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SUMMARY REPORT:

Environmental Flows Workshop for the Santiam River Basin, Oregon

January 2013

North Santiam River downstream from Detroit Lake near Niagara at about river mile 57.
Photograph by Casey Lovato, U.S. Geological Survey, June 2011.

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Introduction

Background

The Willamette River and its tributaries support a rich diversity of aquatic flora and fauna, including important runs of salmon and steelhead. The river is also home to the majority of Oregon's population and provides vital goods and services to the region and beyond. The U.S. Army Corps of Engineers (USACE) operates 13 dams in the Willamette Basin - 11 multiple purpose storage reservoirs and 2 regulating reservoirs. All 13 of the dams are located on major tributaries; there are no USACE dams on the mainstem Willamette River. The dams provide important benefits to society, including flood risk reduction, hydropower and recreation. At the same time, the dams have changed the flow conditions in the river with associated effects on ecosystem processes and native fish and wildlife.

The Willamette River is one of eight demonstration sites within the Sustainable Rivers Program (SRP), a national partnership between the USACE and The Nature Conservancy (TNC) aimed at creating a framework for implementing environmental flows downstream of dams. The goal of the SRP is to identify opportunities to change dam operations to provide more ecologically-based flows while at the same time meeting human needs and congressionally authorized purposes. The environmental flow framework is often developed through an iterative process that includes scientific assessment and expert input to develop the initial flow recommendations. These flow recommendations are then evaluated by dam operators for feasibility, implemented where possible, and monitored by scientists to evaluate their effect on the river ecosystem and dam operations (Tharme, 2003; Acreman and Dunbar, 2004; Richter et al., 2006). This information is used to refine the initial flow recommendations using an adaptive management approach. Given that the dams are located on tributaries, the Willamette SRP process was divided into phases, with flow recommendations determined separately for each of the major tributaries with USACE dams. Once completed for all tributaries, the recommendations will be combined and opportunities for system-wide implementation will be evaluated, tested and refined.

As a first step in the Willamette SRP process, a summary report on the flow requirements of key Willamette species and communities was completed in 2007 (Gregory et al., 2007a). This report was followed by a flow recommendations workshop focusing on the Coast and Middle Forks of the Willamette River. The outcome of the workshop was a set of environmental flow recommendations for the Middle Fork Willamette River below Lookout Point/Dexter dams (Gregory et al., 2007b), with initial implementation of the recommendations occurring in 2008 through 2012. The implementation of environmental flows on the Middle Fork Willamette River serves as a pilot for testing and refining the environmental flows process for the entire Willamette River system, however the results of implementation are still in the initial stages of review.

In 2008 TNC, USACE, the Eugene Water & Electric Board (EWEB) and the U.S. Geological Survey (USGS) began an environmental flow study for the McKenzie River, a major tributary of the Willamette with both USACE and EWEB dams. In 2010 USGS completed a summary report on the hydrology, geomorphology, and ecology in the McKenzie River basin (Risley et al., 2010a). This was followed in November of 2010 by an Environmental Flow Recommendations Workshop for the McKenzie River (Risley et al., 2010b). To date, direct implementation of environmental flows on the McKenzie has not occurred, as additional basinwide analysis is needed to integrate the environmental flow recommendations across the 13-dam system.

Developing flow recommendations for the Santiam River basin is the final step in the Willamette flow recommendations process.

Santiam River

The Corps of Engineers operates four dams in the Santiam River basin: Big Cliff and Detroit Dams on the North Santiam and Foster and Green Peter dams on the South Santiam (Figure 1). In addition, there are two major water withdrawals in the basin: the City of Salem's intake on the North Santiam River at Geren Island, and the City of Albany's Lebanon-Santiam Canal on the South Santiam.

To assist scientists in developing environmental flow recommendations, the USGS completed a summary report on the hydrology and geomorphology in the Santiam River basin (Risley et al., 2012). The report also evaluated how the streamflow and geomorphology of the river have been altered by USACE dams and canals over the past 50 years and described the types of flows that are needed to sustain key ecosystem processes.

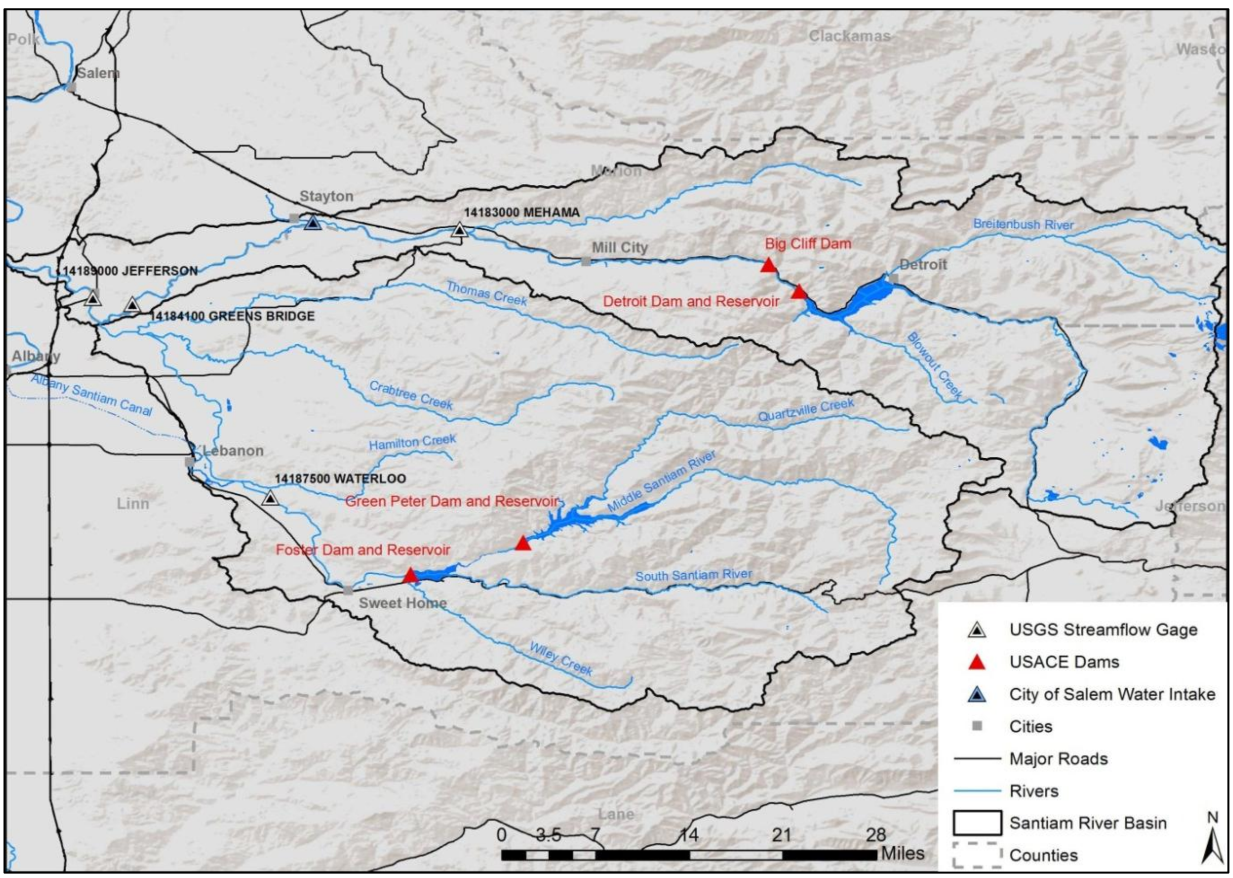

Figure 1. Illustration of the Santiam River basin, Oregon, including the major streams, USACE dams, and gaging stations used in development of flow recommendations and referred to in this summary report.

Environmental Flow Workshop

After Santiam River stakeholders reviewed the USGS report (Risley et al., 2012), the Conservancy held a flow recommendations workshop (August 30, 2012) at ODFW headquarters in Salem, Oregon (Appendix A). Approximately 40 persons, from universities, State, Federal, and local government agencies, and non-governmental organizations attended (Appendix B). After introductions and technical presentations from TNC, USGS and USACE, the attendees were divided into three breakout groups: North Santiam, South Santiam and mainstem Santiam (main channel below the confluence of the North and South Santiam rivers). The groups were formed from a mix of experts representing major disciplines, including fisheries and aquatic biota, hydrology, geomorphology and riparian/floodplain ecology. Each group was asked to develop a full range of flow recommendations that could meet the needs of aquatic species, channel morphology, and riparian and floodplain processes.

Each breakout group was provided with a facilitator, a note keeper, and a person who operated a visual computer software program called the Regime Prescription Tool (HEC-RPT). Developed by USACE and the Conservancy, RPT allows a workshop audience to easily view hydrologic information and create flow recommendations during discussions (*http://www.hec.usace.army.mil/software/hec-rpt/*). As a visual tool, RPT can create a synthetic annual hydrograph for a reach. Individual flow recommendations can be added (or deleted), and their magnitudes and durations can also be easily adjusted.

To support development of the flow recommendations, hydrologic data and statistics on pre- and post- dam streamflow were provided to the breakout groups in the form of summary tables and plotted hydrographs. The statistics are based on measured and estimated pre- and post-dam daily-mean streamflow data at specific streamflow gaging stations[1]. The hydrologic information and data are described in Tables 1 and 2 and the following text. Additional information, such as details of analysis methods and summarized low flow data, may be found in Risley et al., 2012.

North Santiam River

The North Santiam River begins high in the Cascade Range near Three Fingered Jack mountain and flows more than 100 miles before it joins the South Santiam River about 2 miles upstream from Jefferson. The USACE operates two dams on the North Santiam River: Detroit Dam located at RM 60.9 and Big Cliff Dam located just three miles downstream from Detroit Dam. Construction of both dams was completed in 1953. The City of Salem intake is located at RM 31.0, which can divert 227 cubic feet per second (ft^3/s), though it does not currently exceed 116 ft^3/s. Hydrologic data collected at USGS gaging station 14184100 (North Santiam River at Greens Bridge near Jefferson, OR at RM 14.6) and USGS gaging station 14183000 (North Santiam at Mehama, OR at RM 38.7) are used to summarize the conditions from Mehama to Green's Bridge. The flow recommendations were developed specifically for Greens Bridge; however, data from both gages were used to inform development of these recommendations.

[1] Refer to Risley et al., 2012, Table 11 for median monthly streamflow statistics for pre- and post-dam flows.

South Santiam River

The South Santiam River begins at a lower elevation than the North Santiam in the Western Cascades, and flows about 70 miles before joining the North Santiam River. The USACE operates Green Peter Dam located at RM 5.5 on the Middle Santiam and Foster Dam located at the confluence of the South Santiam and Middle Santiam rivers, 7 miles downstream from Green Peter Dam at RM 38.5 on the South Santiam River. Construction of both dams was completed in 1968. Another major water project on the South Santiam is the Lebanon-Santiam Canal at RM 20.8, which can divert 25-200 cfs for the City of Albany's water supply, though it has not been known to exceed 156 cfs. Hydrologic data collected at USGS gaging station 14187500 (South Santiam River at Waterloo, OR at RM 23.3) are used to summarize the conditions in the reach from Foster to Waterloo, with recommendations specific to Waterloo. Recommendations also generally cover the river downstream of Waterloo to the confluence with the North Santiam.

Mainstem Santiam

From the confluence of the North and South Santiam rivers at Jefferson, the mainstem Santiam River flows about 9 miles before it joins the Willamette River south of Salem and north of Albany. Hydrologic data collected at USGS gaging station 14189000 (Santiam River at Jefferson, OR at RM 9.6) are used to summarize the conditions in this reach.

Table 1. Pre- and post-dam flood statistics for selected Santiam River basin, Oregon, streamflow gaging stations, computed from annual peak streamflow data based on the Bulletin 17B Log Pearson III method. [**Abbreviations**: POR, period of record in water years; ft^3/s, cubic feet per second.] (From Risley et al., 2012)

Station Number	Name and Study Reach	Recurrence interval	Pre-dam Period Streamflow		Post-dam Period Streamflow		Percent change
		(years)	POR	(ft^3/s)	POR	(ft^3/s)	
14183000	North Santiam River at Mehama, Oregon	1.5	1906-1952	28,500	1953-2010	17,800	-38
		10		58,300		32,700	-44
		50		79,800		45,500	-43
		100		89,000		51,500	-42
		500		111,000		67,200	-39
14184100	North Santiam River at Greens Bridge near Jefferson, Oregon	N/A	N/A	N/A	N/A	N/A	N/A
14187500	South Santiam River at Waterloo, Oregon	1.5	1906–1966	31,500	1967–2010	14,200	-55
		10		65,600		20,900	-68
		50		91,300		24,800	-73
		100		103,000		26,300	-74
		500		130,000		29,700	-77
14189000	Santiam River at Jefferson, Oregon	1.5	1908–1952	62,400	1953–2010	44,200	-29
		10		152,000		102,000	-33
		50		231,000		157,000	-32
		100		268,000		184,000	-31
		500		364,000		259,000	-29

Table 2. Flow estimates for selected Santiam River Basin, Oregon, streamflow gaging stations. All calculations are cubic feet per second (ft^3/s). (Adapted from Risley et al., 2012)

Station Number	Name and Study Reach	Bankfull	Flood Stage	Extreme Low-flow Threshold*	High-flow Threshold*	2-Year Flood*	10-Year Flood*
14183000	North Santiam River at Mehama, Oregon	17,000	30,500	685	4,270	35,400	53,900
14184100	North Santiam River at Greens Bridge near Jefferson, Oregon	18,000	N/A	767	4,780	39,600	60,400
14187500	South Santiam River at Waterloo, Oregon	18,000	25,700	223	3,980	35,800	59,100
14189000	Santiam River at Jefferson, Oregon	35,000	55,900	551	10,100	85,000	144,000

*Indicators of Hydrologic Alteration (IHA) statistics based on the estimated unregulated flow time series from Risley et al., 2012

Workshop Results

Fall Flows

Description of Flows and Conditions of Implementation:
Early fall is historically a low flow period during the annual hydrograph. As fall progresses, evapotranspiration decreases and watershed soil moisture is replenished after summer drought. Flood flows are historically rare before late November. Fall flow recommendations include minimum and maximum flow objectives for September and October. According to the Willamette Biological Opinion (NMFS 2008), the reservoir release flow rate after October 15th (spring Chinook incubation period) is not as critical as the release flow rate prior to October 15th (spring Chinook spawning period), when flows provide essential access to spawning gravels. Flows higher than those recommended are acceptable if they are sustained through the season to avoid dewatering of redds. Fall pulses are beneficial for creating and maintaining chub habitat, but don't necessarily need to happen during the Chinook spawning window. Recommended flows are shown in Table 3.

Ecosystem Objectives:

- Allow access to appropriate gravels for building redds; these gravels are now more likely to be found on the channel margins due to the modifications to sediment supply and transport associated with the dams.
- Maintain flows within the recommended minimum and maximums to avoid both dewatering and washing out redds during spawning
- Provide minimum flows to benefit chub by maintaining minimum slough volumes
- Allow juvenile Chinook movement downstream, adult Chinook movement upstream and cutthroat movement into tributaries
- Maintain appropriate spawning temperatures

Table 3. Fall flow recommendations for all three reaches in the Santiam basin. Magnitude is in cubic feet per second (ft^3/s).

REACH	DATES	FLOW COMPONENT	FLOW RECOMMENDATIONS			
			Number of Events	Magnitude	Duration	Frequency
North Santiam	September 1 to October 15	Fall flows	steady flow within the identified magnitude range and time period	1,000-1,500	45 days	annually
South Santiam	September 1 to October 15	Fall flows	steady flow within the identified magnitude range and time period	1,500-3,000	45 days	annually
Mainstem Santiam	September 1 to October 15	Fall flows	steady flow within the identified magnitude range and time period	1,500-4,000	45 days	annually

Winter Flows

Description of Flows and Conditions of Implementation:
Winter flows were historically characterized by moderately low baseflow punctuated with rainfall or rain-on-snow dominated floods. Winter flow recommendations were broken down into winter base flows, winter events below bankfull and winter events above bankfull.

The winter base flow objective mimics the unregulated hydrograph and seeks to provide consistent water sufficient for multiple biological targets. The higher winter flows (i.e., near but below bankfull) are important for connecting and wetting side channels, opening up new habitat, initiating gravel movement, and flushing sediment and wood into side channels. Resident trout, macroinvertebrates and other species benefit by increased habitat diversity and clean, unarmored substrates. These flows maintain chub habitat while also potentially reducing non-native fish numbers in off-channel habitats. The winter events above bankfull were proposed to accomplish some of the tasks that only a large events can: deposit fines on new floodplain for colonization of riparian vegetation, mobilize larger wood and larger substrate, open abandoned side channels, enhance pool and off-channel development and scour side channels silted in over a decade or longer. These largest events open the side channels and spill over into the floodplain, rejuvenating it with fresh sediment deposits while also protecting the banks and river bed of the main channel from erosion and cutting during higher flows.

Important to the flow recommendations for the below- and above-bankfull pulsed events is a requirement that the recession limb of these pulses be gradual, even while flows can be brought up to peak conditions relatively quickly. This is necessary to allow those fish that used side channels or floodplains as refugia to move back into deeper water rather than be stranded in these off-channel locations. The recession limb should mimic observed rates from similar flow levels during the pre-dam period of record (the natural flow recession rate).

Base Flow Ecosystem Objectives:

- Provide sufficient water for multiple life stages of multiple fish species including:
    - outmigrating juvenile Chinook
    - upmigrating steelhead
    - rearing juvenile Chinook and steelhead
    - steelhead and Chinook redd protection
    - slackwater deposits for lamprey

Winter Events Below Bankfull Ecosystem Objectives:

- Connect and wet-up side channels; flush sediment and wood into side channels
- Initiate gravel movement
- Provide spawning and rearing habitat for spring Chinook and resident trout in newly connected side channels
- Maintain and enhance chub habitat.
- Remove fines to benefit macroinvertebrates
- Initiate bar formation and plant seed dispersal, allowing for colonization of riparian vegetation

Winter Events Above Bankfull Ecosystem Objectives:

- Provide for channel formation and maintenance
- Increase fish spawning and rearing habitat through newly connected and scoured side channels
- Rejuvenate chub habitat for current or future benefit
- Open side channels and inundate floodplains to rejuvenate with fresh sediment deposits while also protecting the main channel from failure during higher flows

Table 4. Winter flow recommendations for all three reaches in the Santiam basin. Magnitude is in cubic feet per second (ft^3/s).

REACH	DATES	FLOW COMPONENT	FLOW RECOMMENDATIONS			
			Number of Events	Magnitude	Duration	Frequency
North Santiam	November 1 to March 31	Winter base flows	minimum sustained flow	1,000-1,500	150 days	annually
		Winter events up to bankfull	2-5	13,000-18,000	3-5 days	annually
		Winter events above bankfull	1	>18,000	3-5 days	1-3 years in 10
South Santiam	November 1 to March 31	Winter base flows	minimum sustained flow	3,000	150 days	annually
		Winter events up to bankfull	5-6	7,000-15,000	6 days	annually
			1-2	15,000-17,000	2 days	annually
		Winter events above bankfull	1	18,000-26,000	1 day	2 years in 3
			1	26,000-35,000	1 day	1 year in 2
			1	35,000-60,000	1 day	1 year in 7-10
Mainstem Santiam	November 1 to March 31	Winter base flows	minimum sustained flow	5,000	150 days	annually
		Winter events up to bankfull	3-5	30,000	3-5 days	annually
		Winter events above bankfull	2	35,000-40,000	3-5 days	1 year in 2
			1	70,000-100,000	1-2 days	1 year in 5

Spring Flows

Description of Flows and Conditions of Implementation:

Spring flows are historically maintained by high elevation snowmelt, transitioning from winter flood flows to summer low flow. These flows serve to put water into lower elevation side channels and floodplain aquifer storage and provide sufficient low-turbidity flows to support needed velocity for salmonid out-migration. Recommendations are to maintain flows within a range for April through June during normal water years. The flow does not need to remain constant and pulsing water at recommended ramping rates within the objective ranges is acceptable.

However, the rate of recession must be matched to the length of the higher flow pulse. A managed recession provides improved conditions for late vegetative root growth in the floodplain and on gravel bars. Cottonwood seed distribution and germination occurs during this time, and bare substrate is necessary for germination and establishment. The slower exposure of substrate (caused by a more sustained flow drawdown from both pulses and normal snowmelt runoff) provides a better opportunity for seed germination and initial root growth. Additionally, a gradual managed recession of water is recommended following longer periods of high flow (i.e., during snowmelt) to reduce the potential for stranding or dewatering fish or amphibian eggs.

Alternatively, if flows are pulsed more quickly (rapid rise *and* fall), as is often true during the early spring prior to snowmelt, there isn't sufficient time for spawning or egg laying, so there is a reduced risk of dewatering eggs.

In order to balance the needs of different species, varying the rate of recession following pulses over several years may mitigate for impacts to various species.

During dry years, when there is insufficient water to maintain normal water year objectives, a set of pulses in the same flow range may be the best alternative. Pulsed flows, if done correctly, may be the best solution for chub habitat maintenance, rearing (May- June) and recruitment during dry years.

Ecosystem Objectives:

- Provide cooler temperatures in sloughs and side channels, delaying spawning in Oregon chub and therefore allowing for more successful juvenile rearing and survival in June and July
- Provide off-channel habitat for amphibian breeding
- Provide sufficient water for steelhead redds
- Improve riparian (especially cottonwood) seed germination and initial root growth, as well as sufficient flows during drawdown for seedling establishment
- Provide adequate flows for adult Chinook migration
- Provide flows for habitat and for downstream mid-May to mid-June passage of juvenile Chinook salmon and steelhead at Willamette Falls
- Provide rates of flow recession that do not strand or dewater habitat suddenly

Table 5. Spring flow recommendations for all three reaches in the Santiam basin. Magnitude is in cubic feet per second (ft^3/s).

REACH	DATES	FLOW COMPONENT	FLOW RECOMMENDATIONS			
			Number of Events	Magnitude	Duration	Frequency
North Santiam	April 1 to June 30	Spring flows	steady flow within the identified magnitude range and time period with gradual decrease to summer levels	1,500-5,000	90 days	annually
	April 1 to June 30	Spring events above bankfull	1	>18,000	3-5 days	1-3 years in 10
South Santiam	April 1 to June 30	Spring flows	Steadily decreasing flow within the identified magnitude range and time period	4,000 early season, dropping to 1,500 late season	90 days	annually
		Spring events	3-8	1,000 above the normative flow at the time of the pulse. Time with precipitation events and major snowmelt events when possible	1-3 weeks including rise and fall	every 3-5 years
Mainstem Santiam	April 1 to June 30	Spring flows	Minimum flow	3,000	90 days	annually
		Spring events	1 extended snowmelt event in May/June	10,000-20,000	2-4 days	annually

Summer Flows

Description of Flows and Conditions of Implementation:

The minimum flow recommendations mirror or are slightly elevated from the Biological Opinion (BiOp) flow-release targets for Big Cliff and Foster dams during the same time period but are slightly higher than the congressionally authorized low flow levels. Due to diversions downstream of the dams recommendations were made to maintain minimum baseflows from the dams at higher than historic levels. As flow decreases, temperatures increase, putting many aquatic species at risk, but more research is necessary to understand how flow recommendations influence water temperature and general water quality throughout the rivers. Minimum flow recommendations were made to help mitigate this threat. This should be linked with reservoir management (let warmer water out earlier, cooler later), to meet temperature targets. Flows that maintain connection to chub habitat or provide cooler hyporheic inputs in summer are important in order to maintain appropriate temperatures and volumes in side channels and sloughs used by chub. At a baseflow of 1,000 cfs in the North Santiam in summer, chub populations tend to expand.

Ecosystem Objectives:

- Maintain rearing habitat for chub and juvenile salmonids
- Provide minimum flows for upstream migration of Chinook adults
- Protect steelhead redds from stranding
- Maintain and/or expand chub populations
- Maintain temperatures appropriate for species targets

Table 6. Summer flow recommendations for all three reaches in the Santiam basin. Magnitude is in cubic feet per second (ft^3/s).

REACH	DATES	FLOW COMPONENT	FLOW RECOMMENDATIONS			
			Number of Events	Magnitude	Duration	Frequency
North Santiam	July 1 to July 15	Summer flows	minimum sustained flow	1,200	15 days	annually
	July 16 to August 31			1,000	45 days	annually
South Santiam	July 1 to August 31	Summer flows	minimum sustained flow	800-1,200	60 days	annually
Mainstem Santiam	July 1 to August 31	Summer flows	Flows should ramp down during July as the snowmelt peak declines	1,500-4,000	July	annually
			steady flow within the identified magnitude range and time period	1,500-2,500	August and September	annually

Flow Recommendations by Reach

The following section outlines example hydrographs and ecosystem objectives by reach. The hydrographs were generated using RPT. Because RPT is chiefly a visualization tool whose main purpose is to facilitate group communication during and post-workshop, these example hydrographs should not be interpreted as specific recommendations, but rather as a hypothetical water year in which some, but not necessarily all, of the recommended flow components would be achieved. The diagrams summarize the flow recommendations by reach, season and the ecosystem objectives called out individually by groups (see full list of ecosystem objectives within recommendations by season). Implementation hydrographs can be compared with the RPT output and the diagrams to assess success in achieving specific flow recommendations and achieving ecosystem objectives.

North Santiam

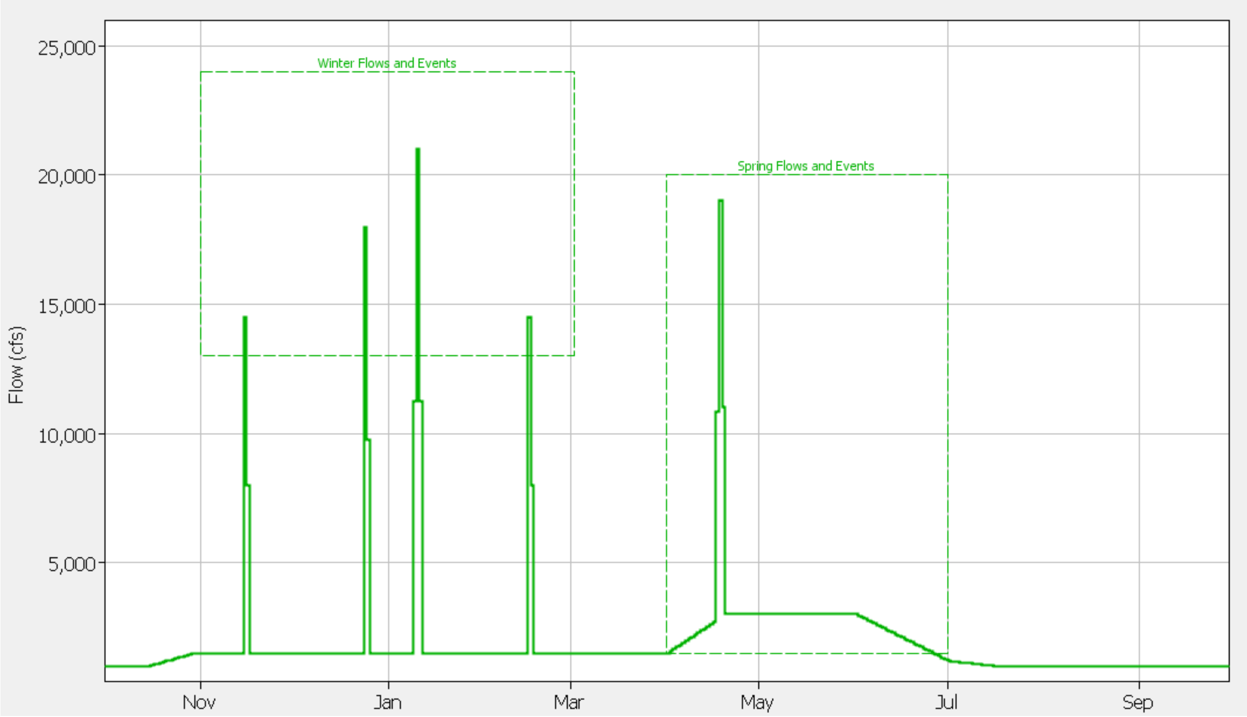

Figure 2. Example hydrograph of North Santiam flow recommendations from RPT.

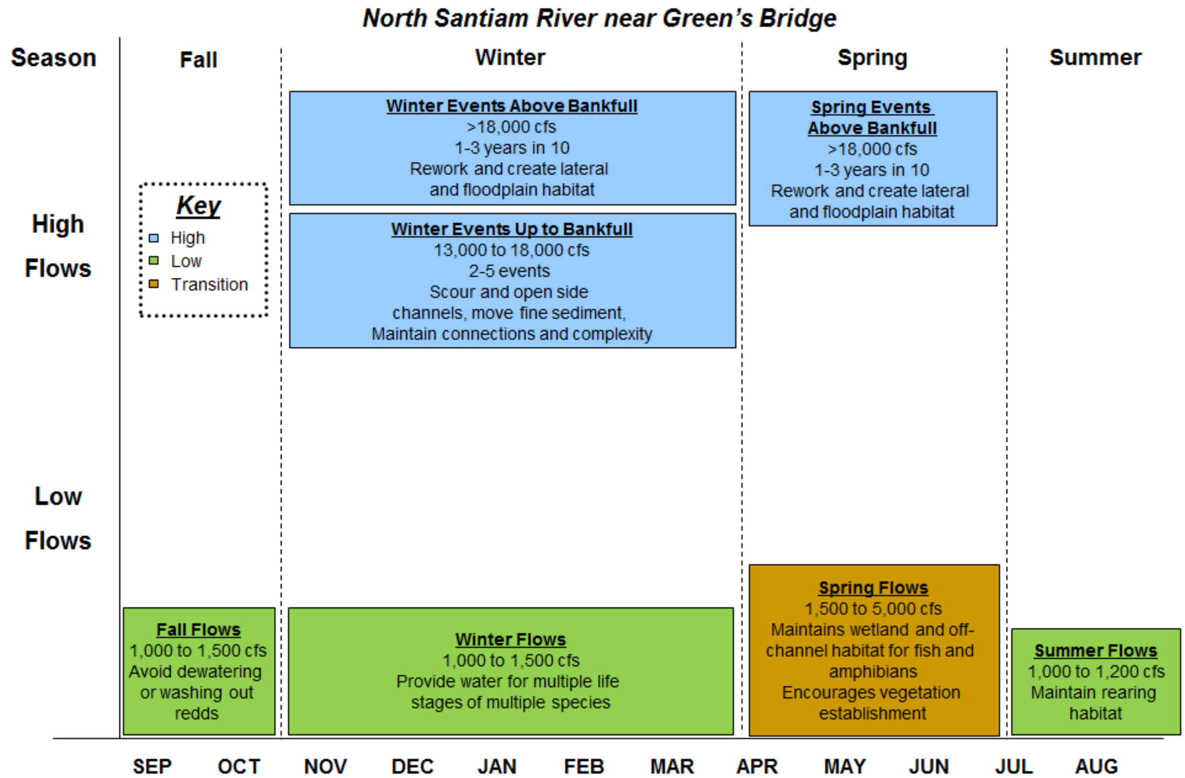

Figure 3. Diagram of North Santiam flow recommendations and ecological objectives.

South Santiam River

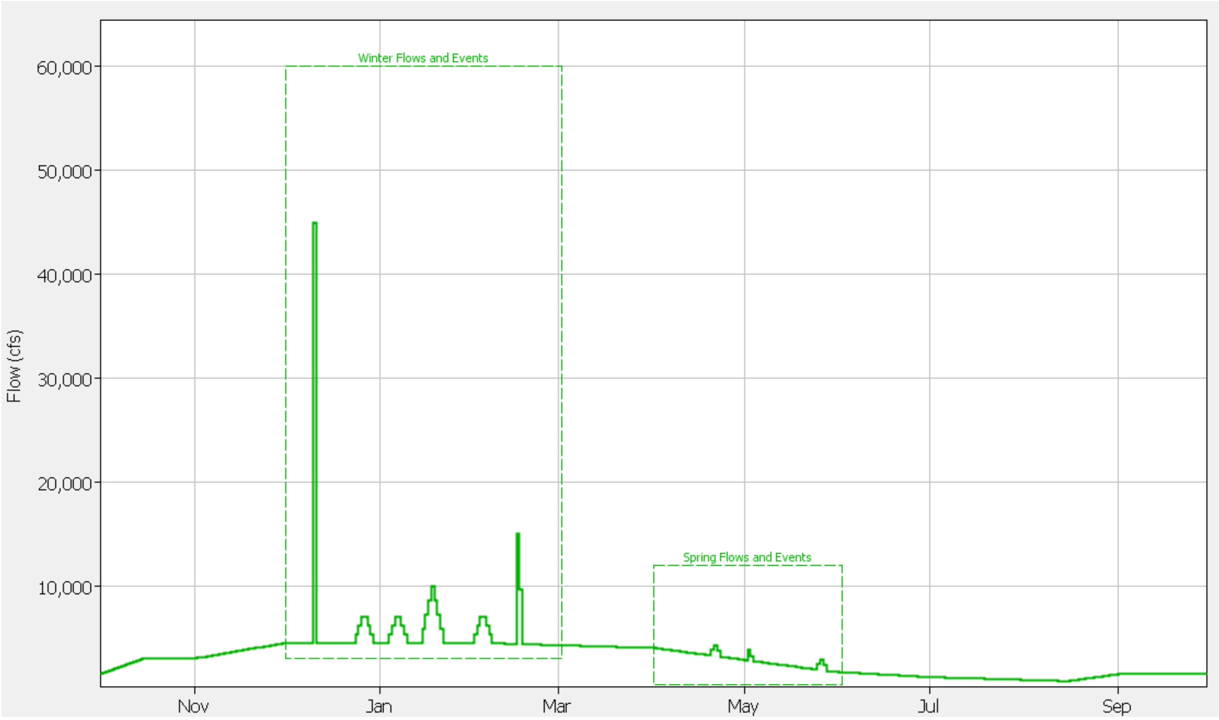

Figure 4. Example hydrograph of South Santiam flow recommendations from RPT.

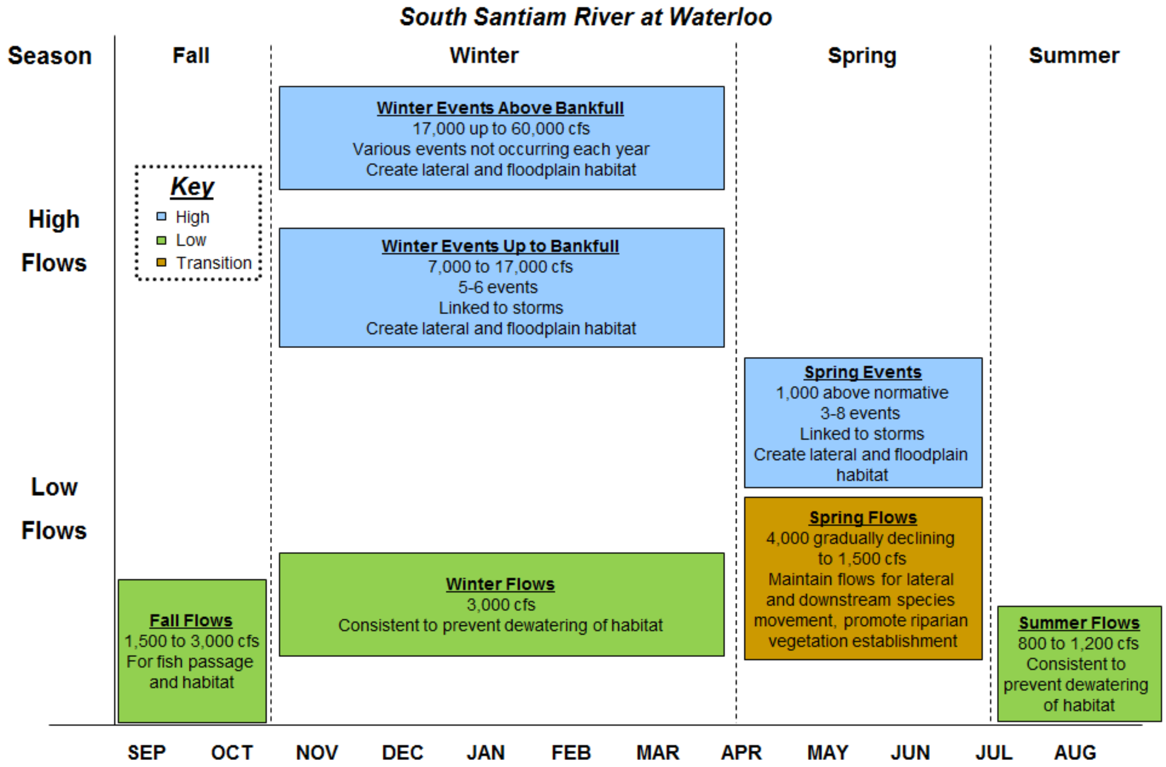

Figure 5. Diagram of South Santiam flow recommendations and ecological objectives.

Mainstem Santiam

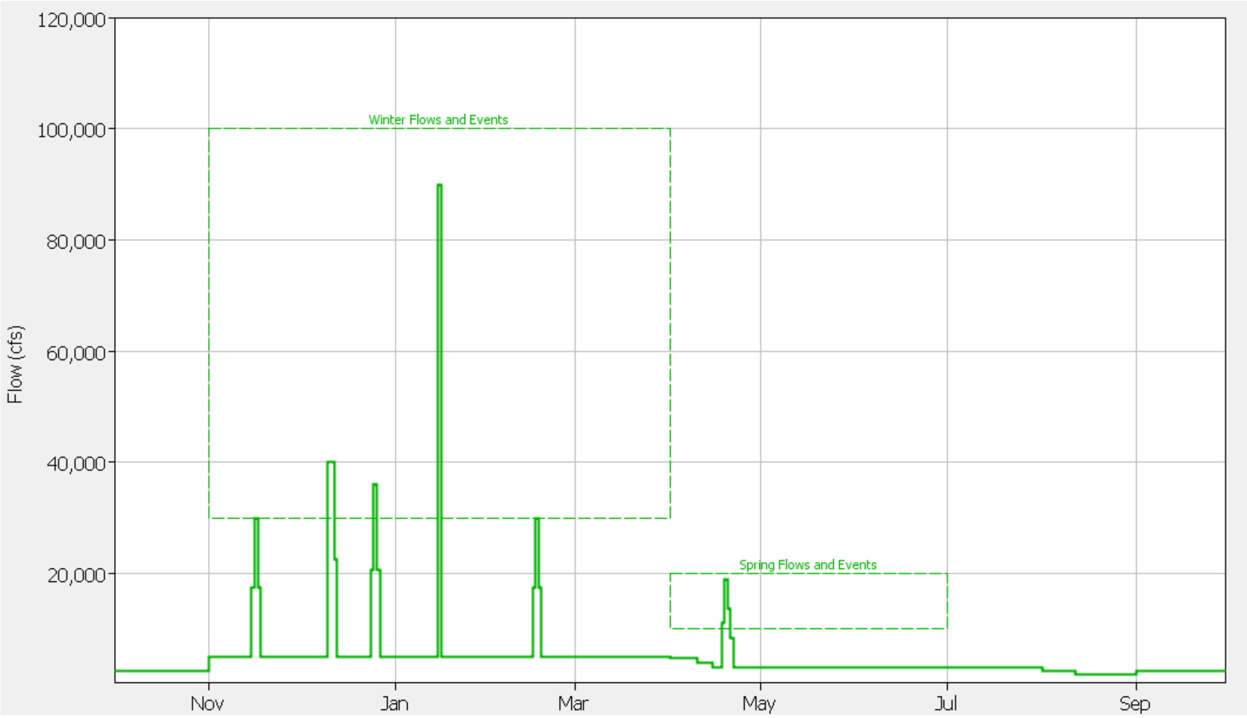

Figure 6. Example hydrograph of mainstem Santiam flow recommendations from RPT.

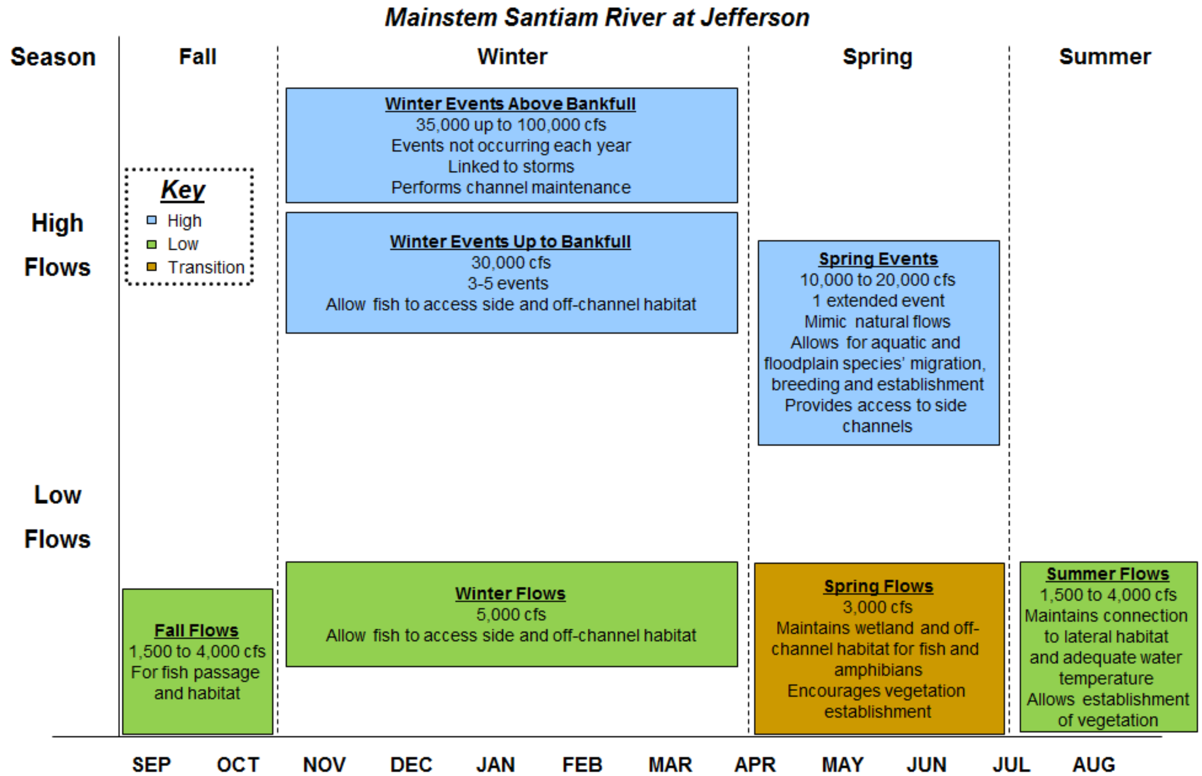

Figure 7. Diagram of mainstem Santiam flow recommendations and ecological objectives.

Recommendations for Future Studies

During the workshop, experts identified a number of gaps in understanding key flow-ecology relationships and the potential benefit and effects of environmental flow implementation. This information is needed to refine environmental flow objectives and support adaptive management of environmental flow implementation. The information is organized by season, although there is some overlap in information needs among seasons.

Fall and Winter Flows

(1) Initiate additional studies on the relationship between flow and
   - channel morphology (for example, what level of flow provides channel maintenance or access to side channels, especially given the prevalence of channel revetments?)
   - sediment transport
   - vegetation establishment, bank stability, and large wood inputs
   - fish stranding (hydrograph recession rate)
   - fish demography (e.g., fewer second year fish are coming out of the river-most are first year-because of temperature limitations below dams)

(2) Determine flow levels that provide access to spawning gravels and subsequently scour redds

(3) Test geomorphic effects under current conditions

(4) Develop wood and sediment budgets for streams and link to flow conditions

(5) Develop studies on gravel recruitment

(6) Quantify appropriate recession rate following higher flows

(7) Address implementation questions, such as:
   - Can you implement high flow releases that do not affect downstream properties while still scouring side channel features? What additional efforts (e.g. floodplain restoration and reconnection) will increase opportunities for environmental flow implementation?
   - Can two smaller high flow events do the work of one larger high flow event? Or what combination of higher flows, in terms of magnitude, frequency, duration, etc. provides the best ecological result while at the same time protecting existing uses?

Spring Flows

(1) Develop local studies on vegetation life cycles and timing, specifically seedling recruitment, establishment and survival

(2) Improve understanding of relationship and trade-offs between vegetation, gravel bars, and flows
   - extent and location of vegetated gravel bars
   - trade-off between higher flows destroying vegetation and recruitment of gravel by mobilizing vegetated bars?
   - flow requirements to provide new floodplain substrate and promote cottonwood and alder establishment

(3) Evaluate side channel connection under recommended flows and the effect of revetments on side channel connections

(4) Quantify appropriate recession rate following higher flows

(5) Evaluate impacts of steady vs. pulsing (potentially detrimental) flows for lamprey

Summer Flows

(1) Determine geomorphic features and characteristics dictating temperature-flow relationships between main channel and side channel habitats; identify effects of flow management on temperature and water quality
(2) Determine levels that provide for Spring Chinook passage for spawning
(3) Study link between summer flows and occurrence and distribution of pools for Chinook refugia
(4) Describe hyporheic exchange features that support Oregon chub and that could provide opportunities for thermal refugia for salmonids
(5) Determine factors affecting pre-spawn mortality in Chinook
(6) Evaluate the ability of species to survive with flows below 1,000 cfs based on historic unregulated flows as low as 500 cfs and potential changes in species composition due to changes in low flow.

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Appendix A. Workshop Agenda

Santiam River
Environmental Flows Workshop
August 30, 2012
Oregon Department of Fish and Wildlife
Commission Room
3406 Cherry Ave. NE Salem, OR.

9:00 Welcome and introductions – Chris Budai, Corps of Engineers, Leslie Bach, The Nature Conservancy

9:15 Review of process, progress to date, discussion of meeting outcomes - Leslie Bach, The Nature Conservancy

9:30 Overview, and discussion of Santiam River hydrology as background for developing environmental flow recommendations – John Risley, U.S. Geological Survey

10:00 Overview of Santiam reservoir management – Mary Karen Scullion, Corps of Engineers

10:15 Overview of Santiam River biology – Greg Taylor, Corps of Engineers

10:30 Discussion of Working Group tasks and goals – Leslie Bach, The Nature Conservancy

11:00 Working groups
Working groups will be organized with a mix of expertise and will develop recommended flows for the North Santiam, South Santiam and mainstem Santiam River. Environmental flow recommendations will address specific flow components (low, moderate and high flows), considering a range of species, communities and ecological processes including fish and other aquatic species, riparian and floodplain systems, channel morphology and water quality. Groups will also identify significant knowledge and information gaps and potential monitoring elements.

3:15 Review of results of breakout groups and synthesis of flow recommendations.

4:00 Adjourn

Appendix B. List of workshop attendees

Group	Role	First Name	Last Name	Organization
	Lead	Leslie	Bach	The Nature Conservancy
	Lead	John	Hickey	U.S. Army Corps of Engineers
	Lead	Chris	Budai	U.S. Army Corps of Engineers

North Santiam	Facilitator	Jason	Nuckols	The Nature Conservancy
North Santiam	RPT	David	Hicks	U.S. Army Corps of Engineers
North Santiam	RPT	Keith	Duffy	U.S. Army Corps of Engineers
North Santiam	Note Taker	Melissa	Olson	The Nature Conservancy
North Santiam		Greg	Taylor	U.S. Army Corps of Engineers
North Santiam		Patricia	Farrell	City of Salem
North Santiam		Rose	Wallick	United States Geological Survey
North Santiam		Liz	Redon	North Santiam Watershed Council
North Santiam		Anne	Mullan	NOAA Fisheries
North Santiam		Alex	Farrand	Oregon Dept. of Fish and Wildlife
North Santiam		Brent	Stevenson	North Santiam Water Control District
South Santiam		Brian	Bangs	Oregon Dept. of Fish and Wildlife
North Santiam		Lawrence	Schwabe	Confederated Tribes of the Grand Ronde

South Santiam	Facilitator	Anne	MacDonald	GeoEngineers
South Santiam	RPT	John	Risley	United States Geological Survey
South Santiam	Note Taker	Emile	Blevins	The Nature Conservancy
South Santiam		Rich	Piaskowski	U.S. Army Corps of Engineers
South Santiam		Eric	Hartstein	South Santiam Watershed Council
South		Cristina	Mateaus	Oregon State University

Santiam				
South Santiam		Rich	Domingue	NOAA Fisheries
South Santiam		Nancy	Gramlich	Oregon Dept. of Environmental Quality
South Santiam		Kirk	Schroeder	Oregon Dept. of Fish and Wildlife
South Santiam		Johan	Hogervorst	U.S. Forest Service
South Santiam		Wes	Messinger	U.S. Army Corps of Engineers

mainstem Santiam	Facilitator	Valerie	Kelly	United States Geological Survey
mainstem Santiam	RPT	Kinsey	Friesen	U.S. Army Corps of Engineers
mainstem Santiam	RPT	Mary Karen	Scullion	U.S. Army Corps of Engineers
mainstem Santiam	Note Taker	Terrence	Conlon	United States Geological Survey
mainstem Santiam		Dave	Hulse	University of Oregon
mainstem Santiam		Kim	Hatfield	NOAA Fisheries
mainstem Santiam		Tim	Harden	Oregon Dept. of Fish and Wildlife
mainstem Santiam		Dan	Bell	The Nature Conservancy
mainstem Santiam		Tara	Davis	Calapooia Watershed Council
mainstem Santiam		Erin	Oost	Oregon Water Resources Dept.
mainstem Santiam		Kat	Beal	U.S. Army Corps of Engineers
mainstem Santiam		Paul	Scheerer	Oregon Dept. of Fish and Wildlife