	9.52			8.18	
22-May	9.10	8.53	10.38			8.30	
23-May	8.80	8.35	9.30			7.74	
24-May	8.05	7.14	8.05		9.14	5.36	
25-May	7.98	7.42	8.77		7.95		
26-May	7.83	7.43	9.32		8.50		
27-May	7.83	7.45	9.01		8.66		
28-May	7.84	7.65	9.26		8.71		
29-May	7.86	7.78	9.90		8.48		
30-May	8.19	7.94	9.61		8.41		
31-May	8.35	7.62	8.94		7.65		
1-Jun	8.74	8.27	9.95		8.44		Summer Irrigation Period
2-Jun	9.23	8.85	10.88		9.01		
3-Jun	8.89	8.65	10.90		9.79		
4-Jun	8.50	8.08	8.88		6.35		
5-Jun	8.55	7.91	9.31		7.97		
6-Jun	8.65	8.48	10.20		8.95		
7-Jun	8.70	8.50	9.76		8.97		
8-Jun	8.65	8.42	9.85	9.97	7.59		
9-Jun	8.52	8.20	9.49	9.45			
10-Jun	8.38	7.89	9.04	9.12			
11-Jun	8.23	7.74	8.84	8.87			

Date	Downstream Floodgate	Upstream Floodgate	Upper Main Channel	Blind Ch 1	Blind Ch 2	Blind Ch 3	Management Period
12-Jun	7.87	7.05	8.29	7.86			Summer Irrigation Period
13-Jun	8.07	7.72	8.62	8.53			
14-Jun	8.25	8.31	10.64	9.72			
15-Jun	7.70	7.49	8.20	8.73			
16-Jun	7.50	7.52	8.10	9.03			
17-Jun	8.34	8.55	10.15	10.15			
18-Jun	7.90	8.16	10.40	9.87			
19-Jun	7.34	7.39	9.75	8.63			
20-Jun	6.70	6.29	7.34	7.76			
21-Jun	6.68	6.52	7.70	9.38			
22-Jun	7.16	7.70	8.98	9.24	8.75		
23-Jun	6.85	7.11	7.54		7.53		
24-Jun	6.64	7.04	8.32		7.55		
25-Jun	6.43	6.75	6.84		8.26		
26-Jun	6.37	7.24	6.87		8.25		
27-Jun	7.10	8.08	8.50		8.29		
28-Jun	6.67	7.58	8.40		9.06		
29-Jun	6.97	8.01	9.49		9.10		
30-Jun	7.34	8.17	9.50		9.13		
1-Jul	7.96	8.47	10.05		9.41		
2-Jul	7.24	8.11	9.36		10.23		
3-Jul	7.49	7.93	7.33		8.77		
4-Jul	7.48	7.59	7.25		6.12		
5-Jul	7.16	7.11	7.28		3.98		
6-Jul	7.18	7.17	7.38		2.71		
7-Jul	7.56	7.45	7.40		7.16		
8-Jul	8.13	7.66	9.67		8.59		
9-Jul	8.50	7.95	9.71		9.76		
10-Jul	8.15	7.69	9.21		8.47		
11-Jul	7.92	7.33	8.53		7.81		
12-Jul	7.62	6.49	6.65		5.57		
13-Jul	8.46	7.85	7.62		6.75		
14-Jul	8.17	7.61	8.84		8.56		
15-Jul	7.74	7.11	7.60		7.40		
16-Jul	6.94	6.18	5.51		4.55		
17-Jul	7.49	7.30	6.77		6.05		
18-Jul	7.42	6.77	6.41		4.99		
19-Jul	8.45	7.82	8.95		8.18		
20-Jul	7.41	6.69	7.70		7.13		
21-Jul	7.22	6.59	6.90		4.56	1.00	

Date	Downstream Floodgate	Upstream Floodgate	Upper Main Channel	Blind Ch 1	Blind Ch 2	Blind Ch 3	Management Period
22-Jul	7.39	6.76	8.36			0.19	Summer Irrigation Period
23-Jul	7.26	6.23	5.93				
24-Jul	7.36	6.75	6.51			0.07	
25-Jul	8.10	7.32	8.08				
26-Jul	8.09	7.18	7.98				
27-Jul	8.07	7.17	8.06				
28-Jul	8.23	7.46	8.85			0.32	
29-Jul	8.38	7.54	9.31			0.33	
30-Jul	8.29	7.55	9.03				
31-Jul	8.42	7.89	9.46				
1-Aug	8.53	8.00	9.52				
2-Aug	8.29	7.85	9.00				
3-Aug	8.61	8.17	9.45				
4-Aug	7.98	6.62	9.50				
5-Aug	7.85	5.93	8.50				
6-Aug	7.49	6.23	6.92				
7-Aug	7.48	5.94	5.87	7.36			
8-Aug	6.71	5.07	7.14	6.87			
9-Aug	7.15	5.79	8.85	8.71			
10-Aug	7.37	6.45	9.55	9.43			
11-Aug	7.26	5.94	9.80	9.71			
12-Aug	6.92	4.87	10.24	9.53			
13-Aug	7.01	5.58	10.86	9.73			
14-Aug	7.06	5.77	7.81	9.17			
15-Aug	7.15	6.13	9.32	10.06			
16-Aug	7.40	6.68	8.29	10.42			
17-Aug	8.07	7.18	6.13	9.87			
18-Aug	7.71	7.11	6.66	9.10			
19-Aug	7.60	7.06	6.37	9.33			
20-Aug	7.71	7.07	8.41	9.36			
21-Aug	7.90	7.49	8.75	4.65			
22-Aug	8.09	7.59	8.63	0.41			
23-Aug	8.07	7.78	9.27	0.55	9.43		
24-Aug	8.74	8.15	11.83	11.02	10.12		
25-Aug	8.65	7.87	10.98	9.61	9.28		
26-Aug	8.34	7.62	10.81	10.04	9.76		
27-Aug	8.08	7.77	11.46	10.60	10.04		
28-Aug	7.92	7.63	11.14	10.11	9.37		
29-Aug	7.98	7.92	11.50	9.85	10.16		
30-Aug	8.76	8.08	12.46	10.21	10.20		

Date	Downstream Floodgate	Upstream Floodgate	Upper Main Channel	Blind Ch 1	Blind Ch 2	Blind Ch 3	Management Period
31-Aug	8.77	8.10	12.40	10.61	9.94		Summer Irrigation Period
1-Sep	8.93	8.03	11.68	10.32	9.79		
2-Sep	8.08	8.08	13.14	10.20	9.40		
3-Sep	8.92	7.89	15.12	10.46	9.10		
4-Sep	9.18	7.79	11.80		9.41		
5-Sep	8.75	7.89	10.79		9.43		
6-Sep	8.76	7.63	13.91		6.51	9.11	
7-Sep	8.70	7.45	13.07			7.29	
8-Sep	8.42	7.11	10.82			7.86	
9-Sep	8.04	6.58	10.15			8.20	
10-Sep	7.83	6.83	10.62			7.08	
11-Sep	7.92	6.75	11.45			7.96	
12-Sep	7.98	7.05	11.03			7.98	
13-Sep	8.12	7.65	11.94			8.59	
14-Sep	8.60	7.98	12.05			8.20	
15-Sep	8.58	7.96	12.33			8.39	
16-Sep	8.47	7.74	12.90			7.49	
17-Sep	8.39	7.67	12.61			7.78	
18-Sep	8.45	7.63	11.78			7.54	
19-Sep	8.41	7.58	11.54			7.16	
20-Sep	8.36	7.49	11.69			6.59	
21-Sep	8.03	7.23	9.20				
22-Sep	7.98	7.19	11.09				
23-Sep	8.08	7.16	12.55				
24-Sep	7.85	6.85	11.55				
25-Sep	7.62	6.56	11.92				
26-Sep	7.63	6.93	11.53				
27-Sep	7.85	7.42	12.18				
28-Sep	7.95	7.34	11.53				
29-Sep	8.11	7.40	12.31				
30-Sep	8.44	7.60	12.39				

Table C2. Water surface dissolved oxygen in mg/L taken during SRSC's fish monitoring at Fisher Slough in 2012. Data highlighted in bold indicate values lower than the restoration target of 8.0 mg/L.

Date	Down- stream of floodgate avg	Down- stream of floodgate min	Down- stream of floodgate max	Upstream of floodgate main ch index avg	Upstream of floodgate main ch index min	Upstream of floodgate main ch index max	Blind Ch 1 avg	Blind Ch 1 min	Blind Ch 1 max	Blind Ch 2 avg	Blind Ch 2 min	Blind Ch 2 max	Blind Ch 3 avg	Blind Ch 3 min	Blind Ch 3 max
2/14	13.8	13.8	13.8												
2/21	13.4	13.4	13.4	12.5	12.3	12.6	12.9	12.3	13.3	12.5	12.0	13.2	11.0	10.3	11.6
3/6							11.9	10.8	13.2	11.5	11.0	12.7			
3/15	12.9	12.8	13.0	13.2	13.0	13.5							11.7	11.5	11.9
3/19							12.9	12.2	15.1	12.5	11.7	13.8			
3/29	11.6	10.4	12.0	10.2	9.9	10.5							10.5	8.4	12.7
4/2							14.7	13.2	15.7	12.6	11.1	13.5			
4/12	12.6	11.9	13.0	12.0	11.6	12.7							11.4	10.4	12.4
4/16							12.1	11.3	12.9	11.8	11.5	12.1			
4/27	11.3	8.1	12.8	9.9	9.4	10.4							8.8	8.5	9.1
5/2							11.1	10.5	12.1	10.1	9.4	11.4			
5/10	10.6	9.0	12.0	9.7	9.4	9.9							9.4	9.0	9.8
5/15							10.9	10.5	11.4	7.4	6.8	8.0			
5/24	12.7	8.3	15.2	8.3	7.3	9.0							7.2	6.9	7.5
6/8	13.1	12.7	13.3	12.5	12.5	12.6							9.3	9.0	9.5
6/11							10.0	9.1	11.3	9.4	6.4	11.8			
7/9	11.5	11.0	11.9	10.0	8.6	10.9							8.6	8.4	8.9
7/18							8.3	8.2	8.7	6.5	4.4	7.1			
7/24	12.7	12.7	12.7	9.2	7.0	12.5							7.5	6.2	8.9

Table C3. Water bottom dissolved oxygen in mg/L taken during SRSC's fish monitoring at Fisher Slough in 2012. Data highlighted in bold indicate values lower than the restoration target of 8.0 mg/L.

Date	Down-stream of floodgate avg	Down-stream of floodgate min	Down-stream of floodgate max	Upstream of floodgate main ch index avg	Upstream of floodgate main ch index min	Upstream of floodgate main ch index max	Blind Ch 1 avg	Blind Ch 1 min	Blind Ch 1 max	Blind Ch 2 avg	Blind Ch 2 min	Blind Ch 2 max	Blind Ch 3 avg	Blind Ch 3 min	Blind Ch 3 max
2/14	13.6	13.6	13.6												
2/21	13.3	13.3	13.3	12.5	12.2	12.6	11.8	11.5	12.6	12.4	12.0	12.7	11.1	10.6	11.5
3/6							11.8	10.6	12.5						
3/15	12.7	12.7	12.8	12.8	12.6	13.1							11.8	11.8	11.9
3/19															
3/29	10.8	10.0	11.9	10.2	10.1	10.4							8.4	8.3	8.5
4/2										12.6	12.0	13.0			
4/12	11.9	11.7	12.1	11.8	11.4	12.1							11.2	11.2	11.2
4/16										11.9	11.3	12.6			
4/27	12.2	10.0	13.2	10.0	9.6	10.3							9.7	8.7	10.7
5/2							11.1	10.5	11.7	9.8	9.6	10.1			
5/10	10.6	8.8	11.5	9.4	9.1	9.5							8.6	8.0	9.2
5/15							10.7	10.1	11.2	7.0	6.4	8.0			
5/24	11.1	7.9	12.5	7.5	7.0	8.1							6.6	6.4	6.7
6/8	12.8	12.6	12.9	12.4	12.4	12.5							9.4	9.3	9.4
6/11							10.1	9.6	10.6	8.1	6.2	10.0			
7/9	11.2	10.9	11.6	10.4	9.7	10.9							9.5	8.7	10.3
7/18							8.0	7.8	8.2	5.3	3.1	6.0			
7/24	12.4	12.4	12.4	8.7	6.9	10.9							6.7	6.5	6.9

Water Temperature

This section shows surface water temperature data relevant to Hypothesis H2, parameter 2.

Data presented show the seasonal variation of water surface temperatures recorded by Solinst data loggers at five sites and one AquiStar® model PS9805 data logger, which is located on the upstream face of the floodgate headwall. Two of the loggers, one at the Downstream Floodgate site and one near the historic Big Ditch Crossing (now called Blind Ch 3) have been in place since 2009. Three Solinst loggers were added in March 2012 at sites created during the dike setback and channel relocation of Project Element 3 at Upper Main Channel, Blind Ch 1 and Blind Ch 2. The AquiStar data logger at the Upstream Floodgate site has been in place since January 2010. Data were taken at 15-minute intervals. The data logger probe is located at the bottom of the water column. The floodgates were disengaged during October, 2011 for the completion of Project Element 3, the dike setback and channel relocation phase of the construction. They were engaged on October 31, 2011 and operated under normal conditions until the middle of the summer. The floodgates were disengaged from August 3 to August 20 to help facilitate low water for a Dike District 3 maintenance project in Hill Ditch located upstream of the Fisher Slough restoration area (Figures C3 and C14). Programming problems with the Solinst data logger occurred at the Upper Main Channel site resulting in intermittent data until May 24, 2012.

The surface water temperature data for Water Year 2012 are plotted by floodgate management period in Figures C1 through C3 and by month in Figures C4 through C15 with data from the main channels shown in the top panel and data from the blind channels shown in the bottom panel of each figure. Please note difference in Y-axis in the monthly graphs starting in May.

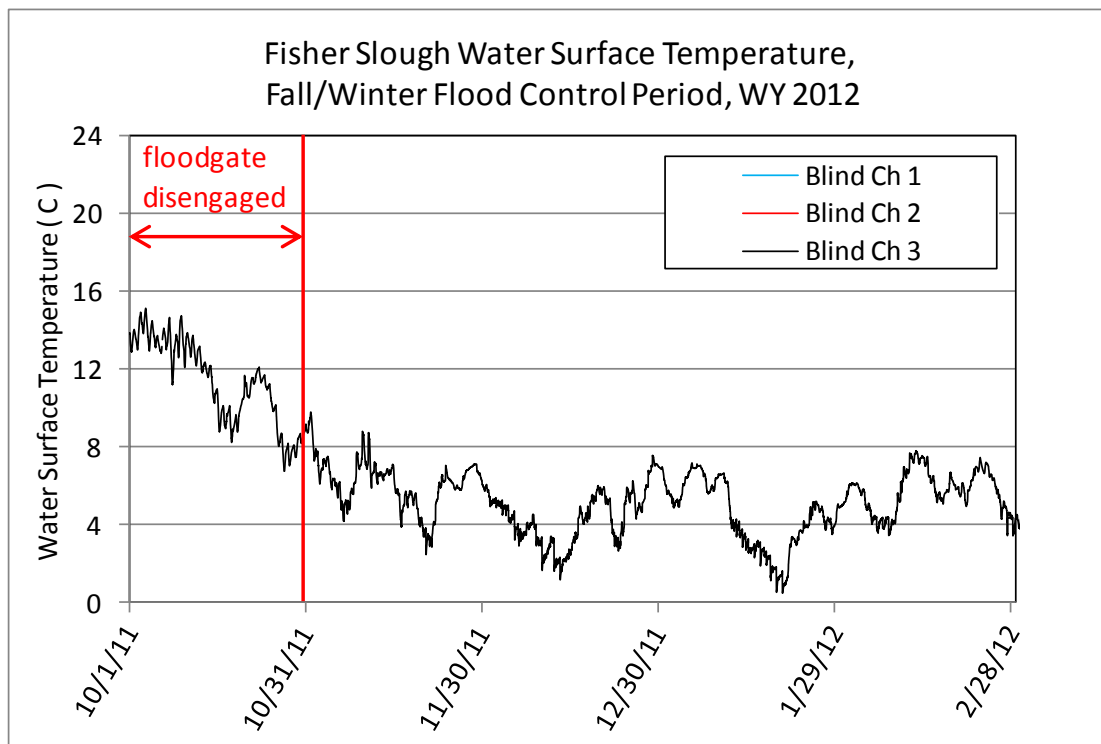
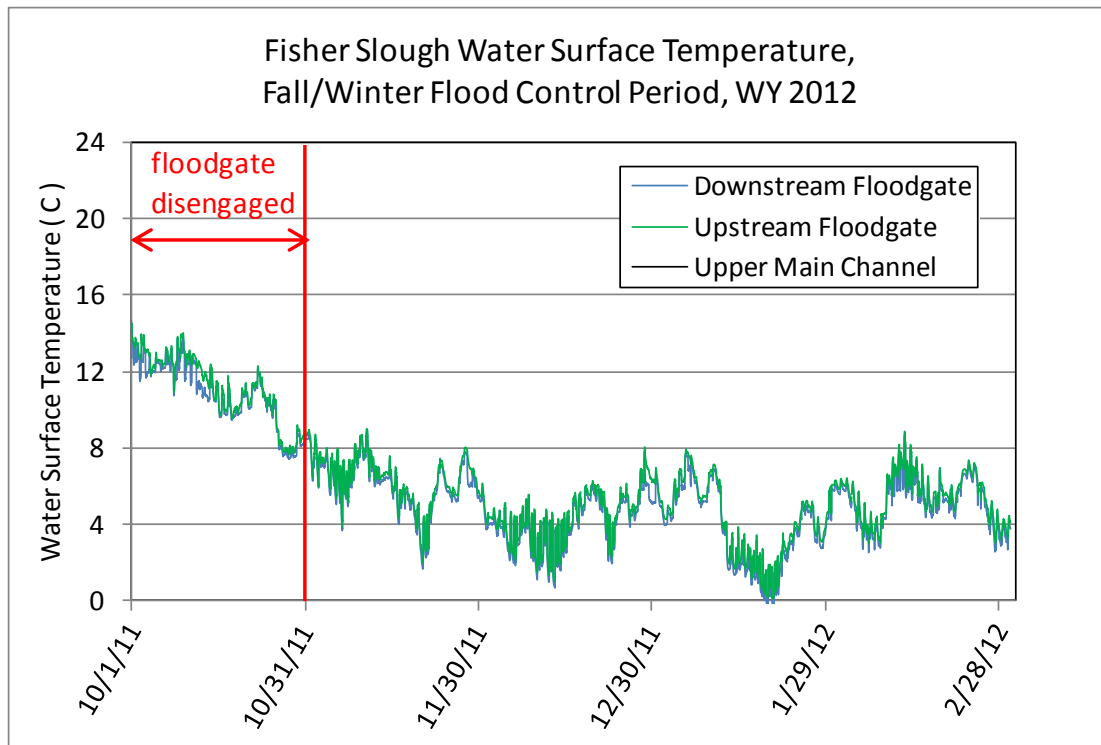


Figure C1. Surface water temperature at Fisher Slough during Fall/Winter Period of WY2012. The floodgate was disengaged during October for restoration construction relating to Project Element 3. The data logger at Upper Main Channel was installed on March 23, 2012. Loggers at Blind Ch1 and 2 were installed on March 5, 2012.

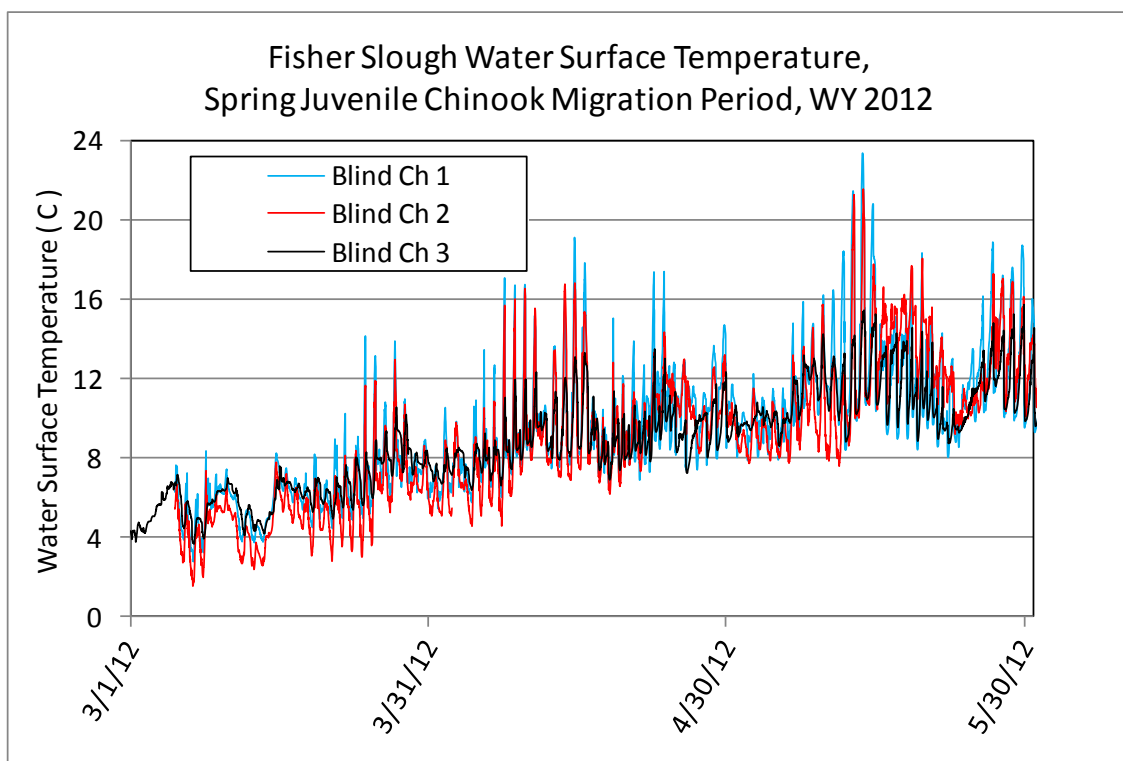
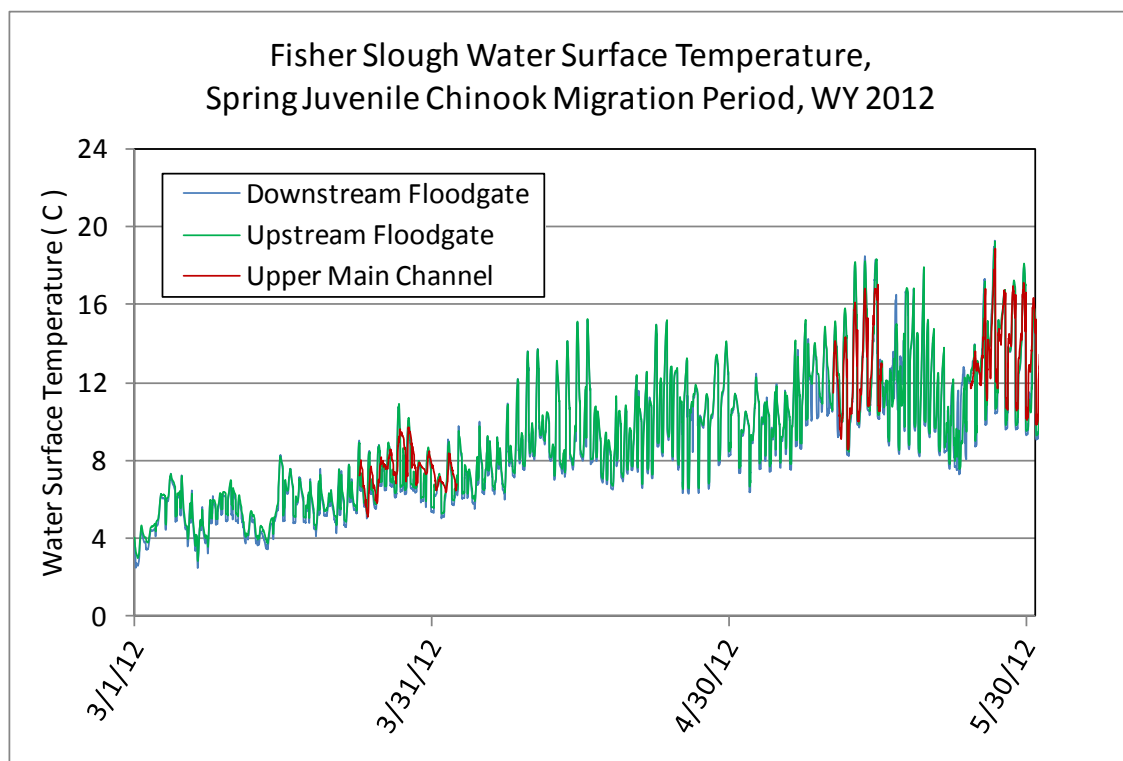


Figure C2. Surface water temperature at Fisher Slough during Spring Juvenile Chinook Migration Period of WY2012. The data logger at Upper Main Channel was installed on March 23, 2012. Loggers at Blind Ch1 and 2 were installed on March 5, 2012.

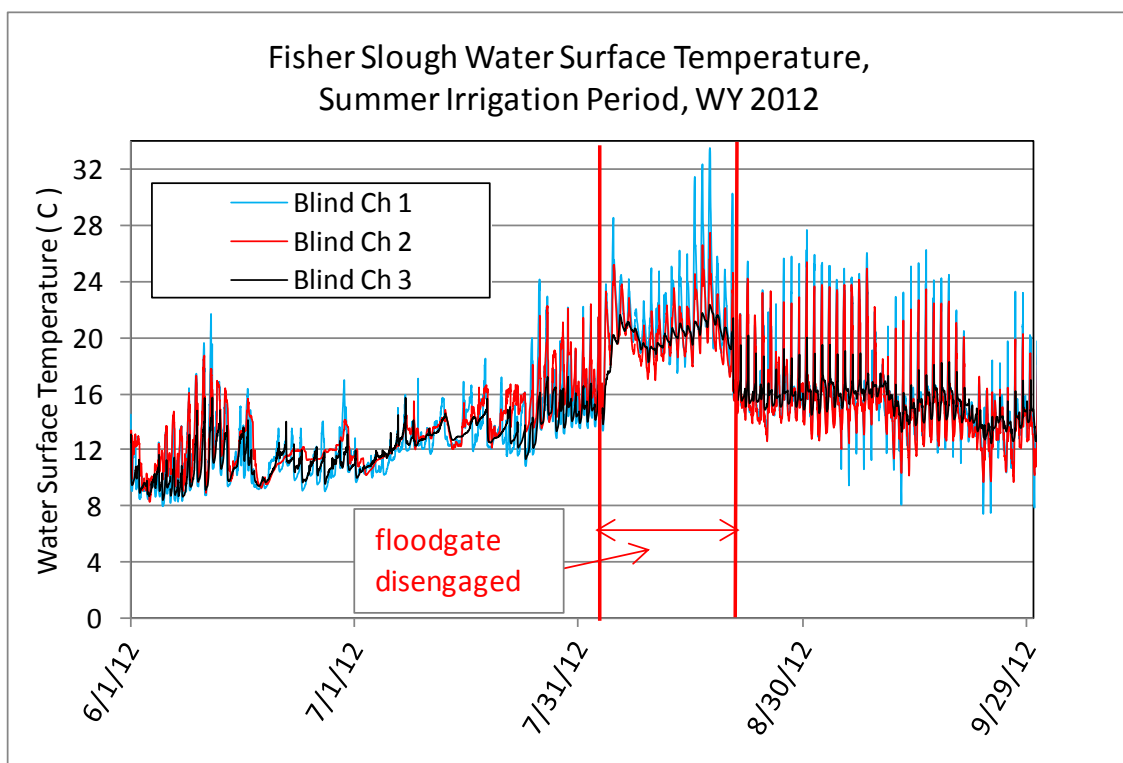
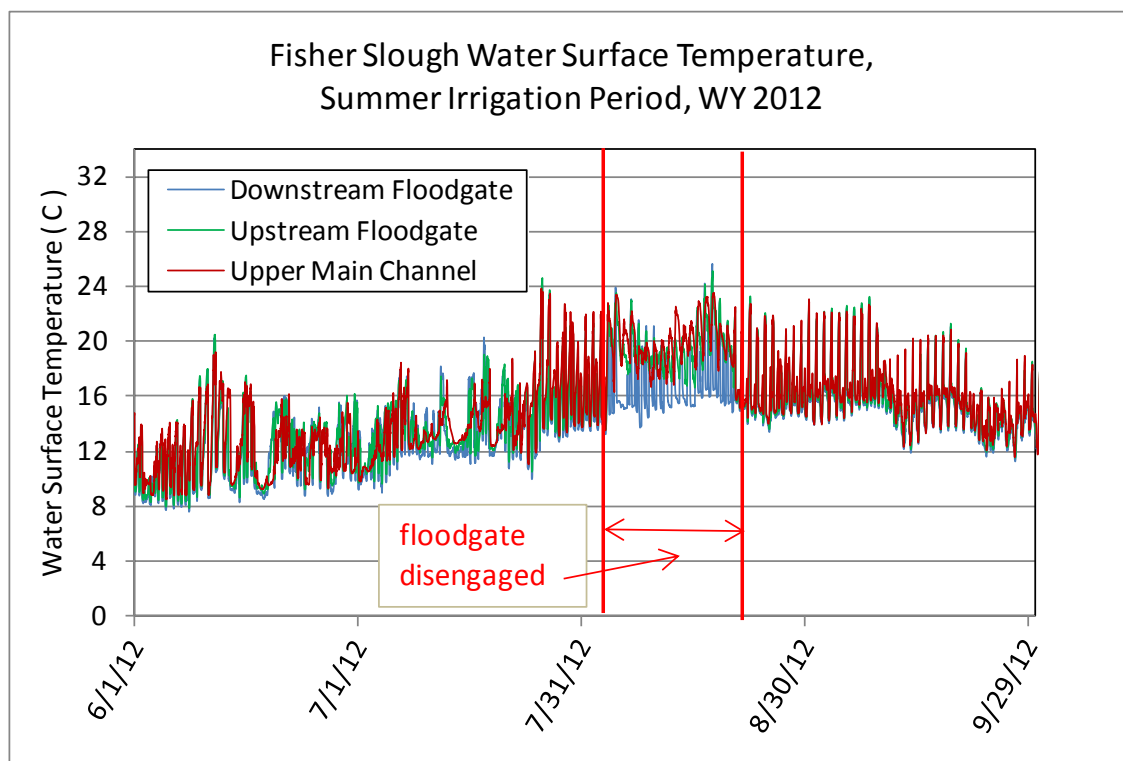


Figure C3. Surface water temperature at Fisher Slough during Summer Irrigation Period of WY2012. Floodgate was disengaged for a Dike District 3 maintenance project in Hill Ditch upstream of Fisher Slough from August 3 through August 20, 2012.

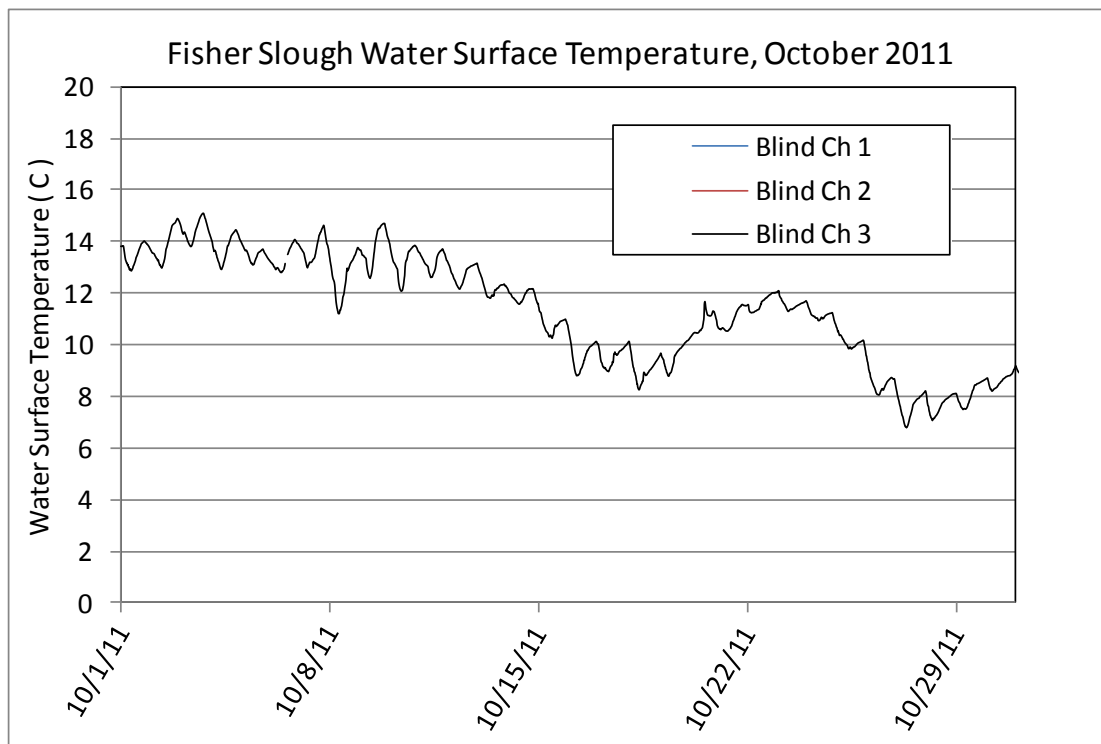
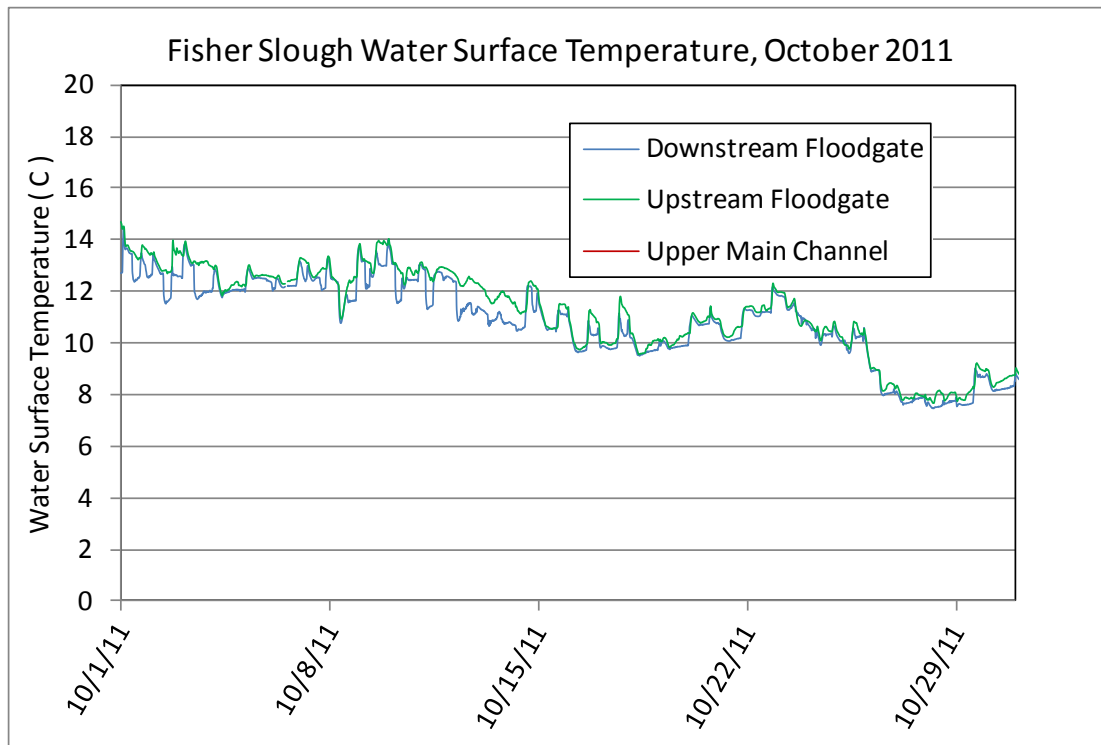


Figure C4. Surface water temperature at Fisher Slough during October 2011. The floodgate was disengaged during October for restoration construction relating to Project Element 3. The logger at Upper Main Channel was installed on March 23, 2012. Loggers at Blind Ch1 and 2 were installed on March 5, 2012.

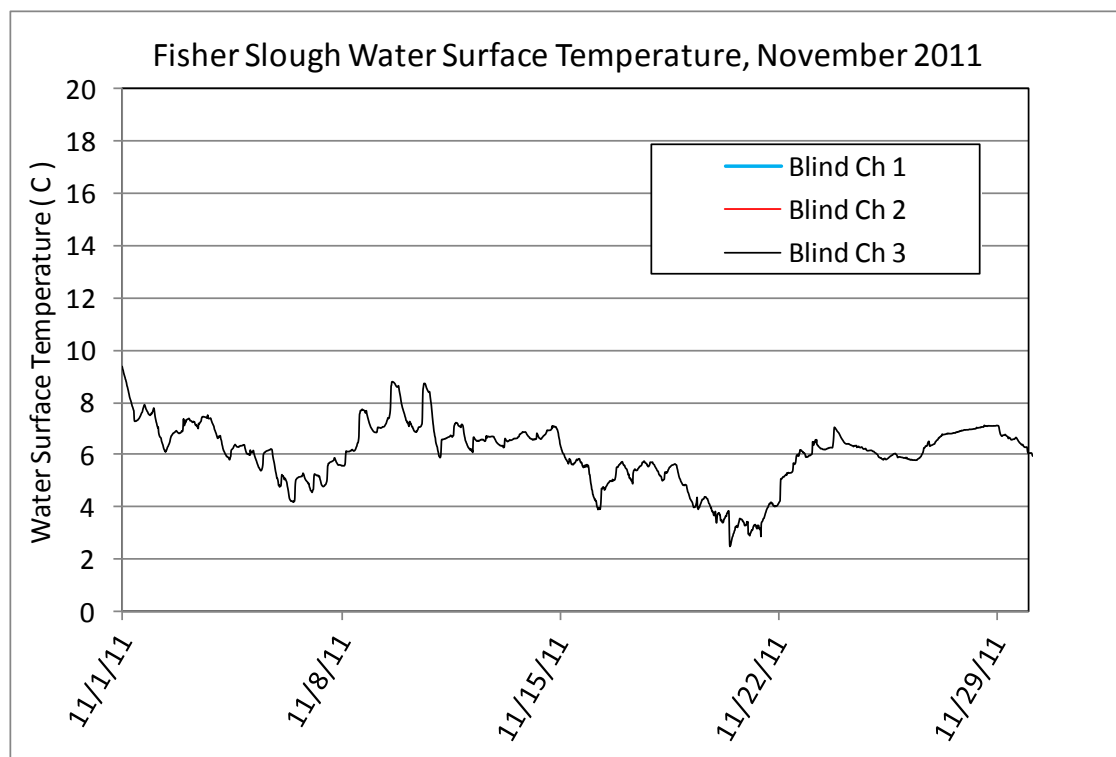
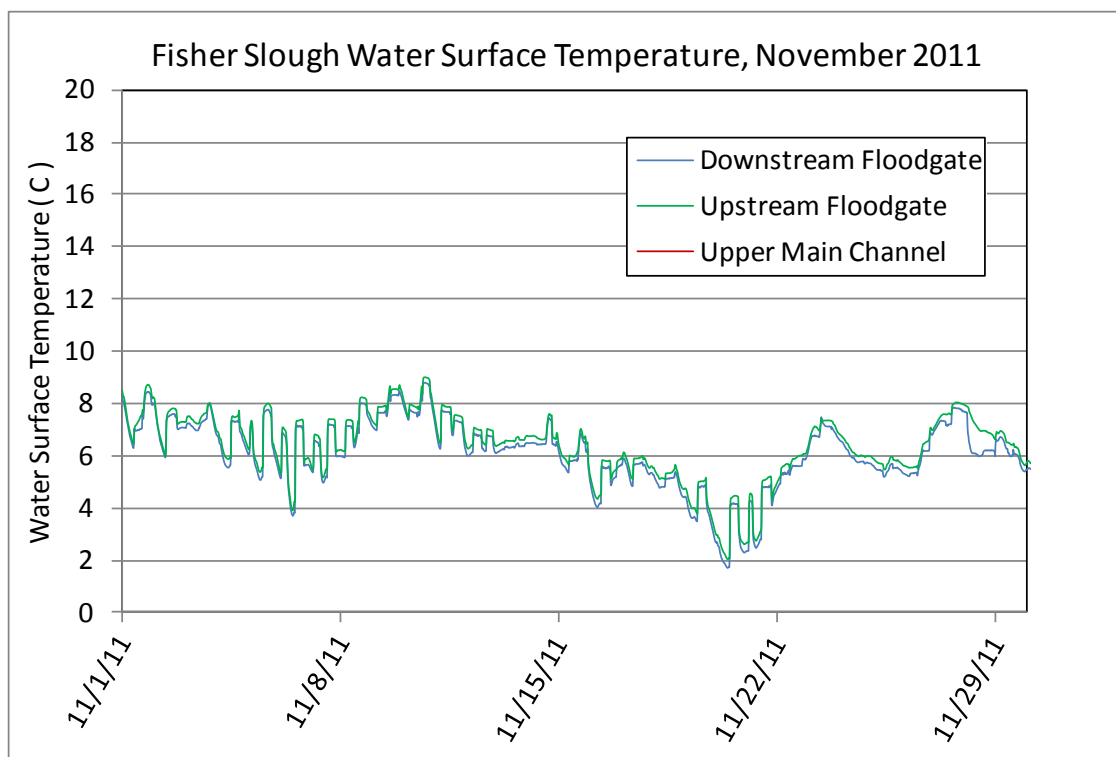


Figure C5. Surface water temperature at Fisher Slough during November 2011. The logger at Upper Main Channel was installed on March 23, 2012. Loggers at Blind Ch1 and 2 were installed on March 5, 2012.

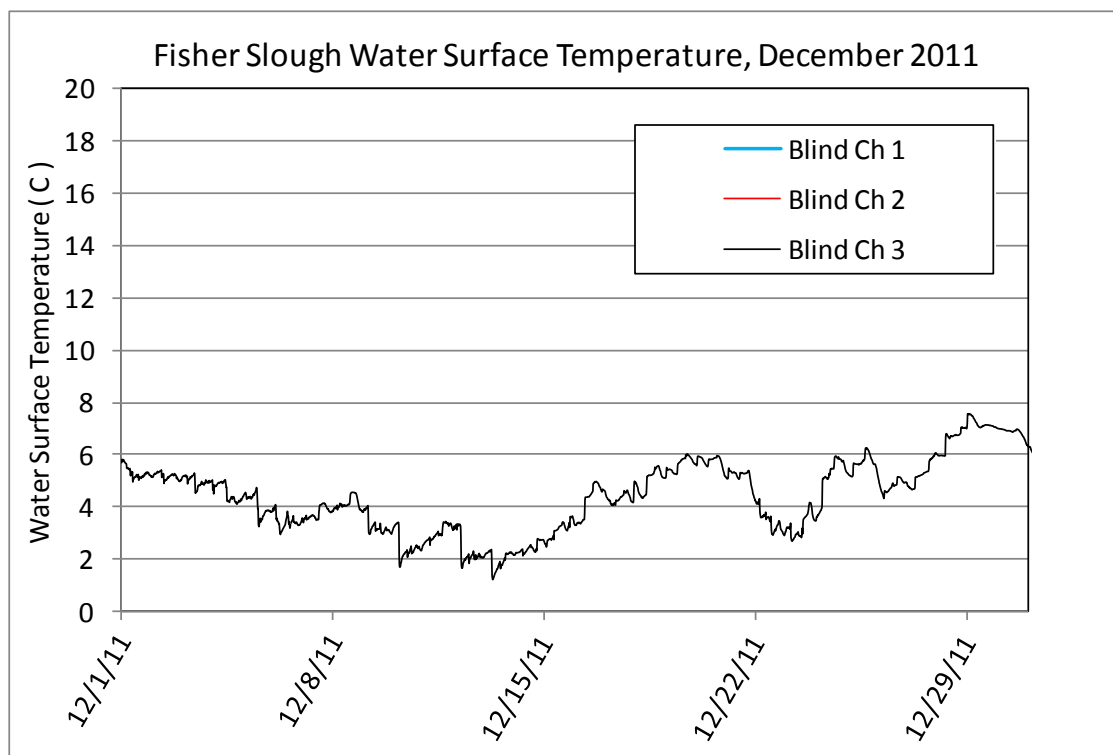
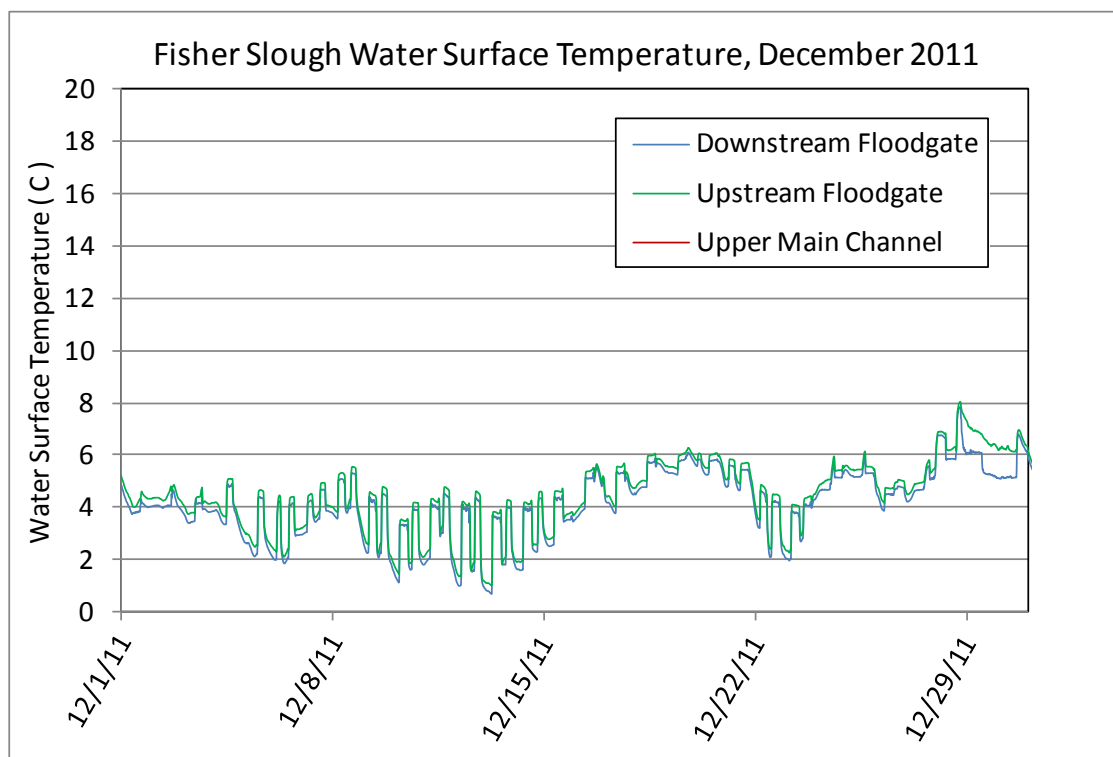


Figure C6. Surface water temperature at Fisher Slough during December 2011. The logger at Upper Main Channel was installed on March 23, 2012. Loggers at Blind Ch1 and 2 were installed on March 5, 2012.

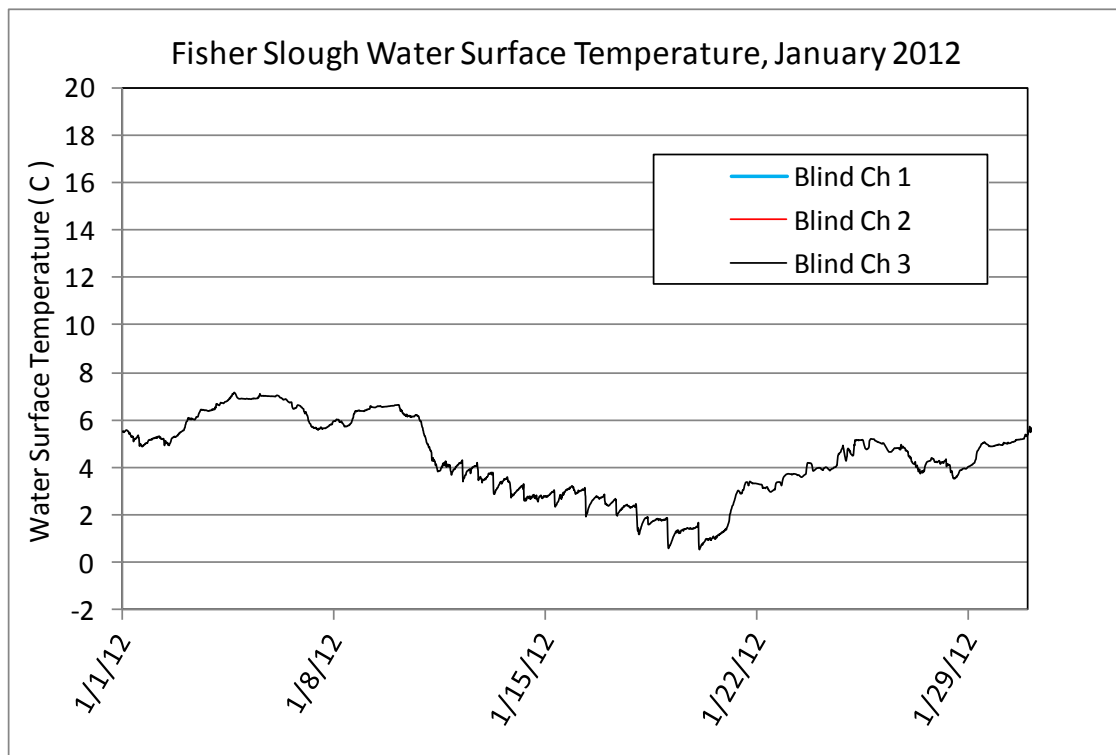
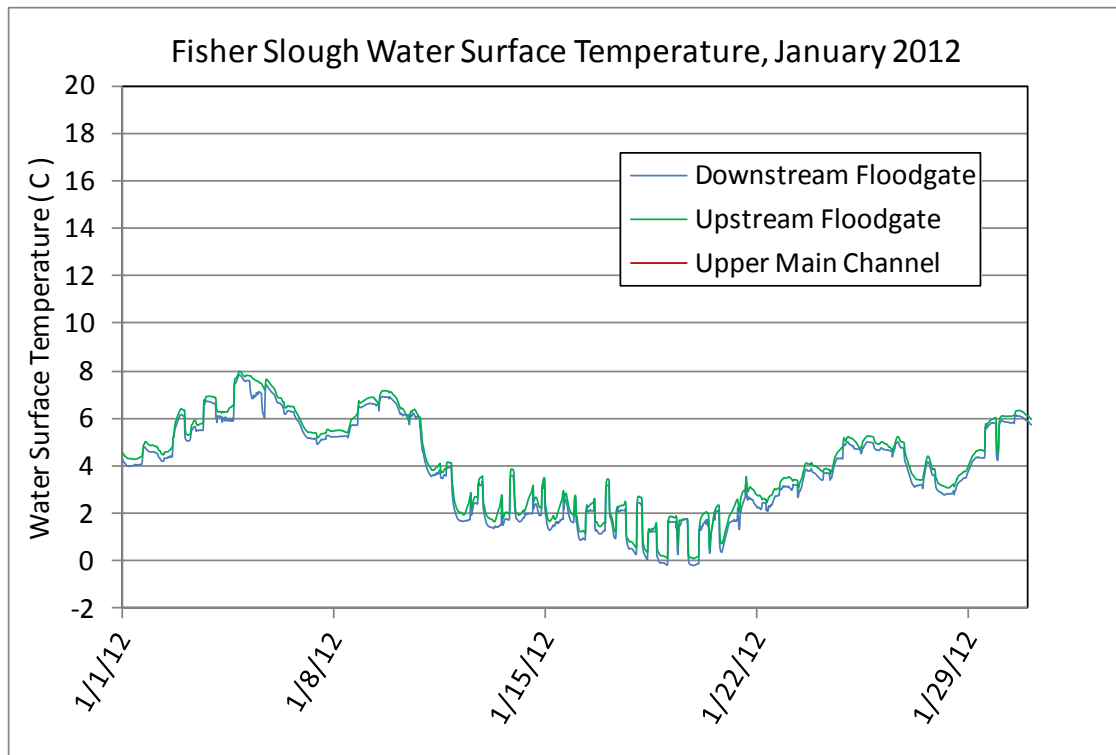


Figure C7. Surface water temperature at Fisher Slough during January 2012. The logger at Upper Main Channel was installed on March 23, 2012. Loggers at Blind Ch1 and 2 were installed on March 5, 2012.

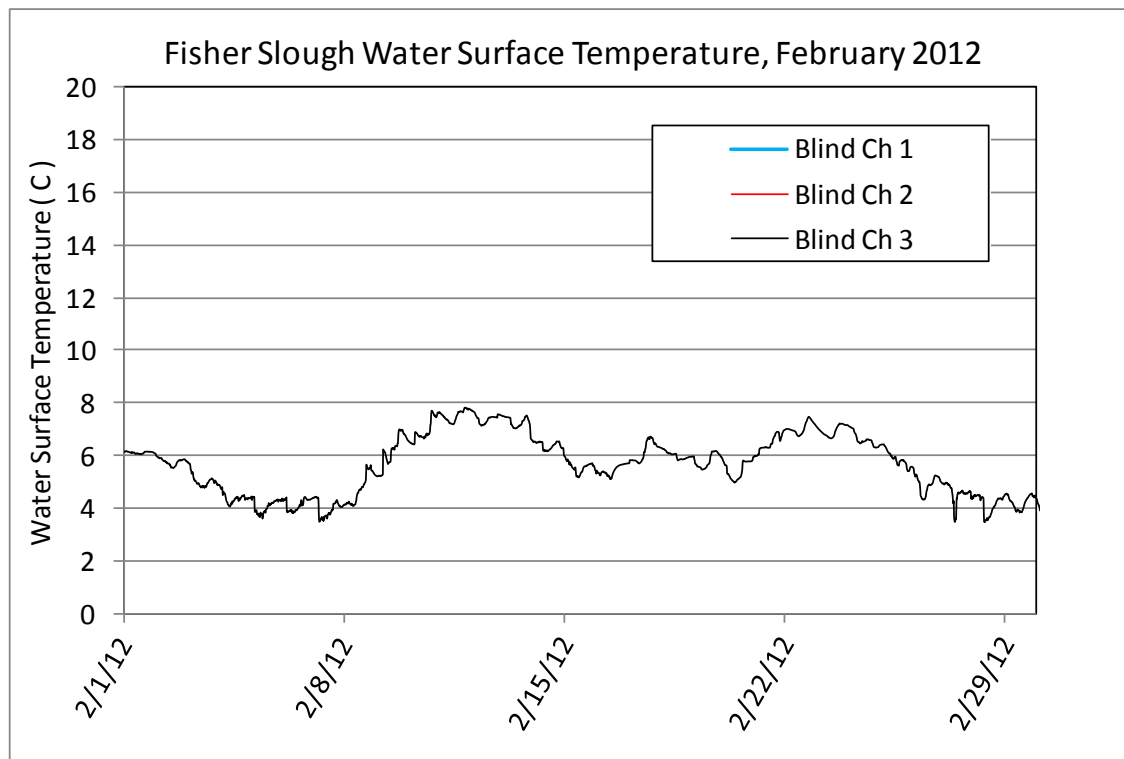
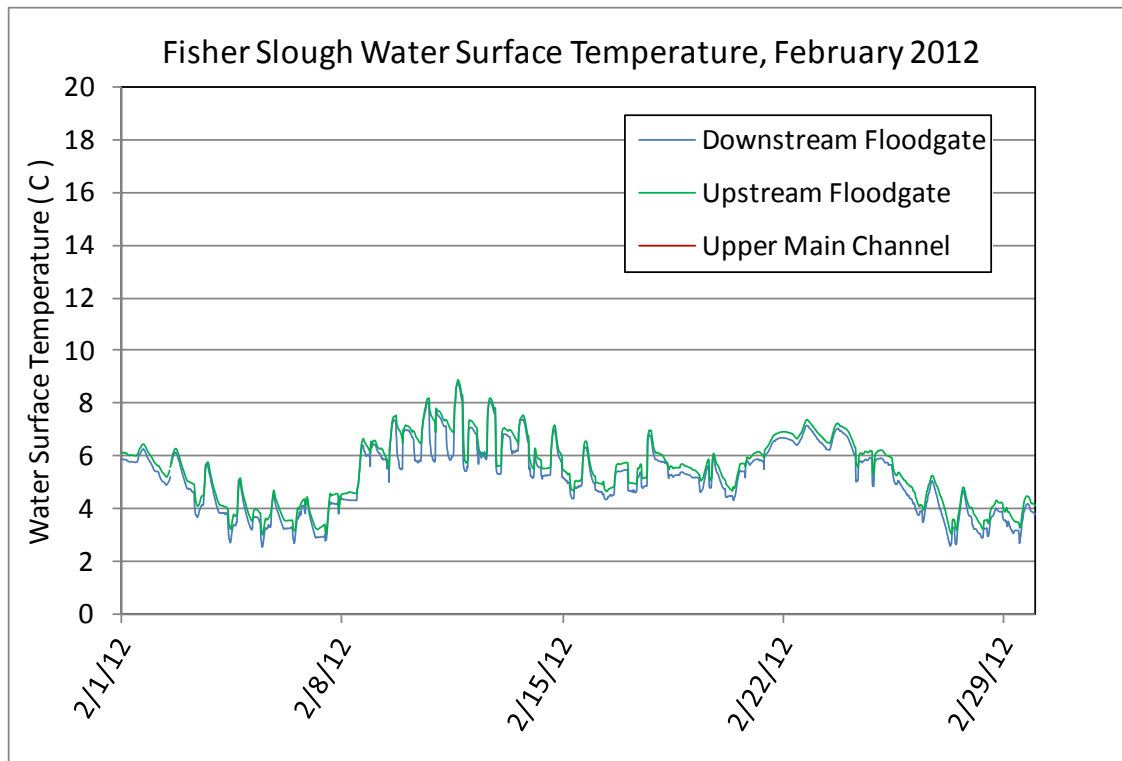


Figure C8. Surface water temperature at Fisher Slough during February 2012. The logger at Upper Main Channel was installed on March 23, 2012. Loggers at Blind Ch1 and 2 were installed on March 5, 2012.

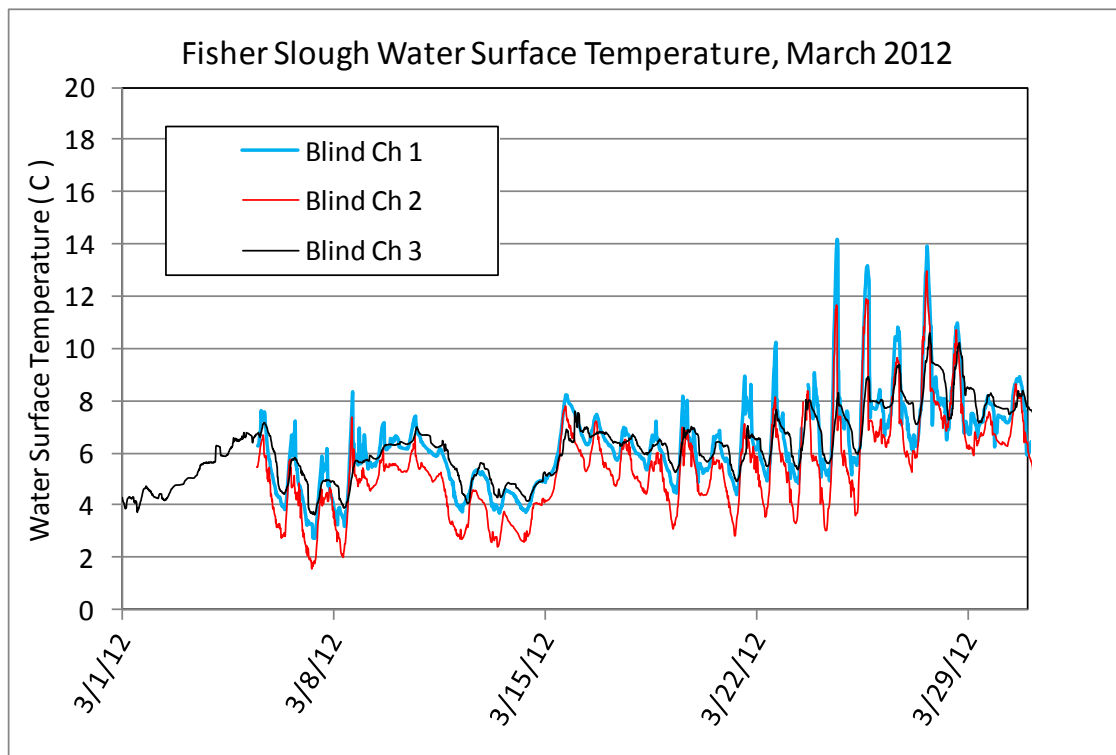
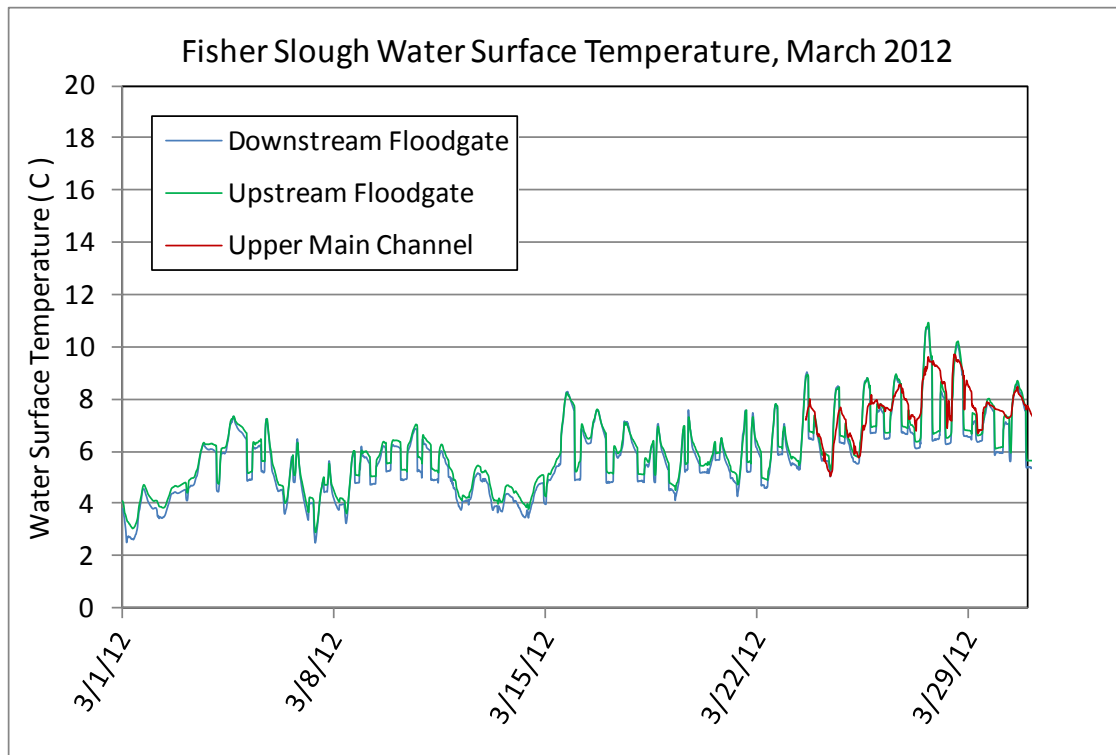


Figure C9. Surface water temperature at Fisher Slough during March 2012. Loggers at Blind Ch1 and 2 were installed on March 5, 2012. The logger at Upper Main Channel was installed on March 23, 2012 and had recorded data intermittently until May 24.

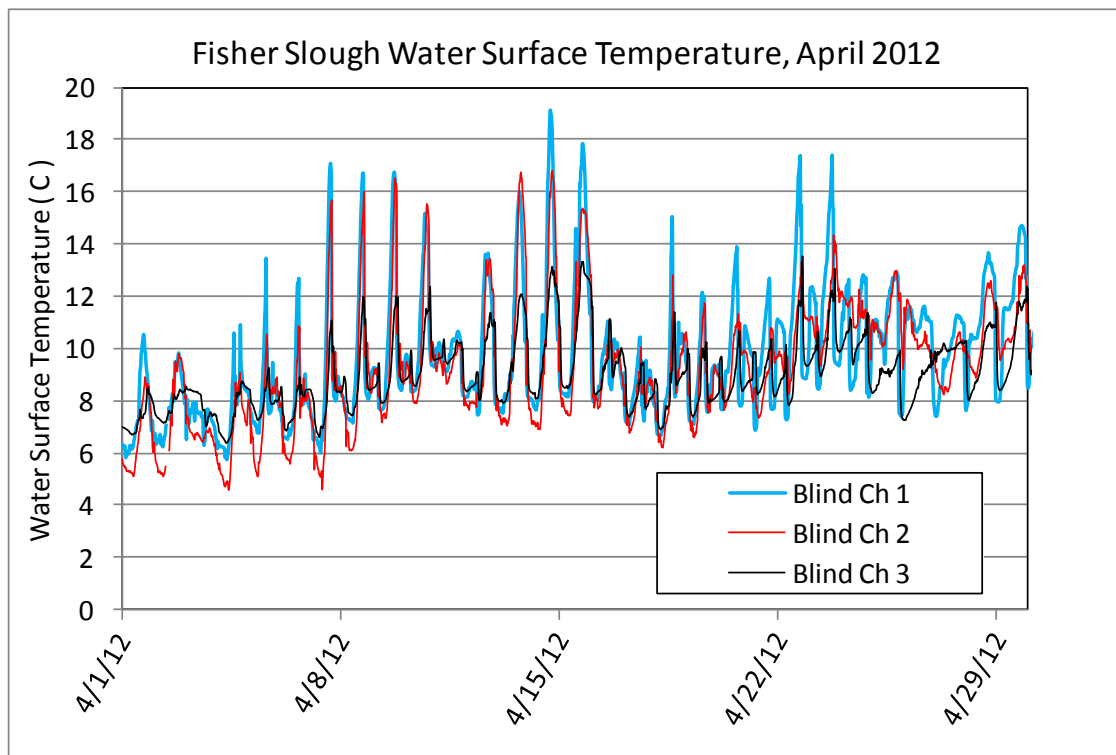
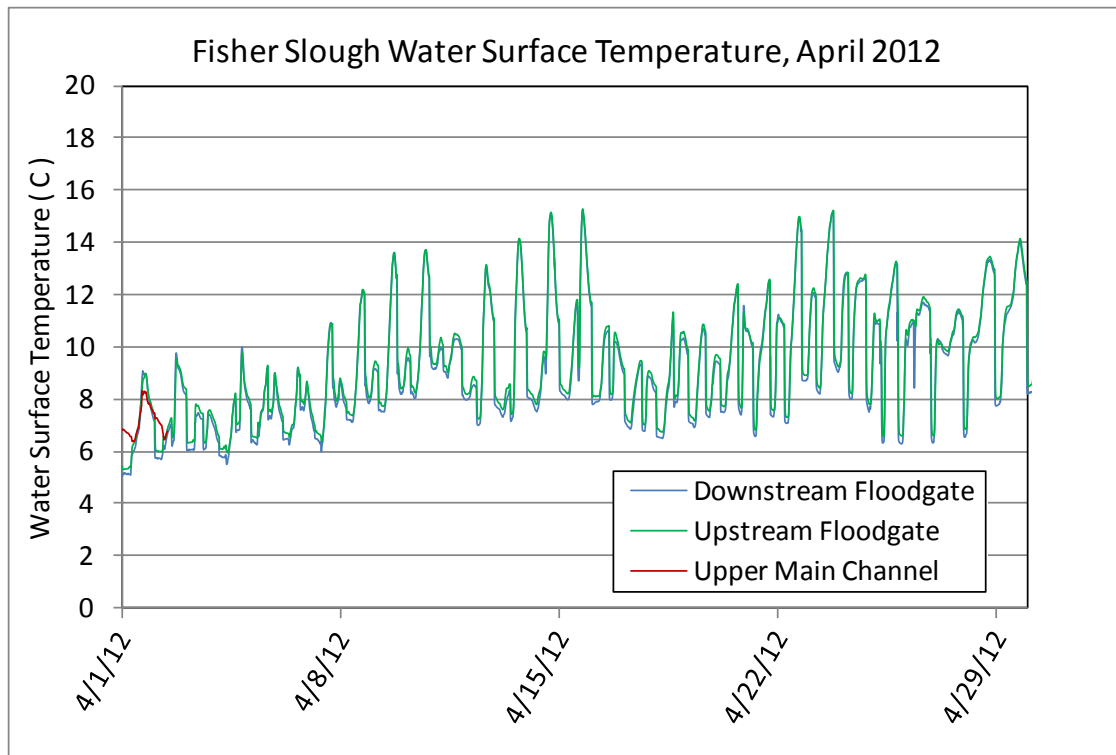


Figure C10. Surface water temperature at Fisher Slough during April 2012. The logger at Upper Main Channel was installed on March 23, 2012 and had recorded data intermittantly until May 24.

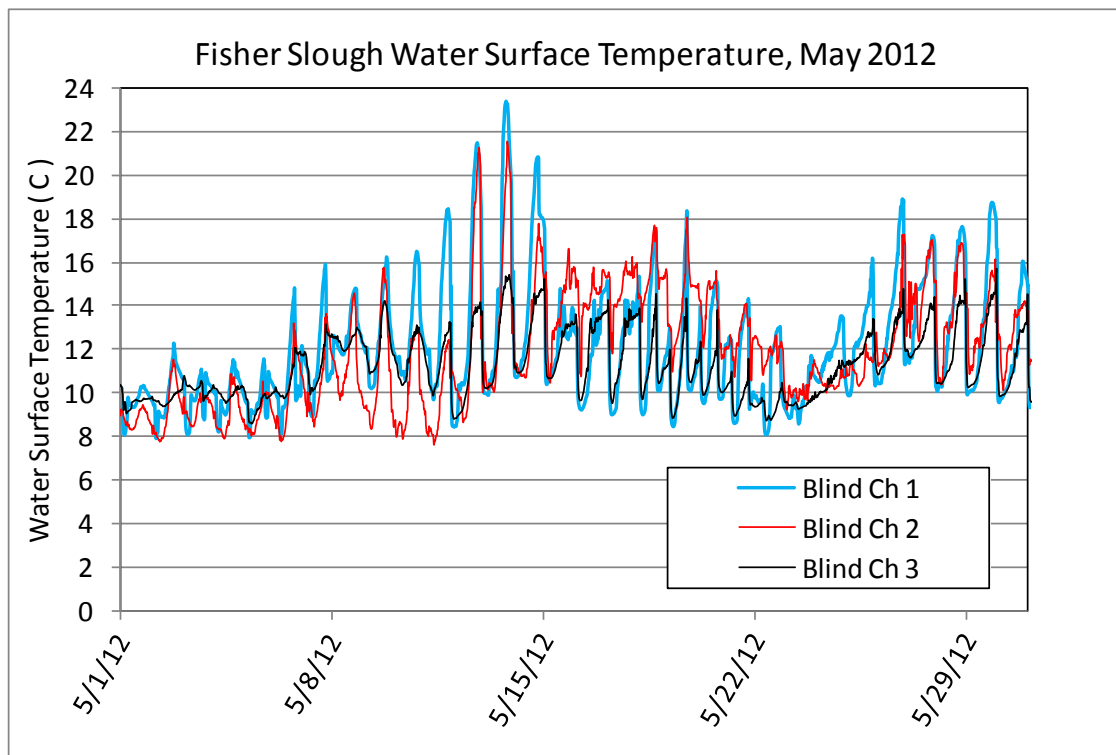
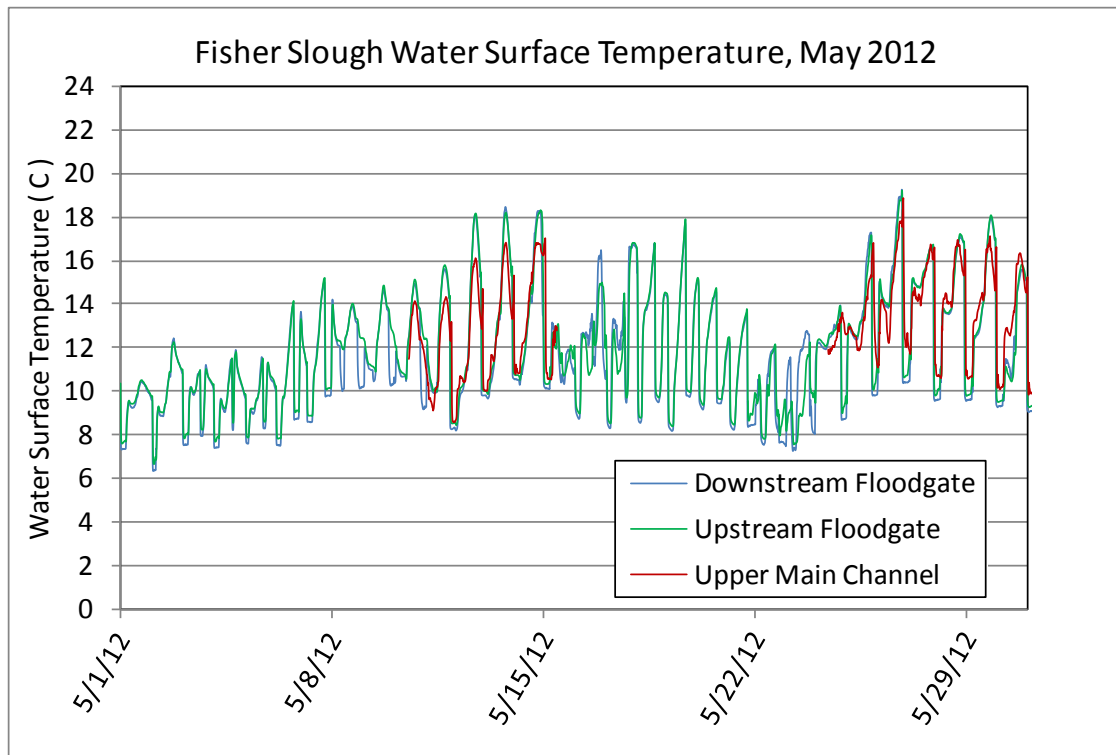


Figure C11. Surface water temperature at Fisher Slough during May 2012. The logger at Upper Main Channel was installed on March 23, 2012 and had recorded data intermittently until May 24.

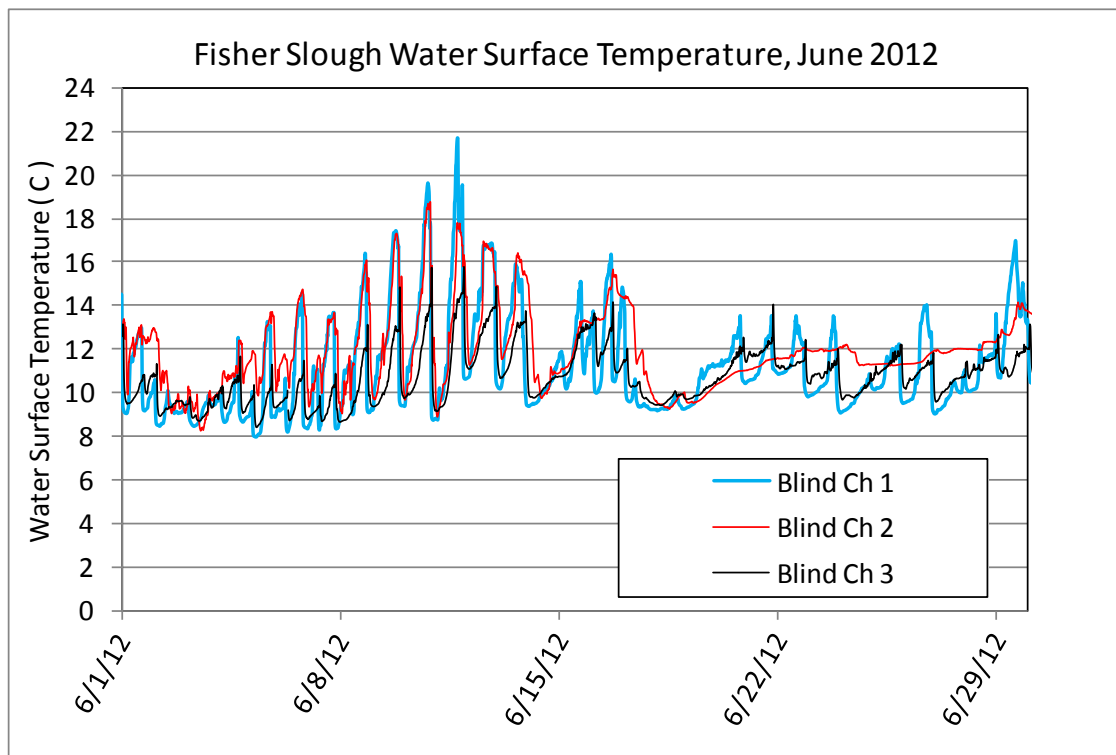
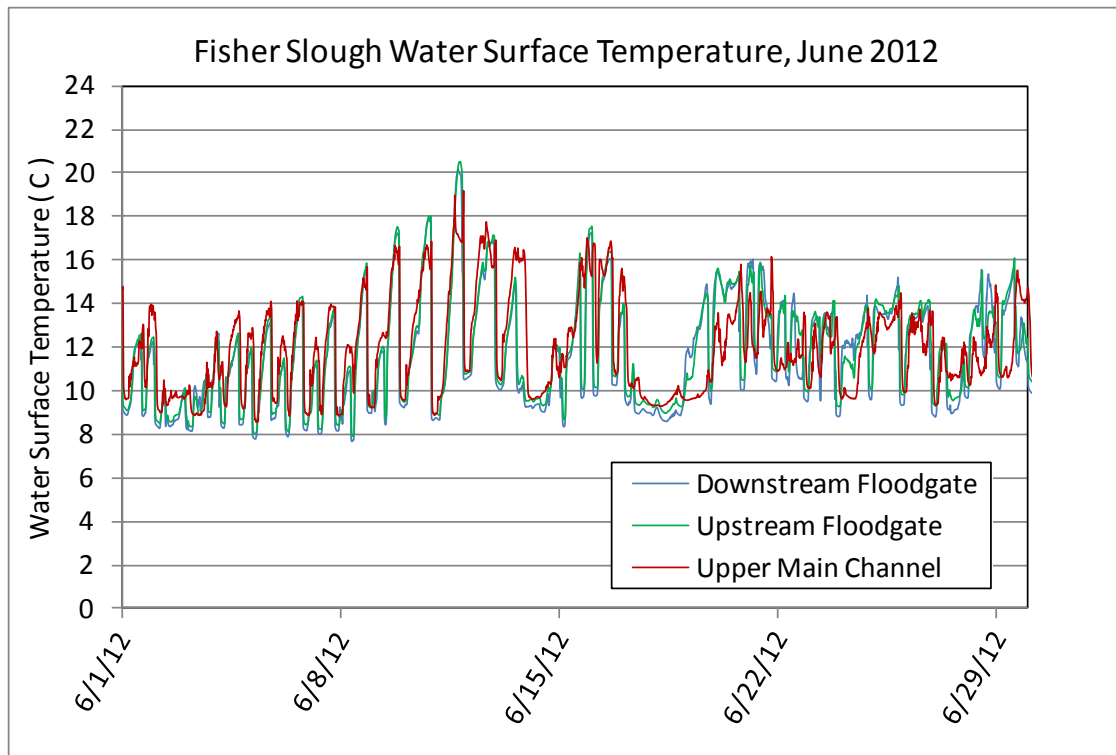


Figure C12. Surface water temperature at Fisher Slough during June 2012.

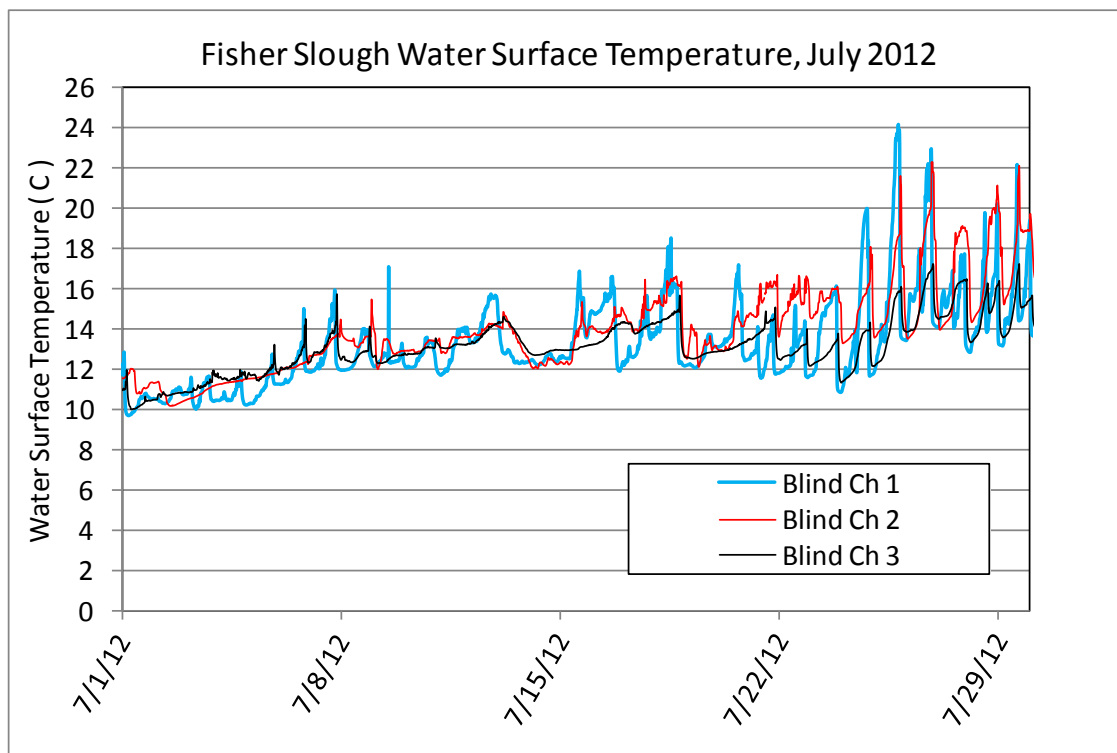
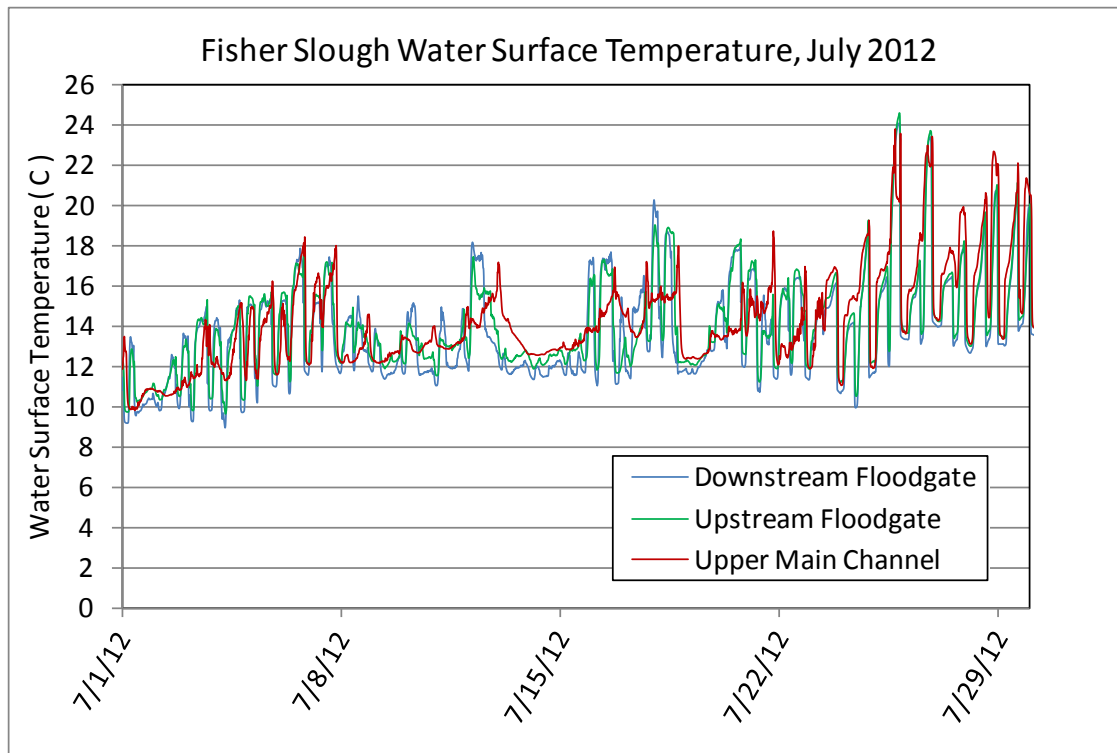


Figure C13. Surface water temperature at Fisher Slough during July 2012.

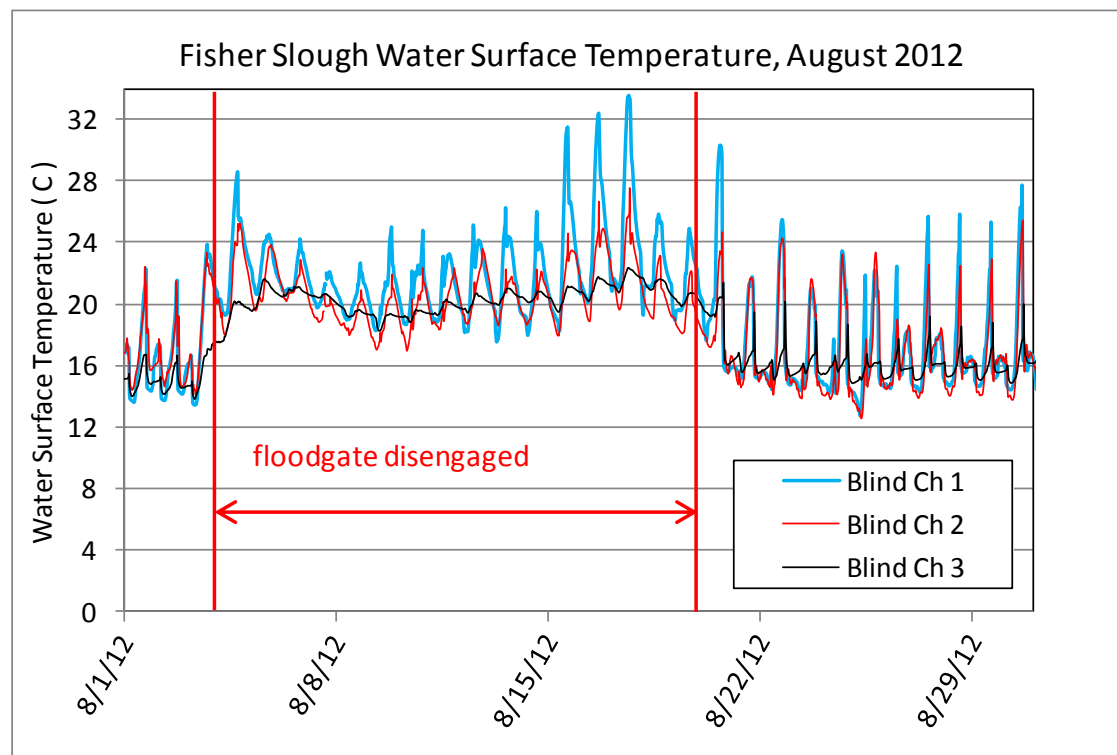
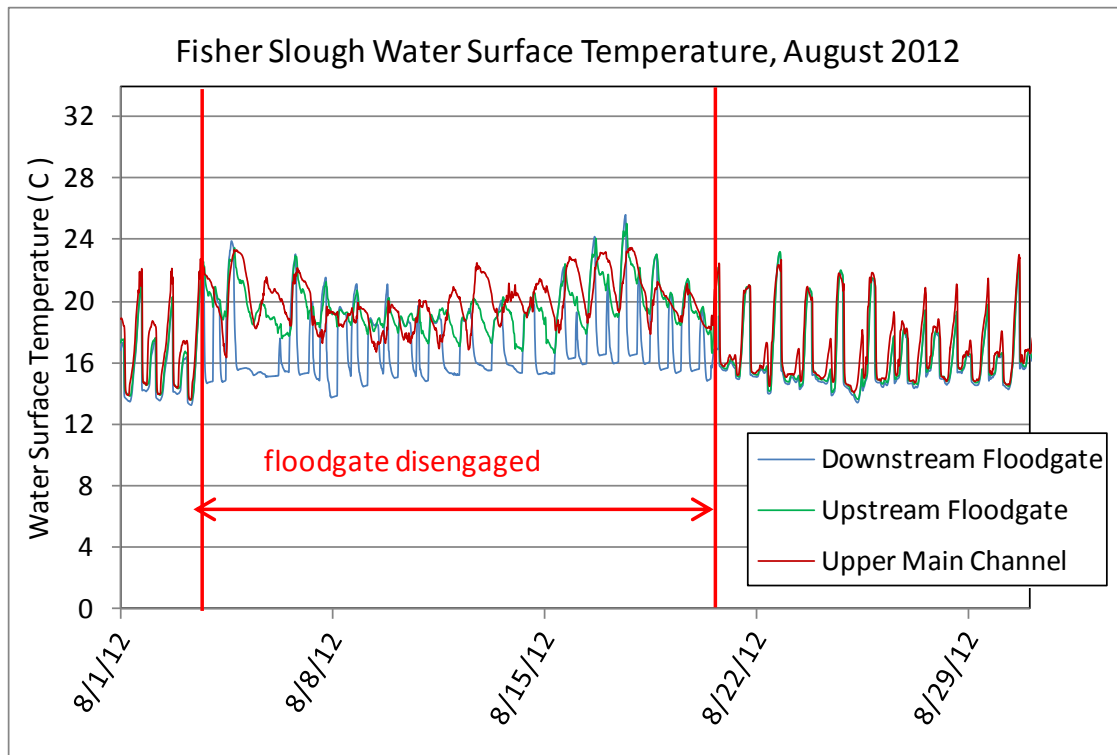


Figure C14. Surface water temperature at Fisher Slough during August 2012. The floodgate was disengaged for a Dike District 3 maintenance project in Hill Ditch upstream of Fisher Slough from August 3 through August 20, 2012.

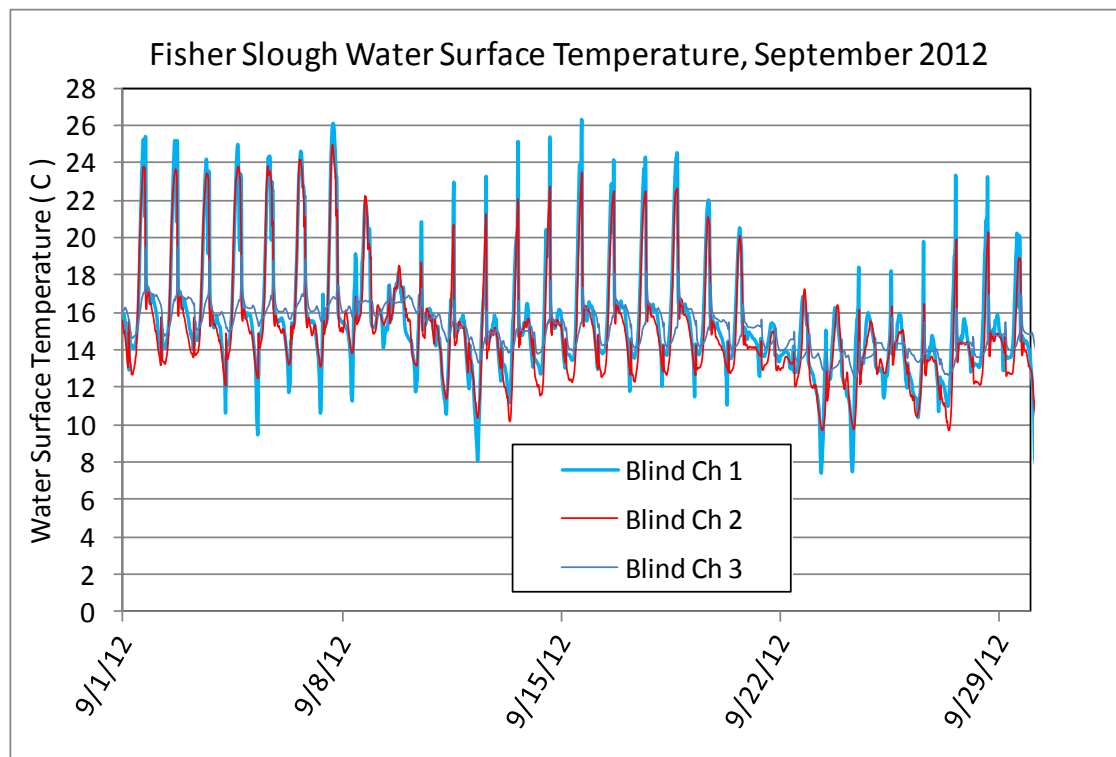
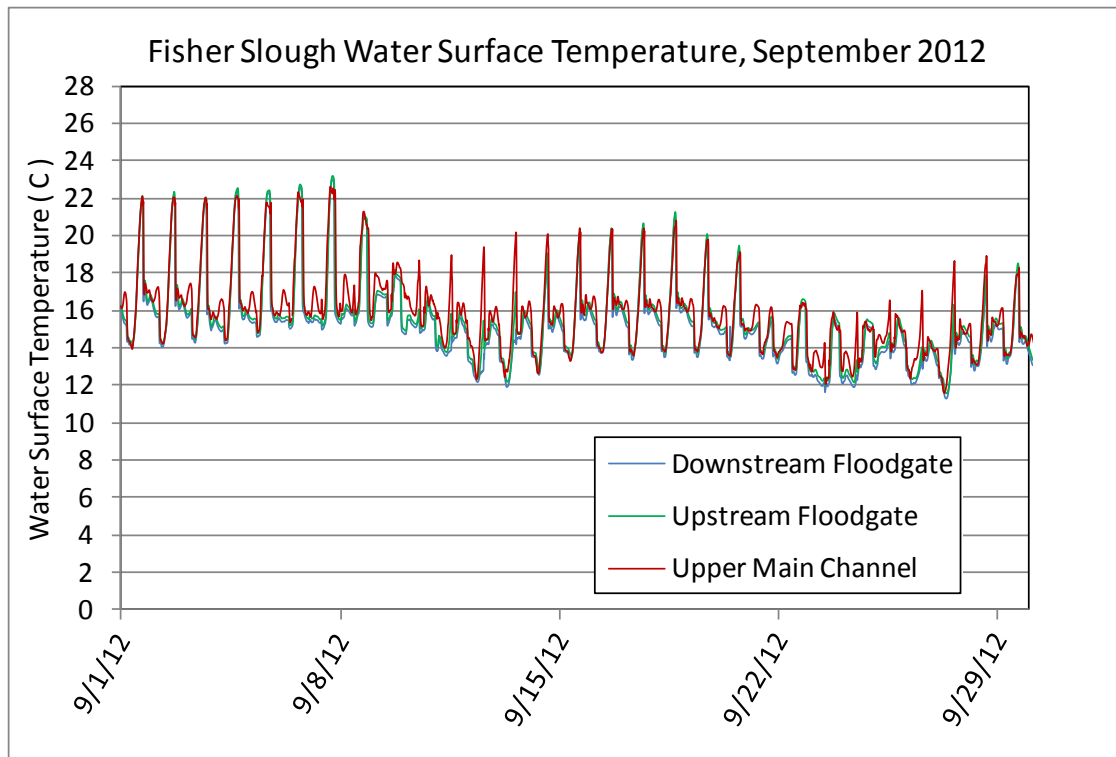


Figure C15. Surface water temperature at Fisher Slough during September 2012.

Appendix D – Site Photographs



Figure D.1. Location of points from which quarterly photos were taken in 2012 (all photos by Joelene Boyd of The Nature Conservancy). Project area is outlined in yellow.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS01 Photograph 1: Taken from the south bank of Fisher Slough at the railroad bridge looking at the downstream side of floodgates.



FS02 Photograph 1: Taken from the north bank of Fisher Slough at the highway bridge looking at the upstream side of floodgates.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS02 Photograph 2: Taken from the north bank of Fisher Slough at the highway bridge looking southwest.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS02 Photograph 3: Taken from the north bank of Fisher Slough at the highway bridge looking southwest at the new crossing for Big Ditch, the new south levee, and Smith A.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS03 Photograph 1: Taken from the south levee of Fisher Slough looking at the upstream side of floodgates.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS03 Photograph 2: Taken from the south levee of Fisher Slough looking northward at north levee.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS03 Photograph 3: Taken from the south levee of Fisher Slough looking eastward at Fisher Slough.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS03 Photograph 4: Taken from the south levee of Fisher Slough looking southeast at Smith A.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS03 Photograph 5: Taken from the south levee of Fisher Slough looking south at the new Big Ditch.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS04 Photograph 1: Taken from the north levee of Fisher Slough looking southeast at the second marsh island and Fisher Slough.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS04 Photograph 2: Taken from the north levee of Fisher Slough looking upstream at the marsh islands and channel, with Smith A in the background.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS04 Photograph 3: Taken from the north levee of Fisher Slough looking southwest at the middle marsh island and Smith A.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS04 Photograph 4: Taken from the north levee of Fisher Slough looking downstream at the marsh islands and Fisher Slough.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS05 Photograph 1: Taken from the north levee of Fisher Slough at the historic Big Ditch Crossing looking upstream at Fisher Slough.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS05 Photograph 2: Taken from the north levee of Fisher Slough at the historic Big Ditch Crossing looking southward at the downstream end of main tidal channel realignment.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS05 Photograph 3: Taken from the north levee of Fisher Slough at the historic Big Ditch Crossing looking southward. The historic crossing structure can be seen January through July.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS05 Photograph 4: Taken from the north levee of Fisher Slough at the historic Big Ditch Crossing looking westward at Fisher Slough and Smith A.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS05 Photograph 5: Taken from the north levee of Fisher Slough at the historic Big Ditch Crossing looking downstream at Fisher Slough and Smith A.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS05 Photograph 6: Taken from the north levee of Fisher Slough at the historic Big Ditch Crossing looking northeastward at the remnant of the historic Big Ditch, upstream of Fisher Slough crossing.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS06 Photograph 1: Taken from the eastern end of the north levee, near an old shed and gate structure looking upstream at Carpenter Creek/Fisher Slough and the upstream end of the new main tidal channel realignment.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS06 Photograph 2: Taken from the eastern end of the north levee, near an old shed and gate structure looking southward at Fisher Creek mouth.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS06 Photograph 3: Taken from the eastern end of the north levee, near an old shed and gate structure looking southwestward at Fisher Slough and Smith B.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS06 Photograph 4: Taken from the eastern end of the north levee, near an old shed and gate structure looking downstream at the historic south levee (gone by October), and Fisher Slough.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS07 Photograph 1: Taken from near the southern edge of the Moyer property, east of Little Fisher Creek looking west.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS07 Photograph 2: Taken from near the southern edge of the Moyer property, east of Little Fisher Creek looking northwest with Smith B in background.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS08 Photograph 1: Taken from the southeast corner of Smith B, on the hillslope where the new levee ties into the Moyer property looking west-southwest at Smith B.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS08 Photograph 2: Taken from the southeast corner of Smith B, on the hillslope where the new levee ties into the Moyer property looking northwest at Smith B.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS08 Photograph 3: Taken from the southeast corner of Smith B, on the hillslope where the new levee ties into the Moyer property looking north-northeast.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS08 Photograph 4: Taken from the southeast corner of Smith B, on the hillslope where the new levee ties into the Moyer property looking east-southeast.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS09 Photograph 1: Taken from the northwest corner of Smith B, in the footprint of the new levee looking east.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS09 Photograph 2: Taken from the northwest corner of Smith B, in the footprint of the new levee looking southeast.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS09 Photograph 3: Taken from the northwest corner of Smith B, in the footprint of the new levee looking south.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS09 Photograph 4: Taken from the northwest corner of Smith B, in the footprint of the new levee looking west-northwest.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS10 Photograph 1: Taken off of Pioneer Highway, south of the old railroad grade looking north at Big Ditch.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS10 Photograph 2: Taken off of Pioneer Highway, south of the old railroad grade looking northeast.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS10 Photograph 3: Taken off of Pioneer Highway, south of the old railroad grade looking east-northeast.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS10 Photograph 4: Taken off of Pioneer Highway, south of the old railroad grade looking east.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS11 Photograph 1: Taken at the south access point from Pioneer Highway to Smith A looking north.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS11b Photograph 1: Taken east of FS11 to capture Smith A and not just the new levee.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS11 Photograph 2: Taken at the south access point from Pioneer Highway to Smith A looking northeast.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS11b Photograph 2: Taken east of FS11 to capture Smith A and not just the new levee.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS11 Photograph 3: Taken at the south access point from Pioneer Highway to Smith A looking east.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

FS11b Photograph 3: Taken east of FS11 to capture Smith A and not just the new levee.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

SF11 Photograph 4: Taken at the south access point from Pioneer Highway to Smith A looking southward along Big Ditch.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

SF12 Photograph 1: Taken on the north dike near the flood return structure, looking east-southeast across the channel to Smith A.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

SF12 Photograph 2: Taken on the north dike near the flood return structure, looking south-southeast across the channel to Smith A.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

SF12 Photograph 3: Taken on the north dike near the flood return structure, looking southwest across the channel to Smith A.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

SF12 Photograph 4: Taken on the north dike near the flood return structure, looking southwest across the channel to Smith A.



January 31, 2012



April 19, 2012



July 16, 2012



October 4, 2012

SF12 Photograph 5: Taken on the north dike near the flood return structure, looking west towards Pioneer Highway.