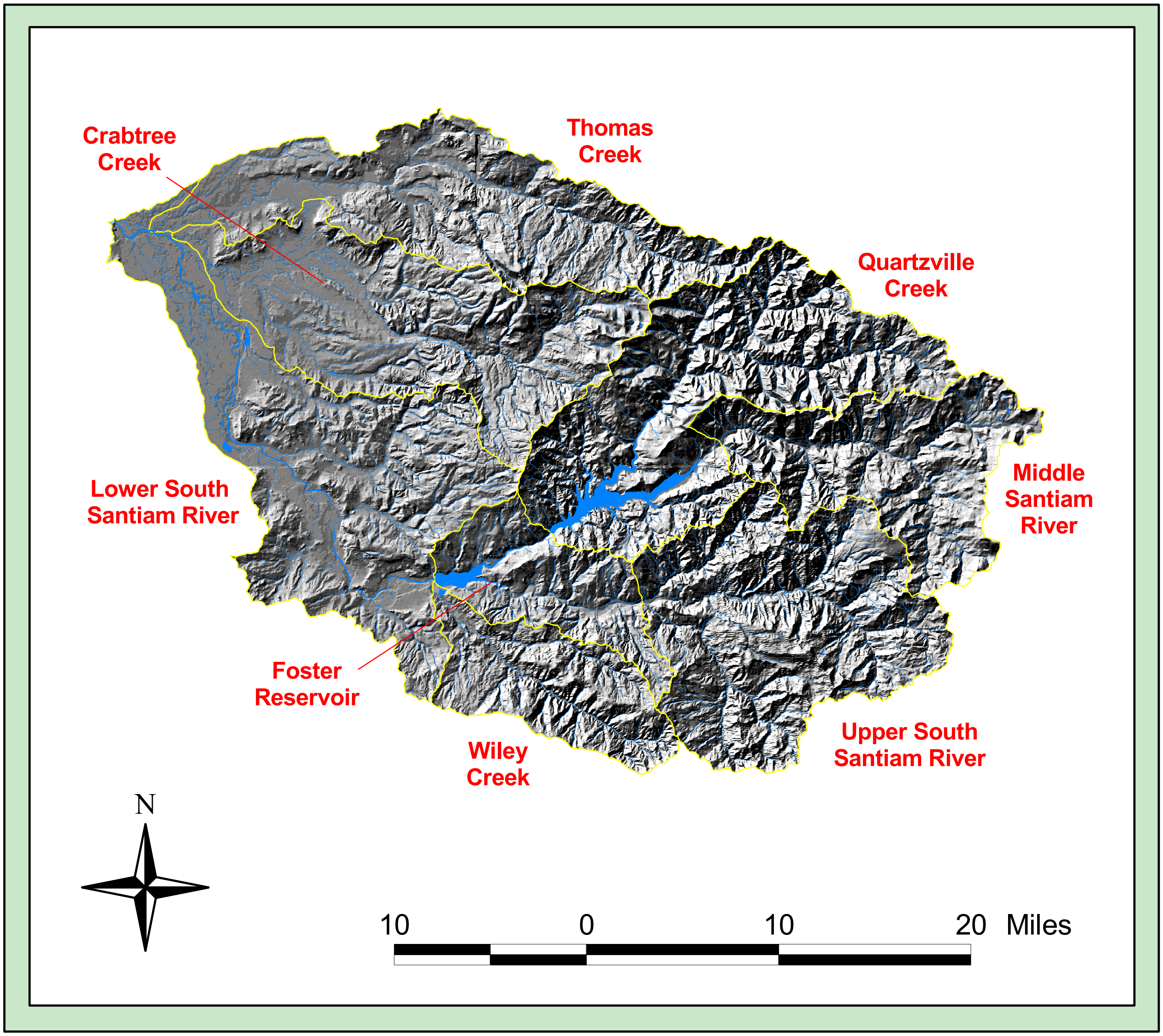
South Santiam Watershed Assessment



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and
South Santiam Watershed Council

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South Santiam Watershed Assessment

Final Report

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SECTION I. SYNTHESIS AND RECOMMENDATIONS

CHAPTER 1. SUMMARY

The purpose of this watershed assessment is to evaluate the current conditions of the South Santiam Watershed and to provide recommendations that address the issues of water quality, fisheries and fish habitat, and watershed hydrology. This assessment was conducted following the guidelines outlined in the draft Governor's Watershed Enhancement Board (GWEB) watershed assessment manual (Oregon Watershed Assessment Manual (OWAM)).

The South Santiam River drains approximately 1,040 square miles and is a primary tributary to the Willamette River. The South Santiam River watershed is situated in the Western Cascades and flows into the Willamette Valley. The River runs approximately from east to west, with steep mountainous terrain comprising the eastern 80% of the watershed. The western 20% of the watershed leading to the Santiam River and ultimately the Willamette River, is comprised of a floodplain dominated by grass seed farming and urban/rural development. The basin ranges in elevation from 220 feet to approximately 5,721 feet.

The South Santiam watershed was divided into an upper section (Headwaters, Quartzville, Middle Santiam and Foster watersheds) and a lower section (Lower South Santiam, Crabtree, Thomas, and Wiley subwatersheds) due to ecological differences such as ecoregion, management, and elevation.

The assessment was conducted in six parts including Channel Habitat Typing, Channel Modification, Riparian, Water Use and Hydrology, Fisheries, and Water Quality. Following is a summary of results from each of the sections.

1.1 Channel Habitat Types

Stream channels were broken into channel habitat type (CHT) categories based on the OWAM protocol. Categories were based on stream geomorphic structure including stream size, gradient, and side slope constraint. Realizing that even under pristine conditions salmonids are not evenly distributed throughout a watershed, this classification system was designed to identify portions of the watershed that have the highest potential for fish utilization (GWEB, 1998).

In general, stream geomorphology in the South Santiam watershed demonstrates a broad range of characteristics providing diverse habitat potential for salmonids. Channel habitat types range from low gradient streams with large floodplains to steep, constrained headwaters. There is a large amount of potential salmonid habitat in the South Santiam Watershed.

1.2 Channel Modification

In-channel structures and activities such as dams, dredging or filling can adversely affect aquatic organisms and their associated habitats by changing the physical character of the stream. These changes can ultimately lead to a change in the community composition of instream aquatic biota. The purpose of this channel modification inventory is to assess the extent and location of in-channel activities in the watershed. Channel modification activities outlined in this section when overlaid with the channel habitat types (CHT) can address how human-created channel disturbances affect channel morphology, aquatic habitat, and hydrologic functioning.

Channel modifications that were identified were concentrated in the lower basins and were typically associated with agricultural and developed land use categories. The majority of channel modifications identified were flood protection and mining.

1.3 Riparian

Riparian zones are the areas along streams, rivers and other bodies of water where there is direct interaction between the aquatic and terrestrial ecosystems. The riparian zone ecosystem is one of the most highly valued and highly threatened ecosystems in the United States (Johnson and McCormick 1979, National Research Council 1995 in Kauffman et al. 1997). Riparian vegetation is one of the most important elements of a healthy stream system, providing several functions that aid in maintaining ecosystem health.

Typically, the higher elevations of the lower South Santiam watersheds are mainly mature, dense forest, while the lower elevations are mainly grass and shrub and mature, sparse forest. Road crossings are the main reason for lack of continuity in the lower South Santiam watersheds with the most discontinuous watersheds being the lower elevations of Noble Creek, Hamilton Creek, and the Mainstem South Santiam watersheds. The majority of narrow buffers occurred in the lower elevation subwatersheds (Lower Thomas Creek, Noble Creek, Lower South Santiam) where the greatest amount of agriculture occurs.

In summary, the poor riparian areas are mainly in the lower elevations of the watersheds where there is the largest amount of agricultural land use. These riparian areas are characterized by narrow, discontinuous riparian zones that are often dominated by grass and shrub vegetation. The headwaters are typically associated with managed forest lands in good condition with wide buffers and mature stands of conifers and hardwoods. However, there were several clearcuts where the riparian area did not appear to remain intact.

1.4 Water Use and Hydrology

Both natural and human-induced changes in vegetation and soil compaction can have large impacts on the hydrology of a watershed. Some examples of human activities that can impact watershed hydrology are timber harvesting, urbanization, conversion of forested land to agriculture, and construction of road networks. These types of changes in the landscape can increase or decrease the volume, size, and timing of runoff events and affect low flows by changing groundwater recharge.

The most notable impact on the South Santiam River's hydrology has been as a result of the construction of Foster and Green Peter Dams. These two dams have increased low flows in the South Santiam River below Foster and reduced flood frequency and intensity, allowing encroachment of the flood plain by developments and agriculture.

Water is withdrawn from both surface and subsurface water supplies within almost all the watersheds in Oregon. Much of this water is for beneficial uses, such as irrigation, municipal water supply, and stock watering. When water is removed from these stores, a certain percentage is lost through processes such as evapotranspiration. Water that is "consumed " through these processes does not return to the stream or aquifer, resulting in reduced instream flows. Reduced instream flows can adversely affect aquatic communities that are dependent upon this water. In fact, the dewatering of streams has often been cited as one of the major reasons for salmonid declines in the state of Oregon.

Water availability was assessed by ranking subwatersheds according to their dewatering potential (Table 1.1). Dewatering potential is defined as the potential for large proportions of instream flows to be lost from the stream channel through consumptive use. The dewatering potential was greatest in the subwatersheds with large amounts of irrigation withdrawals (Table 1.1). The lower elevation watersheds have the greatest potential for dewatering, including Neal, Thomas, Ames and Crabtree Creeks. The mainstem South Santiam River is mitigated by

Table 1.1. Dewatering potential and associated beneficial uses in the South Santiam watershed for the low flow months.

Rank*	Water Availability Watershed	Avg. Percent Withdrawn**	Dominant Water Use	Dewatering Potential
1	Neal Cr. @ mouth	41%	Irrigation, Power, Domestic	High
2	Thomas Cr. @ mouth	40%	Irrigation, Power, Domestic	High
3	Ames Cr. @ mouth	36%	Municipal, Manufacturing	High
4	S. Santiam R. @ mouth	32%	Power, Irrigation, Municipal	High
5	Crabtree Cr. @ mouth	31%	Irrigation, Power, Fish	High
6	Hamilton Cr. @ mouth	17%	Irrigation	Moderate
7	McDowell Cr. @ mouth	12%	Irrigation	Moderate
8	S. Santiam R. @ Waterloo	8%	Power, Irrigation, Municipal	Low
10	Wiley Cr. @ mouth	1%	Fish, Fire Protection	Low
9	Middle Santiam @14186500	1%	Fish	Low
12	S. Santiam R. @ Cascadia	0%	Fish, Domestic	Low
11	Little Wiley Cr. @ mouth	0%	Fish, Fire Protection	Low

* Based on percent water withdrawal.
** Average of low flow months (June, July, August, September, October).

controlled releases from Foster and Green Peter Reservoirs and therefore is not of immediate concern for dewatering.

Dewatering of streams has often been cited as one of the primary reasons for reductions in salmonid counts. Dewatering has the potential to affect two endangered species (winter steelhead and spring chinook) in the South Santiam watershed. The number of months that there is a high dewatering potential during different life stages of winter steelhead and spring chinook are presented in Table 1.2. Stream dewatering has the potential to affect both the migration and adult runs of both species.

Getting appropriated water back into the stream channel can be a difficult process. The Oregon Water Resources Board offers several programs including water right leasing and conversion in an attempt to put water back into the stream channel. However, much of this water has high economic value to its user, generating a demand for the water. Alternatives should be identified to conserve water, especially in streams with a high dewatering potential.

Table 1.2. Potential effects of dewatering on the life cycles of native winter steelhead and spring chinook.

Water Availability Watershed	Fish Presence	Number of Months Water Withdrawals exceed 10% of Natural Stream Flow			
		Spring Chinook Adult Run (Jan-July)	Winter Steelhead Adult Run (Nov-Jun)	Spring Chinook Young Migration (Mar-July)	Winter Steelhead Young Migration (Mar-Jun)
Neal Cr.	S, A	2	1	2	1
Thomas Cr.	C, S, A	2	1	2	1
S. Santiam R.	C, S, A	6	5	5	4
Ames Cr.	A	2	1	2	1
Crabtree Cr.	C, S, A	2	1	2	1
Hamilton Cr.	S, A	1	0	1	0
McDowell Cr.	S, A	1	0	1	0

C= spring chinook, S=steelhead, and A=anadromous

1.5 Fisheries

Fisheries within the South Santiam watershed have undergone significant changes during the twentieth century. The types of fish present and their locations have been altered from historical conditions in the watershed. Arguably, the most significant activities to affect the fisheries during the last one hundred years are habitat modifications and hatchery programs.

Winter steelhead and spring chinook salmon occurred historically above the Willamette Falls and are the only two anadromous fish native to the South Santiam watershed. Both of these species have recently been listed as threatened under the endangered species act. Summer steelhead, fall chinook salmon, kokanee, and coho salmon did not historically occur above the falls, but were introduced through hatchery programs at different times during the century. Of these introduced species, only coho have failed to establish in the watershed. Coho are not present today. Not only have hatchery runs been introduced but a warm water fishery has entered the South Santiam watershed where historically, there was no warm water fishery (WNF 1995).

The South Santiam Watershed is home to the remnants of a run of wild winter steelhead which, prior to construction of Green Peter and Foster dams, numbered in excess of 2600 returning adult fish (WNF, 1996). Historically, spawning by native winter steelhead in the entire Upper Willamette River was concentrated in the North and Middle Santiam River Basins (Fulton 1970). As much as eighty-five percent of the historical spawning area in the Middle Santiam for native winter steelhead was blocked by the construction of Green Peter Dam (WNF 1995). Sixty percent of the run which spawned in the Middle Santiam no longer exists, as no adults pass over Green Peter. Of the other 40% of the historic run only two to three hundred adults pass over Foster and into the South Santiam watershed to spawn each year. Counts of winter steelhead from 1973 to 1996 at Foster Dam suggest a relatively stable population below Foster Dam, with the exception perhaps of the last several years. This population of winter steelhead has been relatively free from the influence of hatchery fish except during a period of time from 1982-88 when late-run hatchery fish from the North Santiam (Marion Forks Broodstock) returned to the basin (ODFW 1997).

The fisheries interactions in the Willamette Basin are complex due to difficulties in identifying distinct populations. Connection with the Columbia River as well as historical connections with coastal basins through stream capture and headwater transfer events contributes to this complexity (Minckley et al. 1996). Hatchery programs and fish ladders constructed as early as 1885 at Willamette Falls to aid the passage of anadromous fish have complicated native anadromous fish presence even further (Bennett 1987, PGE 1994). There may be undue competition due to overlapping life cycles.

Long term habitat changes have affected the salmonid fishery. Bottom et al. (1985) identified specific factors affecting salmon habitat in various areas of Oregon that apply to the South Santiam watershed. They include streamflow and temperature problems, riparian habitat losses, and instream habitat degradation. Bottom et al. (1985) contend that in the Willamette Valley temperatures and stream flows reach critical levels for salmonids in places where there are significant water withdrawals or removal of streamside vegetation. They also conclude that splash dams, debris removal and stream channelization have caused long-term damage to salmonid habitats.

The construction of Green Peter and Foster dams have changed the hydrology of the South Santiam River. Flows have increased in the late summer and fall, changing water temperatures.

Spring and early summer temperatures are colder, which delays juvenile chinook growth, while fall temperatures are warmer, which accelerates egg development and advances emergence times. These changes are thought to have decreased egg-to-smolt survival of spring chinook naturally spawning in the mainstem South Santiam River (ODFW 1995). Construction of the dams may have also blocked passage of steelhead into Ames Creek by diminishing floods which historically brought stream flows high enough for salmonids to pass the falls at the mouth of Ames Creek.

Subwatersheds were ranked for potential fish habitat restoration based on several factors. First, conditions were summarized in terms of potential fish habitat, riparian conditions, dewatering potential, channel modification activities, water quality, and blocked habitat (Table 1.3). Subwatersheds that fell in the moderate category for the majority of these issues were put into a Priority I category. Next, other agency documents were used to identify important fish habitat areas, including the Middle Santiam Watershed Analysis (WNF 1996), South Santiam Watershed Analysis (WNF 1995), and the Willamette River/Sandy River Guide to Restoration Site Selection (ODFW 1998).

Priority I

Priority I watersheds are defined as those watersheds where we believe that restoration is feasible and will have the highest chance for success. Ranking of these watersheds considered information from other documents that include these watersheds as high priority for restoration activity, such as the watershed assessments from the BLM, USFS, and ACOE. Other factors used in prioritization were general riparian condition (where information is available), dewatering potential, potential fish habitat, modification, existing anadromous fish usage (where information is available), and blocked habitat. Priority I watersheds are those which exhibit relatively intact riparian zones, moderate water quality, moderate dewatering potential, and a large potential for providing fish habitat. Although much of the habitat has been degraded in these watersheds, restoration activities have a high probability of success.

Hamilton, McDowell, Ames, Wiley, Little Wiley, South Fork Wiley, Moose, and Canyon Creeks and Soda Fork are Priority I watersheds. These watersheds had low dewatering potential and fair to good fish habitat conditions. Moose and Canyon Creeks and Soda Fork were identified as important refugia and spawning areas for native winter steelhead and spring chinook (WNF 1995, ODFW 1998). Improving the habitat in these watersheds will provide additional

Table 1.3. Prioritization of subwatersheds for restoration activities focused on fisheries and fish habitat.

Subwatershed	Potential Fish Habitat (miles)	Mean Riparian Score	Dewatering Potential	# Channel Mods.	Water Quality	Blocked Habitat (miles)	Priority
Little Wiley Cr.	13.2	NA	Low	0	Temp.	?	I
SF Wiley Cr.	18.7	NA	Low	8	Temp.	?	I
McDowell Cr.	41.1	Fair	Moderate	1	Temp.	?	I
Ames Cr.	18.5	Fair	High	22	Temp.	?	I
Hamilton Cr.	61.6	Fair	Moderate	2	Temp.	?	I
Wiley Cr.	20.5	NA	Low	0	Temp.	?	I
Lower Thomas Cr.	87.5	Fair	High	8	Temp.	?	I
Canyon Cr.	24.9	NA	Low	0	Temp.	?	I, P
Soda Fk.	6.7	NA	Low	0	?	?	I, P
Moose Cr.	11.7	NA	Low	0	?	?	I, P
Lower South Santiam River	104.4	Fair	High	82	Temp. Bacteria	?	I
Neal Creek	32.7	Good	High	1	Temp.	?	I
Noble Cr.	70.4	Fair	High	25	?	?	I
NF Crabtree Cr.	18.8	Good	Low	4	?	?	I
Beaver Cr.	66.9	Fair	High	0	Temp.	?	I
Lower Crabtree Cr.	109.8	Good	High	58	Temp.	?	I
SF Crabtree Cr.	17.2	Good	Low	0	?	?	I
Upper Thomas Cr.	58.1	Good	Moderate	8	?	?	I
Foster	52.5	NA	Low	162	?	?	II
Upper South Santiam	17.0	NA	Low	14	?	?	II
SF South Santiam	22.9	NA	Low	3	?	?	II
NF Quartzville Cr.	19.6	NA	Low	3	Temp.	All	III
SF Quartzville Cr.	23.7	NA	Low	0	Temp.	All	III
NF Middle Santiam	14.8	NA	Low	0	Temp.	All	III
Quartzville Cr.	16.4	NA	Low	6	Temp.	All	III
SF Middle Santiam	24.7	NA	Low	1	Temp.	All	III
Green Peter	38.4	NA	Low	4	Temp.	All	III
Middle Santiam	24.0	NA	Low	0	Temp.	All	III

habitat and refugia and an improved corridor to spawning grounds above Foster Dam. Many of these watersheds are only moderately altered through agriculture and land forming practices.

South Fork Crabtree, North Fork Crabtree, Neal, Upper and Lower Thomas, and Beaver Creeks are also categorized as Priority I due to existing fish runs. They were characterized by a high potential to be dewatered. The lower portions are highly altered for agricultural practices. The headwaters have good fish habitat conditions, but the corridor to these areas is highly degraded. There is also a high potential for blocked fish passage in areas such as the push-up dam at the Lacomb Irrigation District and the district's hydropower dam on Crabtree Creek. There is evidence that the water quality (bacteria, nutrients, temperature) is poor in these areas as well.

Priority II

Priority II watersheds are those watersheds for which restoration is believed to be feasible but with high cost and/or high failure rate probability. Most are characterized by highly degraded stream reaches, large percentage of the lands have been modified, high dewatering potential, degraded riparian conditions, or poor water quality. These watersheds have the potential to provide important fish habitat, but the issues are diverse and restoration is more complex. Most include heavy agricultural activity.

Foster, Upper South Santiam, and SF South Santiam are all categorized as Priority II. These basins are mostly federal lands and consequently are managed according to federal practices and management plans. Therefore, these watersheds are seen as a lower priority for the watershed council under the assumption that restoration is currently being conducted by the managing federal agencies.

Priority III

Priority III watersheds are those which are blocked from anadromous fish passage and therefore no longer provide anadromous fish habitat. These include the Quartzville Creek and Middle Santiam watersheds. With the construction of Green Peter Dam, anadromous fish habitat was blocked above the dam. These areas are still important to resident fish species, however.

Priority P

Priority P watersheds are defined as those where stream reaches are in relatively good condition and need to be protected. These areas are characterized by low dewatering potential, good riparian conditions, and good habitat quality. Several sites have been identified as important anadromous fish habitat and spawning areas. Moose and Canyon Creeks and Soda Fork were identified as primary spawning grounds for winter steelhead (WNF 1995). Moose Creek is also recognized as important refugia for anadromous fish above Foster Dam. In 1994 spring chinook smolts were released in Foster Reservoir to seed those areas not being used by steelhead, including Squaw Creek, Sheep Creek, and the upper areas of Moose Creek, Canyon Creek, Soda Fork, and the mainstem South Santiam (WNF, 1995). Moose Creek is currently closed to all fishing. Moose Creek and Lower Canyon Creek were also identified by ODFW as requiring a high level of protection (ODFW 1998).

1.6 Water Quality

Water quality is controlled by the interaction of natural and human processes in the watershed. Processes that occur on the hillslope can ultimately control instream water quality. Pollutants are mobilized through surface and subsurface runoff and can cause degradation of stream water quality for both human use and fish habitat. Consequently, many water quality parameters are highly episodic in nature and often associated with certain land use practices. The water quality assessment is based on a process that identifies the beneficial use of water, identifies the criteria that protects these benefits, and evaluates the current water quality conditions using these criteria as a rule set (GWEB, 1997).

Overall, the monitoring data from the South Santiam Watershed Council suggests that water quality exceeds minimum standards throughout the lower South Santiam subwatersheds. Monitoring data suggests that both bacteria and turbidity are potential concerns throughout the lower South Santiam watersheds and need to be further characterized to better understand sources and variability across storm types (intensity, antecedent moisture conditions). Dissolved oxygen met the cold water fisheries standard, although improvements need to be made to meet salmonid spawning requirements.

Water quality issues identified as important in the upper and lower South Santiam River watersheds include bacteria, nutrients, temperature, dissolved oxygen, and turbidity. Each is discussed below.

Bacteria

Preliminary results suggest that high bacteria concentrations occur throughout the lower portions of the watersheds, and that many of the tributaries are contributing significant bacterial loads to the South Santiam and Santiam Rivers. Land use in the lower portions of the watershed includes large proportions of rural, urban and pastureland scattered throughout the watershed. Only limited fecal coliform bacteria data are available for the upper South Santiam watersheds, although the land use suggests that bacteria is probably not an important issue. Figure 1.1 shows potential bacterial source areas in the South Santiam watershed based on land use.

Nutrients

Nutrient data (N, P) are scarce throughout the watershed, although what data does exist suggest that nutrient concentrations are moderate to high in the lower South Santiam watersheds. Additionally, models developed for the Willamette Basin suggest that nutrient loading from the Santiam River system are higher than many of the other subbasins in the Willamette River (Tetra Tech, 1992). Nutrient loading can occur from agricultural lands as well as urban and rural areas. Figure 1.2 shows potential source areas in the South Santiam watershed for nutrients, based on land use.

Temperature and Dissolved Oxygen

Temperature is a widespread problem throughout the upper and lower South Santiam watersheds. Thirteen sites were monitored for summer temperatures in the lower South Santiam watersheds by the South Santiam Watershed Council in 1998. All sites had temperature exceedences (7-day moving average of daily maximum temperatures greater then $64^{o}F$). There is some indication that increased stream temperatures may have occurred historically. Further investigation is warranted to elucidate stream reaches that significantly contribute to increased stream temperatures.

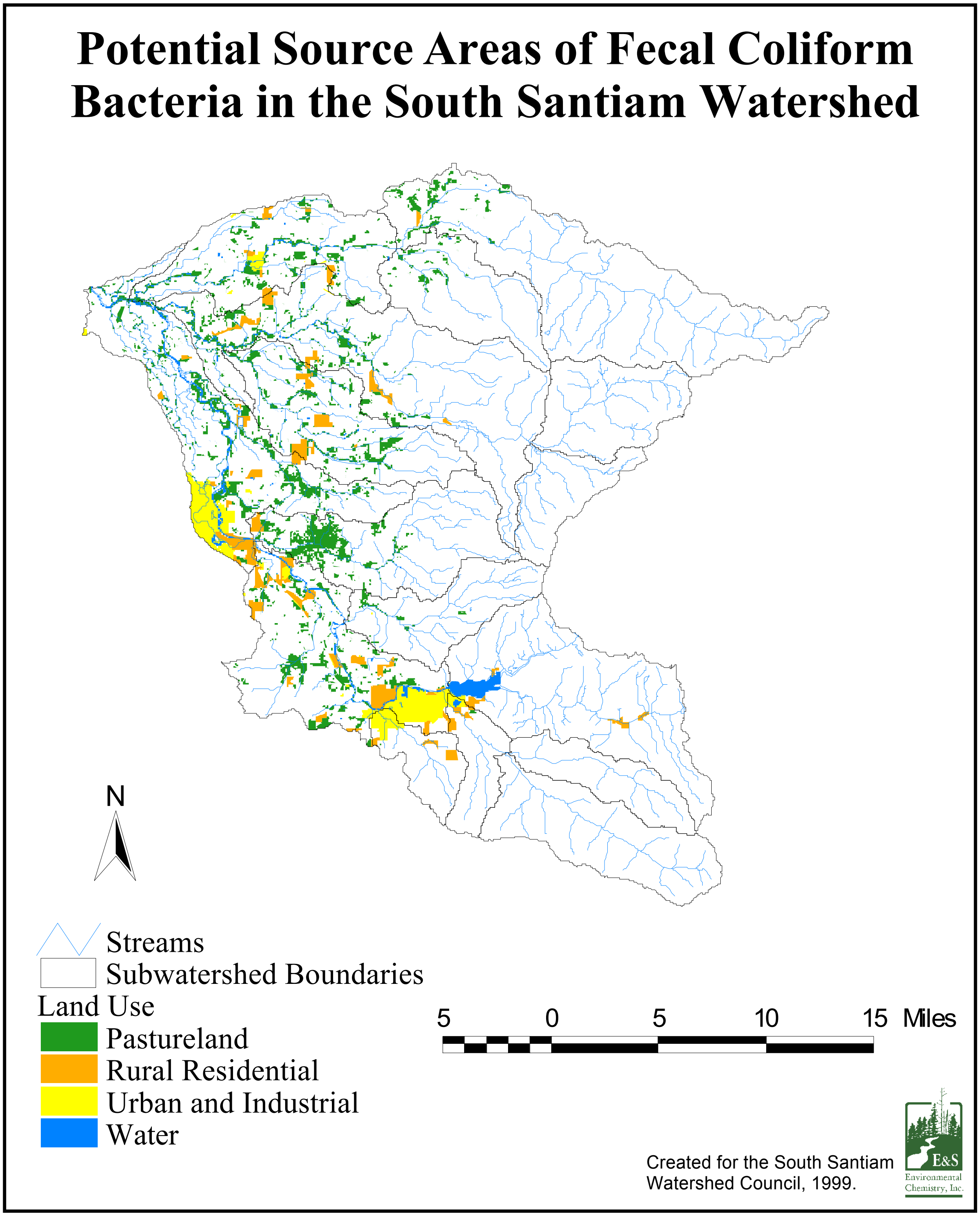


Figure 1.1. Potential sources of fecal coliform bacteria based on land use in the South Santiam watershed. Only the watersheds with urban, rural residential, and pastureland areas are shown.

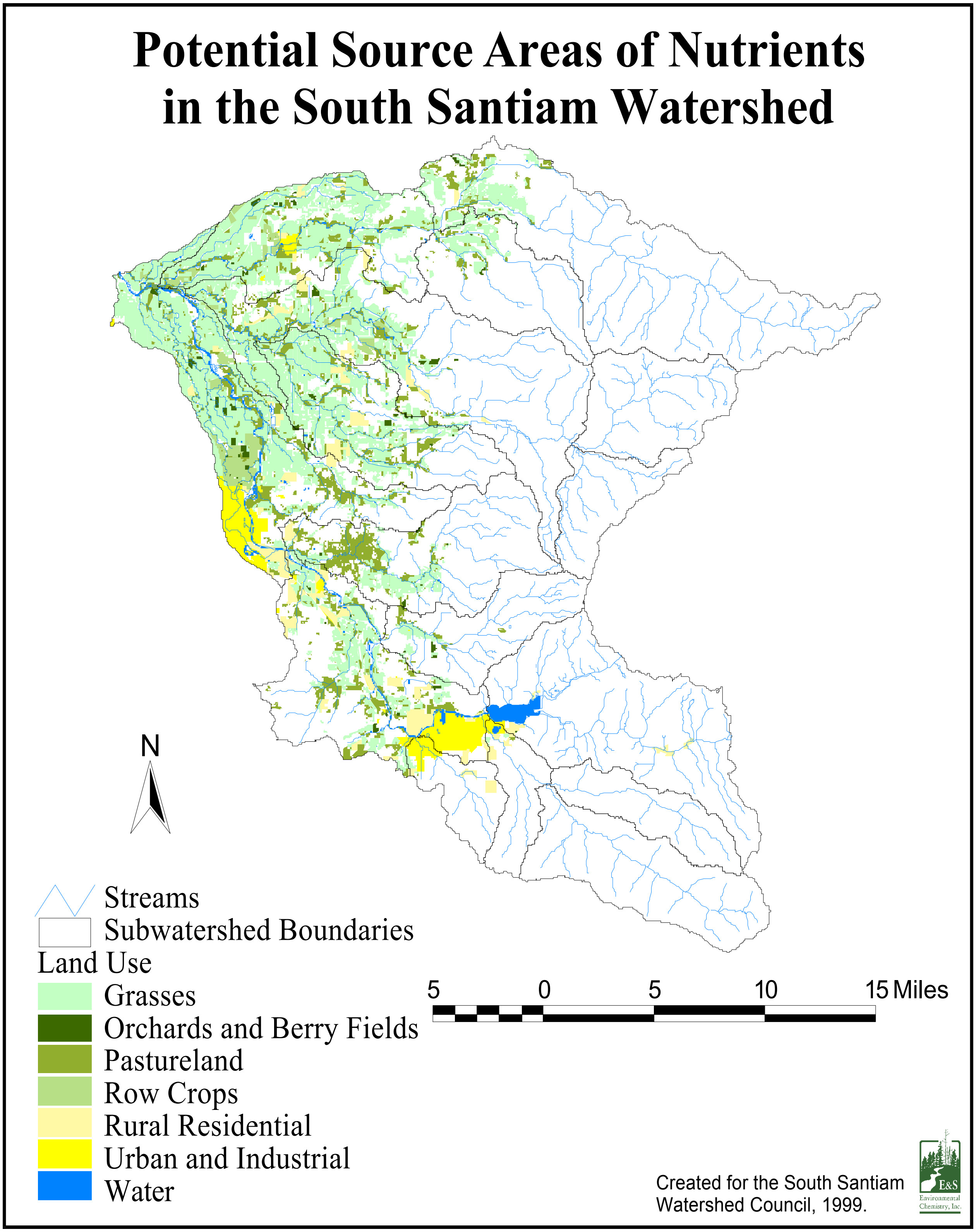


Figure 1.2. Potential sources areas of nutrients based on land use in the South Santiam watershed.

Dissolved oxygen (D.O.) concentrations in the watershed generally meet the cold water fisheries standard, but D.O. concentrations rarely exceeded the Salmonid Spawning criterion. This is most likely a result of increased stream temperatures; D.O. decreases with decreasing temperature. Areas identified as important salmonid spawning areas need to be identified and evaluated for dissolved oxygen concentrations.

Turbidity

Turbidity can be generated from almost all of the land use categories in the South Santiam watershed. However, forest management practices can generate large sediment loads through the construction of roads and removal of vegetation. Turbidity is a concern throughout both the lower and upper South Santiam watersheds. Figure 1.3 shows potential source areas in the South Santiam watershed for total suspended solids based on land use.

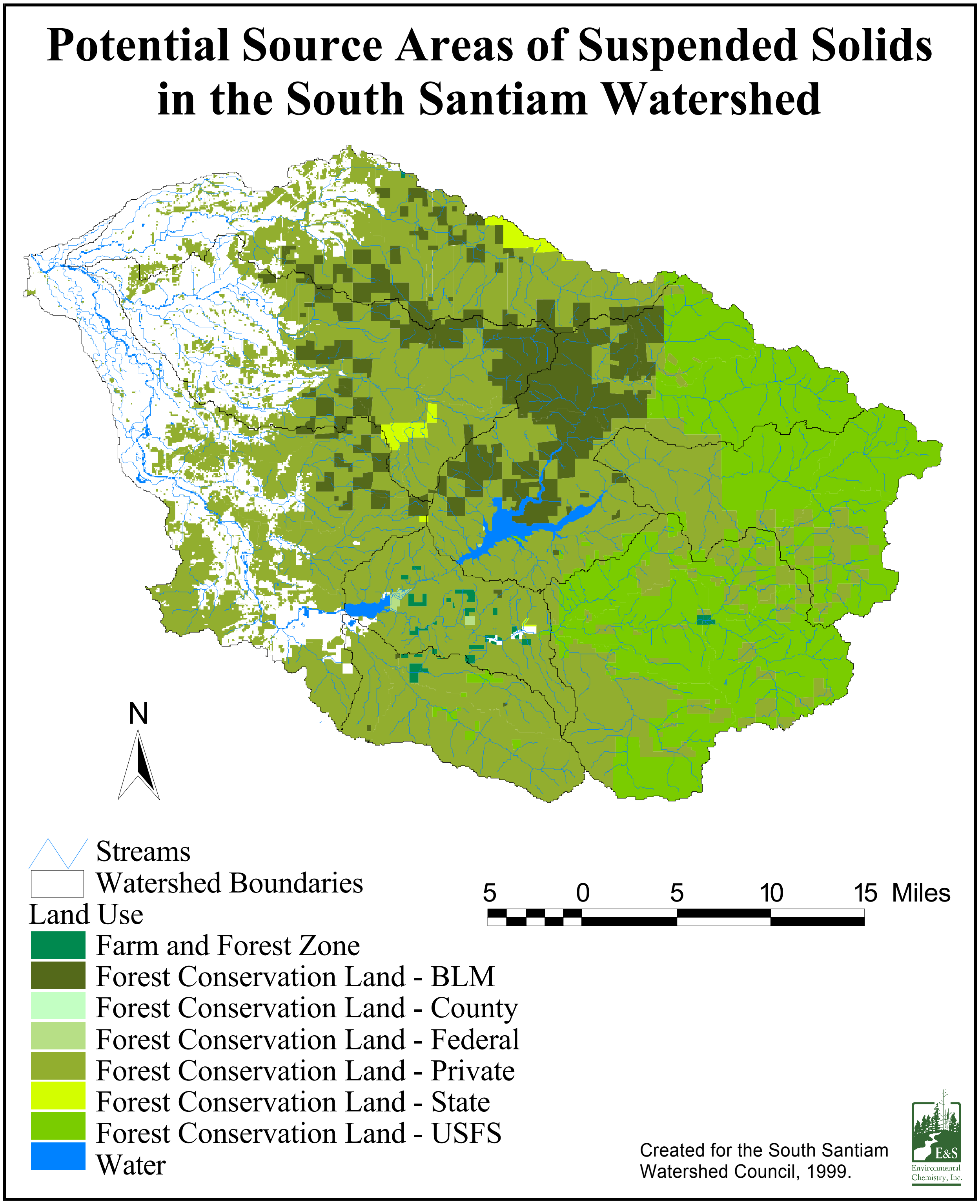


Figure 1.3. Potential sources of total suspended solids based on land use in the South Santiam watershed.

CHAPTER 2. ACTIONS IDENTIFIED BY THE SOUTH SANTIAM WATERSHED COUNCIL

2.1 Water Quality

Priority 1

- In the following subwatersheds, decrease stream temperatures to at least the state standard of 64º F. In waters supporting salmonid spawning, the temperature should be reduced to the state standard of 55º F.

  Crabtree, Thomas, McDowell, Hamilton, Beaver, Wiley, Ames, and Canyon Creeks

- In the following subwatersheds, identify restoration activities to decrease fecal coliform bacteria to state levels considered safe for water contact recreation (maximum of 400 CFU/100 mL, 200 *E. coli*/100 mL):

  Crabtree, Thomas, McDowell, Hamilton, Beaver, and Ames Creeks; South Santiam River

Priority 1 Actions:	
Monitoring	• Monitor temperature (May - Oct) at key locations in each stream with continuous temperature monitors. Sites should be located at the agricultural/forest/rural residential/urban interfaces, as well as other locations. • Continue monitoring fecal coliform from May through October. • Identify sites for fecal coliform clean-up. • Investigate macroinvertebrate biodiversity in streams to locate sources of productivity and fish production within the basin. We will use the Clackamas Study as a model.
Fencing and temporary restriction of livestock	• Work with landowners to keep domestic animals out of creeks to reduce bank erosion; allow riparian growth for stream shading; decrease turbidity and temperature; and filter fecal coliform bacteria from runoff before it reaches streams. • Study best management practices for temporary riparian pastures. • Identify practical alternatives for off-stream watering, fencing, funding sources, when to keep cattle out of streams, etc. • Work with extension to develop educational materials (brochure/ packet) on best management practices. • Distribute information in feed stores, newsletters, extension bulletin.

	• Host a public workshop on controlling erosion (mud) on farms. • Develop a direct mailing to livestock owners on best management practices.
Riparian improvement of plants:	• Plant trees along riparian areas including ponderosa pine, western red cedar, ash, cherry, plum, apple, pear, and species listed in the "Guide for Using Willamette Valley Natives Along Your Stream". Target areas using watershed assessment data.
Encourage repair of failing septic systems	• Host workshops on septic system maintenance, and provide information on septic systems at community events. • Provide information on loans to replace or repair failing septic systems.

Priority 2

- Reduce nutrient and sediment input into waterbodies.

Priority 2 Actions:	
Monitoring	• Monitor nutrients and sediment to determine sources of pollutant loading. • Photo-document potential problem areas.
Education	• Encourage landowners to use proper amounts of fertilizer on lawns in urban and rural areas. • Work with agricultural extension and landowners to encourage implementation of best management practices for agriculture, including reductions in fertilizer use. • Work with City of Albany on Lebanon-Santiam canal improvements. • Encourage pollutant trading for water quality problems
Streambank stabilization	• Work with landowners to stabilize streambanks to decrease sediment inputs.

2.2. Water Conservation: Irrigation, Livestock, Municipal

Priority 1

- The dewatering potential is high for the following subwatersheds (above 30% water withdrawal):

Water Availability Watershed	Avg. % Withdrawn
Neal Subwatershed	41%
Thomas Subwatershed	40%
Ames Subwatershed	36%
Crabtree Subwatershed	31%

Priority 1 Actions:	
Monitoring	• Install gaging station to monitor flows at the mouth of creeks listed as Priority 1. (cost approx. $5,000 per year)
Improve irrigation efficiency throughout South Santiam Watershed	• Work with individual farmers to improve irrigation efficiency and meter irrigation withdrawals. • Work with irrigation districts to improve irrigation efficiency. • Identify large water users.

Priority 2 Issues

- The dewatering potential is moderate for the following subwatersheds

Water Availability Watershed	Avg. % Withdrawn
Hamilton Subwatershed	17%
McDowell Subwatershed	12%

Priority 2 Actions:	
Monitoring	• Install gauging station to find out the actual flow at the mouth of Creeks listed as Priority 2. (cost approx. $5,000.00 per year)
Urban	• Improve municipal water use efficiency through working with municipalities • Encourage residential and business conservation of water
Improve irrigation efficiency throughout the South Santiam Watershed	• Work with individual farmers to improve irrigation efficiency and meter irrigation withdrawals. • Work with irrigation districts to improve irrigation efficiency. • Identify large water users.

2.3 Fish Passage and Habitat Restoration

2.3.1 Fish Passage

Priority 1

- Ensure fish passage within Division of State Lands Essential Salmonid Habitat.
- Screen water withdrawals within Division of State Lands Essential Salmonid Habitat.
- Improve smolt passage at Foster Dam.
- Improve fish passage and screen at Lebanon Dam.
- Improve fish passage at Sankey Dam.

Priority 1 Actions:	(Fish passage should be restored starting at the downstream end and moving up the stream system.)
Culverts	• Assess culverts within Division of State Lands Essential Salmonid Habitat. • Quantify habitat above culverts blocking fish passage. • Replace culverts with the largest amount of desirable habitat above them.
Fish Screens	• Identify unscreened water withdrawals. • Encourage landowners to screen water withdrawals within Division of State Lands Essential Salmonid Habitat; assist landowners with grants, funding, etc. • Install fish screen at the Albany-Lebanon canal intake.
Dams	• Improve smolt passage at Foster Dam. • Work with the City of Albany to improve passage at Lebanon Dam. • Work with the City of Sweet Home to improve passage at Sankey Dam.

Priority 2

- Ensure fish passage in areas with historic fish presence. Screen water withdrawals in areas with historic fish presence.
- Fish passage at Green Peter Dam (there is currently no fish passage).

Priority 2 Actions:	(Fish passage should be restored starting at the downstream end and moving up the stream system.)
Culverts	• Assess culverts in areas with historic fish presence outside Division of State Lands Essential Salmon Habitat. • Quantify habitat above culverts blocking fish passage. • Replace culverts with the largest amount of desirable habitat above them.
Fish Screens	• Screen water withdrawals in areas with historic fish presence.
Dams	• Work with congressional representatives to install passage at Green Peter.

Priority 3

- Ensure fish passage in all areas with cutthroat trout.

2.3.2 Fish Habitat Restoration

Priority 1

- Identify and protect the healthiest and most productive anadromous fish-bearing streams.

- Restore habitat in Thomas, Crabtree, Wiley, Little Wiley, lower mainstem S. Santiam, Hamilton, McDowell, and Ames subwatersheds below natural barriers.

- Protect Canyon, Moose, Soda Fork subwatersheds.

- Restore and enhance riparian shade in Division of State Lands Essential Salmonid Habitat, in areas with historic and current anadromous fish, and in Priority 1 subwatersheds listed above.

- Identify instream projects (large wood, boulder structures) to be conducted in Division of State Lands Essential Salmonid Habitat, in areas with historic and current anadromous fish, and in Priority 1 subwatersheds listed above.

Priority 1 Actions:	(Fish habitat work should be conducted below natural barriers, and initially below manmade barriers.)
Identify and protect the healthiest and most productive anadromous fish-bearing streams	• Conduct study on macroinvertebrate production in order to determine areas with the most fish production. • Look at historic and current fish presence. • Identify key tributaries for fish redd counts. • Evaluate the numbers of fish in the entire area; we only have counts at Foster Dam. Little is known about the Lower South Santiam, Crabtree, Thomas, Hamilton, McDowell, and other subwatersheds. • Develop partnership with federal and other landowners.
Restore and protect priority 1 areas	• Develop specific restoration actions on each high priority stream reach based on the watershed assessment, GIS coverages developed and the Access database containing the watershed data. Actions can include such things as: instream projects (large wood, boulder structures), improving canopy closure over small streams, and improving riparian zones in areas classified as "poor" by the watershed assessment.

Priority 2

- All other streams below Green Peter Dam not listed as Priority 1.

Priority 3

- All areas above Green Peter dam.

2.4. Further Assessment/Data Gaps

2.4.1 Water Quality

Water quality data are scarce and of varied quality in the South Santiam watershed. However, a few data needs can be elucidated from the current database that has been compiled. DEQ has identified data gaps in the 1998 draft 303(d) list, which concentrates heavily on the tributaries flowing into the South Santiam River (Table 2.1). Water quality is not well known in either Thomas and Crabtree Creeks, or in their tributaries. Focusing water quality monitoring on

Table 2.1. Stream segments listed as in need of data by DEQ (DEQ Decision Matrix, 1998)

Watershed	Stream Segment	Parameter	Listing Status	Season
Thomas Cr.	Mouth to White Rock Cr.	Dissolved Oxygen	Potential Concern	Summer
Thomas Cr.	Mouth to Neal Cr.	Sedimentation	Need Data	
		Flow Modification	Need Data	
		Habitat Modification	Need Data	
Hamilton	Mouth to Deer Creek	Temperature	Need Data	Summer
		Flow Modification	Need Data	
		Sedimentation	Need Data	
Crabtree Cr.	Mouth to White Rock Cr.	Sedimentation	Need Data	
		Flow Modification	Need Data	
Beaver Cr.	Mouth to Headwaters	Nutrients	Need Data	
		Flow Modification	Need Data	
		Sedimentation	Need Data	
		Temperature	Need Data	
Canyon Creek	Mouth to Headwaters	Aquatic Weeds Algae or Algae	Need Data	
		Habitat Modification	Need Data	
		Temperature	Need Data	
Gold Creek	Green Peter Reservoir to Headwaters	Sedimentation	Need Data	
Middle Santiam River	Green Peter Reservoir to Headwaters	Temperature	Need Data	
		Sedimentation	Need Data	
		Habitat Modification	Need Data	
Moose Creek	Mouth to Headwaters	Habitat Modification	Need Data	
		Sedimentation	Need Data	
		Temperature	Need Data	
Pyramid Creek	Mouth to Headwaters	Temperature	Need Data	
		Sedimentation	Need Data	
Quartzville Creek	Green Peter Reservoir to Headwaters	Sedimentation	Need Data	
		Habitat Modification	Need Data	

Table 2.1. Continued				
Watershed	Stream Segment	Parameter	Listing Status	Season
Soda Creek	Mouth to Headwaters	Sedimentation	Need Data	
		Habitat Modification	Need Data	
		Temperature	Need Data	
South Santiam River	Foster Reservoir to Headwaters	Temperature	Need Data	
		Sedimentation	Need Data	
		Habitat Modification	Need Data	
Squaw Creek	Mouth to Headwaters	Sedimentation	Need Data	
		Temperature	Need Data	
		Habitat Modification	Need Data	

these areas will help improve our understanding of water quality in the South Santiam watershed. Following is a list of areas that are in particular need of further investigation and data collection, some of which are under current investigation by the SSWC:

1. Collect sediment/turbidity, nutrient, and bacteria data for the tributaries flowing into the South Santiam River, including Thomas Creek, Crabtree Creek, Beaver Creek, Hamilton Creek, McDowell Creek, and Ames Creek to elucidate watershed areas contributing high pollutant loads.

2. Collect sediment/turbidity, nutrient, and bacteria data at all sites across a suite of flow regimes. Ambient monitoring should include flow data and attempt to characterize a number of different flows.

3. Characterize turbidity and sediment loads across a suite of storm types and flows. Ambient monitoring should include samples across many discharge levels. Storm samples should be collected to characterize storms under different conditions (antecedent moisture conditions; season, intensity).

4. Characterize fecal coliform bacteria concentrations and loads across a suite of storm types and flows. Ambient monitoring should include samples across many discharge levels. Storm samples should be collected to characterize storms under different conditions (antecedent moisture conditions; season, intensity).

5. Characterize temperature distributions to elucidate stream reaches that contribute to stream temperature increases. Additionally, areas that may provide refugia from high summer temperatures can be identified.

2.4.2 Water Conservation

1. Current flow information is not available for Thomas and Crabtree Creeks. Instream flows during the summer low flow months need to be monitored and appropriate flows for the protection of fish need to be established. Current information is based on modeled values of natural stream flow conditions. However, these modeled values do not always agree with instream flow measurements. Appropriate instream flows need to be established to protect aquatic resources and then monitored through stream gaging.

2. Development of appropriate instream water needs for the water availability subwatersheds in the South Santiam watershed. Instream water rights have been set for many of the streams, although they often exceed natural instream flows. Appropriate instream flows need to be established for the watersheds and then evaluated using actual instream flow measurements.

2.4.3. Priorities

Priority I Actions

- Characterize fecal coliform bacteria concentrations and loads across a suite of storm types and flows.

- Characterize temperature distributions to elucidate stream reaches that contribute to stream temperature increases. Additionally, areas that may provide refugia from high summer temperatures can be identified.

- Field surveys of all culverts for fish passage (integrate existing studies from ODOT, USFS, Avery Properties, Willamette Industries, etc.). Priority should be on culverts in fish bearing streams

- Quantification of habitat blocked by culverts.

- Field evaluation of stream shading where riparian area was not classified as “mature” (to increase our understanding of temperature).

- Current flow information is not available on Thomas or Crabtree Creeks. Instream flow during the summer low flow months need to be monitored.

- More data needs to be obtained on productive stream reaches (including macroinvertebrate communities), where fish are doing well.

Priority 2 Actions

- Development of appropriate instream water needs. Instream water rights for fish and water quality have been set for many of the streams, although they often exceed natural instream flows. Appropriate instream flows need to be established and evaluated using actual instream flow measurements.

- Collect sediment/turbidity, nutrient, and bacteria data for the tributaries flowing into the South Santiam River, including Thomas Creek, Crabtree Creek, Beaver Creek, Hamilton Creek, McDowell Creek, and Ames Creek to elucidate watershed areas contributing high pollutant loads

- Collect sediment /turbidity, nutrient and bacteria data at all sites across a suite of flow regimes. Ambient monitoring should include flow data and attempt to characterize a number of different flows.

- Characterize turbidity and sediment loads across a suite of storm types and flows. Ambient monitoring should include samples across many discharge levels. Storm samples should be collected to characterize storms under different conditions.

SECTION II. BACKGROUND

CHAPTER 1. PURPOSE AND SCOPE

The purpose of this watershed assessment is to evaluate the current conditions of the South Santiam Watershed and to provide recommendations that address the issues of water quality, fisheries and fish habitat, and watershed hydrology. This assessment was conducted following the guidelines outlined in the draft Governor's Watershed Enhancement Board (GWEB) watershed assessment manual (Oregon Watershed Assessment Manual (OWAM)). During the course of the assessment, a later revised manual was released. The authors have attempted to incorporate the new methodologies where possible.

The scope of the watershed assessment is to evaluate watershed conditions at the fifth field watershed level. We have conducted the assessment maintaining this level of analysis. However, we have adjusted the presentation of this material to also provide an overall view of the South Santiam River Watershed, which is a fourth field watershed composed of eight fifth field watersheds. The assessment begins with an introduction to issues addressed, followed by a description of the methodology used. We have written methodology sections only for those areas in which we deviated from the Oregon Watershed Assessment Manual. Next, the South Santiam River watershed is addressed in two sections. The first includes what we have defined as the lower South Santiam watersheds including Crabtree Creek, Thomas Creek, Lower South Santiam River, and Wiley Creek. The next section, which we have defined as the upper South Santiam watersheds, includes Foster Reservoir, Upper South Santiam River, Middle Santiam River, and the Quartzville Creek watersheds. This delineation was based on a number of factors. First, as the assessment progressed, it became clear to the authors that there were two distinct regions in the South Santiam watershed: 1) the lower elevation basins where there are no major fish passage problems (i.e. Foster and Green Peter Dams), but the land is highly developed (Urban, Rural Residential, and Agriculture); and 2) the higher elevations of the watershed where habitat conditions are quite good but much of it is blocked by the dams and, in some cases, culverts. This delineation is also consistent with the ecoregion approach outlined in the latest version of OWAM. Four ecoregions occur in the South Santiam Watershed: Western Cascades Lowlands and Valleys, Western Cascades Montane Highlands, Willamette Valley Foothills, and Willamette Valley Plains. All of the upper basins are in the Western Cascades Montane Highlands

Ecoregion, while the lower basins are a mix of all four. Consequently, the upper and lower portions of the South Santiam watershed are very different in their characteristics. This delineation groups together the most similar basins based on ecoregions.

CHAPTER 2. INTRODUCTION

2.1 Channel Habitat Types

Stream channels were broken into channel habitat type (CHT) categories based on the OWAM protocol. Categories were based on stream geomorphic structure including stream size, gradient, and side slope constraint. Realizing that even under pristine conditions salmonids are not evenly distributed throughout a watershed, this classification system was designed to identify portions of the watershed that have the highest potential for fish utilization (GWEB, 199). Table 2.1 lists the channel habitat types and their associated fish usage. However, it is important to note that the fish utilization descriptions of the CHT's in the Watershed Assessment Manual are specifically oriented towards coastal rivers. For our purposes, we have substituted spring chinook for coho on the advice of Oregon Department of Fish and Wildlife (Wayne Hunt, pers. comm. 1999) because there are no coho in the South Santiam River or above the falls at Oregon City.

2.2 Fisheries

Fisheries within the South Santiam watershed have undergone significant changes during the twentieth century. The types of fish present and their locations have been altered from historical conditions in the watershed. Arguably, the most significant activities to affect the fisheries during the last one hundred years are habitat modifications and hatchery programs.

This fisheries assessment will:

- describe the watershed's fisheries
- provide an overview of hatchery programs and their influences
- identify native spring chinook and winter steelhead distributions
- characterize life cycles of spring chinook and winter steelhead
- present stream habitat conditions for selected streams
- identify critical habitat areas, and
- identify several features blocking fish passage

Table 2.1. Channel habitat type descriptions and their associated fish usage.

Channel Habitat Type Code	Channel Habitat Type General Description	Fish Utilization
FP1	Wide, Lowland Floodplain	Anadromous: Important steelhead and spring chinook spawning, rearing & migration corridor. Resident: Important spawning, rearing & overwintering
FP2	Low-Gradient Floodplain. Channel Large-Medium	Anadromous: Important steelhead and spring chinook spawning & rearing. Resident: Important spawning, rearing & overwintering
FP3	Low-Gradient Floodplain. Channel Small	Anadromous: Important steelhead and spring chinook spawning & rearing. Resident: Important spawning & rearing.
LC	Low-Gradient Constrained Channel	Anadromous: Potential steelhead and spring chinook spawning & rearing. Resident: Potential spawning, rearing, & overwintering.
MM	Moderate Gradient, Moderately Constrained Channels	Anadromous: Limited spring chinook rearing and Spawning. Potential steelhead spawning & rearing. Resident: Potential spawning, rearing & overwintering.
MC	Moderate Gradient, Constrained Channels	Anadromous: Potential steelhead spawning & rearing. Resident: Potential spawning, rearing, & overwintering.
MV	Moderately Steep, Narrow Valley Channel	Anadromous: Potential steelhead spawning & rearing. Resident: Potential spawning & rearing.
SV	Steep Narrow Valley Channel	Anadromous: Lower gradient segments may provide limited rearing (if accessible). Resident: Limited spawning & rearing.
VH	Very Steep, Headwater Channel	Resident: Very limited spawning & rearing.
MH	Moderate Gradient Headwater Channels	Anadromous: Potential steelhead spawning & rearing (if accessible). Resident: Important spawning & rearing.
WC	Connected, Formerly Connected Wetland	Anadromous: Potential steelhead and spring chinook rearing & overwintering (if accessible & large enough). Resident: Potential rearing & overwintering (if accessible and large enough)

2.3 Channel Modification

In-channel structures and activities such as dams, dredging or filling can adversely affect aquatic organisms and their associated habitats by changing the physical character of the stream. These changes can ultimately lead to a change in the community composition of instream aquatic biota. The purpose of this channel modification inventory is to assess the extent and location of in-channel activities in the watershed. Channel modification activities outlined in this section when overlaid with the channel habitat types (CHT) can address how human-created channel disturbances affect channel morphology, aquatic habitat, and hydrologic functioning. The critical questions for the channel modification portion of this assessment are:

1. Where are the locations of channel, wetland, and floodplain modification?
2. Where are the locations of historic channel disturbances such as dam failures, splash damming, hydraulic mining, and stream cleaning?
3. Where are the known locations of current channel disturbances such as channel widening, extensive bank erosion, large sediment bars, etc.? and
4. What stream habitat types have been impacted by channel modification?

2.4 Riparian Zones

Riparian zones are the areas along streams, rivers and other bodies of water where there is direct interaction between the aquatic and terrestrial ecosystems. The riparian zone ecosystem is one of the most highly valued and highly threatened ecosystems in the United States (Johnson and McCormick 1979, National Research Council 1995, Kauffman et al. 1997). Riparian vegetation is one of the most important elements of a healthy stream system, providing several functions that aid in maintaining ecosystem health. Examples include:

- providing bank stability and controlling erosion
- moderating water temperature
- providing food for aquatic organisms
- providing large woody debris to increase aquatic habitat diversity
- filtering surface runoff to reduce the amount of sediments and pollutants that enter the stream

- providing wildlife habitat, and
- dissipating energy flow and storing water during flood events.

Natural and human degradation of riparian zones diminishes their ability to provide these critical ecosystem functions.

The riparian zone is the primary source of natural large woody debris (LWD). Instream LWD provides important fish habitat features such as cover, production and maintenance of pool habitat, creation of surface turbulence, and retention of small woody debris. Functionally, LWD dissipates stream energy, retains gravel and sediments, increases stream sinuosity and length, slows the nutrient cycling process, and provides diverse habitat for aquatic organisms (BLM 1996). LWD is most abundant in intermediate sized channels in third- and fourth-order streams (BLM 1996). In fifth-order and larger streams, the channel width is generally wider than a typical piece of LWD, and therefore, LWD is not likely to remain stable in the channel (BLM 1996). In wide channels LWD is more likely to be found along the edge of the channel.

Riparian vegetation also provides shade that helps control stream temperature in the warm summer months. While shade will not actually cool a stream, riparian vegetation blocks solar radiation before it reaches the stream preventing the stream from heating (Beschta 1997, Boyd and Sturdevant 1997, Beschta et al. 1987). The shading ability of the riparian zone is determined by the quality and quantity of vegetation present. The wider the riparian zone and the taller and more dense the vegetation, the better the shading ability (Beschta 1997, Boyd and Sturdevant 1997).

This assessment focuses on current riparian conditions. The four critical questions are:

1. What is the current condition of the riparian areas?
2. What is the current level of instream large woody debris (LWD)?
3. What is the potential for future delivery of LWD based on current vegetation composition? and
4. What is the current level of stream shading?

2.5 Water Quality

Water quality is controlled by the interaction of natural and human processes in the watershed. Processes that occur on the hillslope can ultimately control instream water quality. Pollutants are mobilized through surface and subsurface runoff and can cause degradation of stream water quality for both human use and fish habitat. Consequently, many water quality parameters are highly episodic in nature and often associated with certain land use practices. The water quality assessment is based on a process that identifies the beneficial use of water, identifies the criteria that protects these benefits, and evaluates the current water quality conditions using these criteria as a rule set (GWEB 1999). The water quality critical questions are:

1. What are the designated beneficial uses of water for the stream segment?
2. What are the applicable numerical and narrative water quality criteria that apply to the stream reaches?
3. Are the stream reaches identified as Water Quality Limited Segments by the State?
4. Are any stream reaches identified as high quality waters or Outstanding Resource waters?
5. Do water quality studies or evaluations indicate that water quality has been degraded or is limiting the beneficial uses?

2.6 Hydrology and Water Use

Both natural and human-induced changes in vegetation and soil compaction can have large impacts on the hydrology of a watershed. Some examples of human activities that can impact watershed hydrology are timber harvesting, urbanization, conversion of forested land to agriculture, and construction of road networks. These types of changes in the landscape can increase or decrease the volume, size, and timing of runoff events and affect low flows by changing groundwater recharge. The critical questions for the hydrology component are:

1. What are the climate and streamflow characteristics of the watershed?
2. What is the flood history in the watershed?
3. How are current land use activities or changes potentially affecting the watershed and how have the natural processes changed the landscape of the watershed?

Water is withdrawn from both surface and subsurface water supplies within almost all the watersheds in Oregon. Much of this water is for beneficial uses, such as irrigation, municipal water supply, and stock watering. When water is removed from these stores, a certain percentage is lost through processes such as evapotranspiration. Water that is "consumed " through these processes does not return to the stream or aquifer, resulting in reduced instream flows. Reduced instream flows can adversely affect aquatic communities that are dependent upon this water. In fact, the dewatering of streams has often been cited as one of the major reasons for salmonid declines in the state of Oregon. The critical questions for the water use component are:

1. For what beneficial uses is water primarily used in the watershed?
2. Are there any withdrawals of water for use in another basin (interbasin transfers)?
3. Do water uses in the basin have any effects on peak flows?
4. Do water uses in the basin have an effect on low flows?
5. Is there enough information to discern how water use affects fish habitat?

CHAPTER 3. METHODS

This assessment was conducted according to the draft Oregon Watershed Assessment Manual produced for GWEB. However, the GWEB manual is still in the early stages of development and testing, leaving many of the decisions of how to deal with data up to the group conducting the assessment. Furthermore, the OWAM assumes that much of the data manipulation needed to produce the watershed assessment will be done by hand using topographic maps. We have developed appropriate methodologies that incorporate state-of-the-art technologies such as Geographic Information Systems (GIS) and Statistical Analysis Systems (SAS) while maintaining the scope of the OWAM. We have been able to achieve significant cost and time savings, with improved accuracy, using GIS. Additionally, in an effort to make this assessment as usable as possible, we have modified the methodologies to be more consistent and reproducible. Following is a descriptions of the methodologies that were developed for the South Santiam Watershed Assessment.

3.1 Subbasin Delineations

The South Santiam watershed is a fourth field watershed composed of eight fifth field watersheds. The fifth field watershed size is too large to use as the analysis unit. Therefore, to facilitate the assessment process, the fifth field watersheds were divided into smaller units, based on priority areas of the watershed council and stream drainage characteristics (such as the North Fork of the Middle Santiam). Digital Elevation Models developed by the United States Geologic Survey (USGS) were used to delineate the watershed boundaries.

3.2 Land Use

Current land use data are available in the form of a zoning coverage developed by the Oregon State Department of Land Conservation and Development (DLCD) in conjunction with the State Service Center for Geographic Information Systems (SSCGIS). Since there is some overlap within land use categories and the zoning categories which vary by county, the land use data needed to be refined to be sufficiently detailed for our assessment. We combined this coverage with a vegetation coverage provided by Linn County to produce a more detailed coverage of land use in the South Santiam basin. Categories included under each general land use are listed in Table 3.1. Ownership was also incorporated into the forestry lands to elucidate

Table 3.1. Descriptions of landuse categories used for the South Santiam watershed.

Land Use Class	Description
Aggregate Resource Zone	Mining and natural resource zone
Row Crops	Row crops
Grasses	Grasses
Orchards	Orchards
Farm and Forest Zone	Small farm and woodlot; Farm/forest transition
Managed Forest	Private timber lands; Federal and state managed timber lands
Pastureland	Managed and unmanaged pasture lands
Public Facility	Dumps; Utilities; Various public uses
Recreational Fields and Parks	State, county, national and public parks; Golf courses
Riparian	Riparian buffers; Riparian vegetation
Rural Residential	Rural residential communities
Rural Service Center	Rural commercial zones; Unincorporated towns
Urban and Industrial	Urban growth boundaries;
Water	Open water; Lakes and reservoirs
Wetland	Wetlands

areas that fall under different management practices. For example, private timber lands are managed differently that either Forest Service lands or BLM lands. Identifying the ownership will help to identify management practices and resultant effects on stream ecosystems.

3.3 Channel Modification

3.3.1 Inventory

Background information was gathered to identify basic characteristics of the watershed and a cursory overview of the history of human activity in the basin. Searches were done at the University of Oregon and Oregon State University library systems. Local inquiries were made at the Lebanon and Albany libraries in search of potential social history/land use anecdotes pertinent to channel modification activities. Furthermore a survey was sent out as an enclosure in the Watershed Council newsletter to query for undocumented historical channel modifications and begin to identify sources of oral history in the South Santiam watershed. Visits were made to the Oregon Department of Forestry, and the US Forest Service Sweet Home Ranger District. Information from the Bureau of Land Management was obtained via phone interview. Below is a brief summary of the type of information found, listed by its respective source.

Division of State Lands (DSL)

The Division of State Lands manages the state's submerged and submersible lands under navigable rivers, lakes, estuaries, and the territorial sea to maintain fisheries, commerce, recreation and navigation. DSL also arranges leases for sand and gravel removal, storage, marinas and commercial or marine industrial facilities. In addition, DSL is a regulatory agency responsible for administration of Oregon's Removal-Fill Law. That law, enacted in 1967, is intended to protect, conserve and allow the best use of the state's water resources. It generally requires a permit from DSL to remove, fill or alter more than 50 cubic yards of material within the bed or banks of waters of the state. Removal/Fill permits were queried with help from DSL staff and photocopies were made of relevant materials to define type and location of channel modification activity.

Army Corps of Engineers (ACOE)

The Flood Control Act of 1944 authorizes the Corps of Engineers in consultation with State Governments to develop projects relevant to the navigation, recreation, and flood control of our river systems. A list of impacts was provided by the ACOE indicating the type of activity and degree of impact. Below is an abbreviated legend of the terms used in the attribute data table to detail the varying types of structures placed in the lower portion of the South Santiam mainstem:

Class III - Class III rock has a maximum weight of 800 lbs.,

Class IV – Class IV rock (riprap) has a maximum weight of 1600 lbs.

Class III & W BARR - Class III riprap with a drift barrier

STONE – Stone revetment (stone retaining wall)

Department of Geology and Mineral Industries (DOGAMI)

The Department of Geology and Mineral Industries issues permits for all extraction, processing, and reclamation for minerals. A permit is required from DOGAMI for any mine where more than 5,000 cubic yards of material are removed or where mining affects more than one acre of land within a twelve month period. Information was obtained that included latitude and longitude coordinates of the location of a particular permitted activity. This information included a mix of permits that are closed (listed as "closed" in attribute data), on-going "permitted"), or under review for possible changes to original permitted activity ("amendment").

Oregon Department of Fish and Wildlife (ODFW)

ODFW is responsible for the administration of stream surveys conducted in various river reaches throughout the state. The surveys contain information on fluvial geomorphic characteristics that can influence fish habitat. They also detail salient features of a stream including instream structures that may modify a given channel. This information was very valuable in inventorying channel modification activities that may not have been documented previously. Examples of significant impacts found in the surveys include:

- Screened/unscreened diversions
- Culverts
- Rip-rap
- Streambank failures
- Channelized streambanks
- Bridge crossings

Oregon Department of Transportation (ODOT)

ODOT is responsible for the construction and maintenance of transportation access for state highways in Oregon. Road construction and repair along streams can potentially affect the natural behavior of a river with the use of rip-rap or other streambank protection measures. Detailed engineering plans from ODOT were obtained for specific activities that took place along Hwy 20 and the mainstem of the South Santiam River.

3.3.2 <u>Mapping</u>

Mapping Channel Modifications

Accuracy in pinpointing the exact location of the channel modification impact was a challenge given the varied reporting methods of modification locations. For example an ODFW survey would indicate the distance of an impact from the starting point of the survey (i.e. 2500 meters from confluence *x*). These points were placed in the digital coverage by measuring upstream and finding the location of the modification. As a result the point coverages represent the best estimate in the *digital* environment. Where latitude and longitude information was provided (i.e. DOGAMI information) a high level of confidence was attained in locating an activity because coverages were projected directly from these coordinates.

Additional Mapping Analysis

One of the advantages of GIS is its ability to analyze relationships between sets of geo-referenced data. Two additional coverages were created to supplement the information researched above:

Flood Plain Mapping- Channel modification activities adjacent to the floodplain are set aside as a sub-set of the inventory. The information compiled here will identify areas where diversions or levees have disconnected the river from its floodplain. It will also provide a basis for the decision making process regarding flood protection versus restoration potential.

Culvert Counts/Bridge Crossings- Point coverages were created at the intersection of streams and roads using GIS technology. These points represent potential fish barrier locations and may represent natural hydrological disturbances in the watershed.

3.4 Riparian Assessment

The key components of the riparian assessment are: 1) the riparian condition summary, 2) the current level of LWD, 3) the future potential for LWD delivery, and 4) the current level of stream shading. The riparian condition summary consists of three components: buffer width, vegetation composition, and continuity. Each of these components was assessed using digital orthophotos or aerial photos. Current LWD and stream shading information was obtained from the Oregon Department of Fish and Wildlife (ODFW) stream surveys and BLM watershed analyses. Future potential for natural LWD was determined based on the current vegetation composition.

3.4.1 Photo Analysis

The Linn County GIS office provided 1:1,625 scale (1:19,500 absolute scale) digital orthophotos taken in 1996 for all areas west of Range 2 East. For this area the assessment was performed using ArcView software (version 3.0a). A streams data layer was overlaid on the orthophotos and a 30 meter (98.4 foot) buffer was drawn on each side of the streams. The buffer width, vegetation composition, and continuity were then assessed within this 30 meter (98.4 foot) buffer. Where digital orthophotos were not available, east of Range 1 East, 1:12,000 scale aerial photos from the BLM were used. A ruler was used to visually approximate the width of the buffer on the photos.

3.4.2 Ground Truthing

After approximately one-third of the photo analysis was completed, each 5th field watershed was divided into four subwatersheds. Each stream mile was assigned a number, starting with the mainstem in each subwatershed (sixth field subwatershed) and proceeding to the tributaries. A random number list of 15-20 numbers was generated for each subwatershed and the first five sites that were accessible and where landowner permission was obtained were field checked. However, if the sites were in reaches that had already been assessed by BLM or ODFW, ground truthing was done based on the agency reports since the field work was already completed by the agency. A total of 20 sites were ground truthed either through field checking or analysis of agency reports.

3.4.3 Riparian Condition Summary

The riparian condition summary combines the assessment of buffer width, continuity, and vegetation composition into a single measure of riparian health. To ensure consistency throughout the assessment, a scoring system was developed for each of the three components of the riparian condition summary (Table 3.2). Each of the scores ranged from 0 to 10 with 0 representing no data, low scores of 1 to 3 representing the most degraded systems, and 10 representing the healthiest ecosystem. The scoring system, based on definitions provided in the OWAM and current literature, was reviewed by Dr. Stan Gregory, Dr. Sherri Johnson and Linda Ashkenas of Oregon State University, and Kathryn Staley of the Natural Resource Conservation Service (NRCS).

Table 3.2. Scoring system used to evaluate riparian width, continuity, and vegetation.

Buffer Width Scoring and Definition of Categories		
Riparian Buffer Width	Definition	Score
No information available	No information available	0
Little or no buffer	Woody riparian vegetation absent (little or no woody vegetation in the riparian zone)	2
Narrow buffer	Less than 30 m (98.5 ft.) buffer between stream and other land use	5
Wide buffer	30 m (98.5 ft.) or greater buffer, between stream and other land use	8
Forested	Riparian zone and uplands are forested	10
Continuity Scoring System and Definition of Categories		
Riparian Continuity Class	Definition	Score
No information available	No information available	0
Discontinuous	More than one interruption or change in riparian vegetation or buffer width per mile	3
Somewhat discontinuous	One or less interruptions or changes in riparian vegetation or buffer width per mile	7
Mostly continuous	Fewer than one interruption or change in riparian vegetation or buffer width per mile	10
Vegetation Composition Scoring System and Definition of Categories		
Composition Class	Definition	Score
No information	No information	0
Urban	Urban area, riparian area may include: weeds, brush, hardened bank, and/or occasional trees	1
Grass/shrub	Weeds, blackberries, willows, reed-canary grass, crop land	3
Young forest, sparse	Open woodland, young trees – greater than 1/3 of ground exposed	5
Riparian wetland	Ponds, wetlands, side channels	6
Mature forest, sparse*	Open woodland, sparse older trees – greater than 1/3 of ground exposed – interspersed with shrubs and grasses	7
Young forest, dense	Open or closed canopy, young trees – less than 1/3 of ground exposed	8
Mature forest, dense**	Closed canopy, older trees – less than 1/3 of ground exposed	10

* Often includes high percentages of grass and shrub as well as sparsely placed trees
** Many of the areas are younger than the 80 years generally used to classify forests as mature. A more appropriate name for the category may be closed canopy forest.

It is difficult to rank riparian vegetation because different types of vegetation provide different riparian functions, so the ranking often depends on the goals of the assessment. The scoring system ranks the vegetation composition classes according to their ability to provide the ecological functions of LWD recruitment and stream shading.

The vegetation composition assessment categorized deciduous and coniferous trees separately, however, in the scoring system deciduous and coniferous trees were combined for the following reasons:

1. To provide a fair score for both the upper and lower elevation riparian areas. Historically, the lower elevations in the South Santiam watershed were likely dominated by deciduous, oak savanna riparian areas, and the upper elevation riparian zones were likely dominated by coniferous forests (OWAM 1999).

2. The OWAM does not distinguish between conifers and deciduous trees in its definitions of the riparian condition summary classifications.

The scores for buffer width, continuity, and vegetation composition were then combined to get a riparian condition summary score (Table 3.3). The scores range from 0 to 30 with 6 representing the most degraded riparian areas and 30 representing the healthiest riparian

Table 3.3. Riparian Condition Summary Scoring System

Classification	Definition	Score Range
Need more information	One or more categories were lacking information therefore a classification could not be given	< 6
Poor	Riparian vegetation absent, bank hardened, streamside roads, road/utility crossings or current land uses producing highly fragmented, interrupted riparian corridor and/or reaches where no trees are present in riparian zone. Land use is less likely to allow regeneration of riparian areas (industrial, some suburban, some urban, highways, some irrigated agriculture).	6 – 14
Fair	Narrow riparian zone, interrupted continuity, some trees in riparian area even if limited by streamside roads or road/utility crossings. Land use has some potential to allow regeneration of riparian areas (agriculture, pasture, forest, some urban and suburban).	15 – 23
Good	Wide riparian zone, mature trees, fairly continuous or only somewhat interrupted. Land use has potential to allow regeneration of riparian area (agriculture, pasture, forest, some urban and suburban).	24 – 30

conditions. A score of 30 represents suitable conditions in buffer width, continuity, and vegetation class. Scores less than 6 represent areas that had insufficient information to assess current riparian conditions.

3.4.4 Future Potential for LWD Delivery

Future potential for LWD delivery was determined based on current vegetation composition from the photo analysis. A scoring system was developed based on the current vegetation composition from the aerial photo interpretation (Table 3.4).

The current riparian vegetation composition assessment categorized deciduous and coniferous trees separately, however, in the scoring system the two are combined in the same manner as described in the vegetation analysis. While conifers do provide larger and longer lasting LWD, deciduous trees also provide LWD that is valuable for stream structure and fish habitat.

Table 3.4 Future Potential for LWD Delivery Scoring System

Future Potential for LWD Delivery	Current Vegetation Composition	Score
Need more information	Lacking data on current vegetation composition	0
Low	Grass/shrub and urban	1 – 2
Moderate	Young forest, sparse and dense and riparian wetland vegetation	3 – 6
High	Mature forest, sparse and dense	7 – 10

3.4.5 Current Stream Shading

Stream shading is difficult to assess without surveying streams in the field. However, some estimates of stream shading can be inferred using the vegetation classification conducted during this assessment. Any area that scored as a dense forest (mixed, hardwood, conifer) was classified as having good stream shading. The remaining areas were classified as poor stream shading. These areas need to be field assessed to determine real stream shading potential.

Stream shading analysis was conducted by ODFW for parts of the watersheds, however it was compiled on a habitat unit basis. Consequently, the data is beyond the scope of this assessment.

3.4.6 Data Confidence

Orthophoto and aerial photo analysis were combined with field verification and review of agency documents. By using multiple methods the level of accuracy was likely improved. However, due to the scale limitations of the BLM aerial photos, the assessment of the upper watersheds is likely less accurate than the areas where digital orthophotos were available.

The vegetation composition category of mature, dense forest may be somewhat misleading because of the difficulty of discerning age from aerial photos. Many of the areas classified as mature, dense forest are younger than the 80 years generally used to classify forests as mature. The future potential for LWD may be inflated, particularly in the short term, because it is based on the current vegetation composition. All areas currently classified as mature-dense or mature-sparse forest are considered to have a high potential for future LWD delivery. As noted above, these areas may be younger than 80 years and may not provide LWD until many years into the future. A more appropriate name for the category may be closed canopy forest. Second, the category of mature-sparse forest often includes high percentages of grass and shrub as well as sparsely placed trees.

3.5 Hydrology

3.5.1 Flood Stage Estimation

Flood stage was defined by the Northwest River Forecast Center and is when the river flows exceed bank full and moves into the floodplain potentially damaging adjacent property. Flood stage was estimated in the basins where established flood stages were not available through regression analysis using either the Waterloo gauging station or the gauging station for the Santiam River in Jefferson, OR (Table 3.5). These sites were selected as reference sites since flood stage had already been established for these sites. These flood stage values represent only estimates of flood stage to be used as a reference point. To establish actual flood stage values, further analysis would be necessary. However, these estimates will be useful in characterizing the flooding history of the South Santiam basins.

All relationships were statistically significant ($p<0.05$) and r-square values ranged from 0.43 to 0.99. All sites were compared to both the Santiam River at Jefferson and the South Santiam River at Waterloo. The site with the highest r-square value was then chosen as the reference site.

Table 3.5. Estimated discharge at flood stage for the gauging stations in the South Santiam watershed.

Gauge	Discharge at Flood Stage (cfs)	Estimated Discharge at Flood Stage (cfs)	r-square	Reference
Santiam at Jefferson	47,200	55,870	0.91	Waterloo
S. Santiam at Waterloo	24,700	19,213	0.91	Santiam
Thomas Creek at Scio	--	4,215	0.61	Waterloo
S. Santiam at Foster	--	22,302	0.98	Waterloo
S. Santiam near Foster	--	24,097	0.99	Waterloo
Crabtree Cr. near Crabtree	--	3,371	0.77	Waterloo
Wiley Cr at Foster	--	2,049	0.57	Waterloo
Wiley Cr. near Foster	--	1,716	0.50	Waterloo
Middle Santiam near Foster	--	13,683	0.94	Waterloo
Middle Santiam at Foster	--	13,929	0.97	Waterloo
Middle Santiam near Upper Soda	--	3,027	0.51	Waterloo
Middle Santiam near Cascadia	--	5,216	0.66	Waterloo
Quartzville Cr.	--	5,909	0.43	Waterloo
South Santiam below Cascadia	--	6,860	0.77	Waterloo

For example, the relationship for the Thomas Creek and Waterloo sites had a higher r-square value than the relationship for the Thomas Creek and Santiam River sites at Jefferson. Consequently, the Waterloo site was chosen as the reference point.

SECTION III. OVERVIEW OF THE SOUTH SANTIAM RIVER WATERSHED

CHAPTER 1. CLIMATE AND TOPOGRAPHY

The South Santiam River drains approximately 1,040 square miles and is a primary tributary to the Willamette River. The South Santiam River watershed is situated in the Western Cascades and flows into the Willamette Valley. The entire drainage is a fourth field watershed comprised of eight fifth field watersheds averaging 83,000 acres in size. A fifth field watershed simply refers to the size of the watershed. The USGS has delineated watersheds in the state of Oregon, and the whole United States that describe both the nesting of watersheds and their relative size. For example, several fifth field watersheds would comprise one fourth field watershed such as the South Santiam River. The River runs approximately from east to west, with steep mountainous terrain comprising the eastern 80% of the watershed. The western 20% of the watershed leading to the Santiam River and ultimately the Willamette River, is comprised of a floodplain dominated by grass seed farming and urban/rural development. The basin ranges in elevation from 220 feet to approximately 5,721 feet.

The climate within the watershed ranges from warm, dry summers to cool wet winters. Average annual precipitation ranges from 43 inches in the lowland to 111 inches in the higher elevations. Precipitation is predominantly winter rain in the lower reaches, transient or intermittent snow at mid-elevations and rain with persistent snow in the high elevations. Snow in the higher and mid-elevation portions of the basin is an important factor because of potential rain on snow events.

The four ecoregions that occur in the South Santiam watershed are the Western Cascades Lowlands and Valleys, Western Cascades Montane Highlands, Willamette Valley Foothills, and Willamette Valley Plains.

The Willamette Valley Plains are characterized by low gradient streams with a low gradient topography and adjacent tributaries in steeper ecoregions (GWEB, 1999). Soils are deep silty clay loams and the geology is fluvial deposits from the Missoula Floods. Conifer regeneration in the riparian zones is naturally scarce except in well drained areas. Many streams in these regions have been channelized to drain agricultural fields and the water is heavily withdrawn for irrigation purposes.

The Willamette Valley Foothills are characterized by moderate gradient streams with tributaries often in steeper ecoregions. Soils are deep silty clay loam to silt loam and the geology is comprised of basalt and sandstone. The terrain is rolling hills where landslides are few but sometimes exist in the form of earth flows. Streamside vegetation is typically characterized by a conifer hardwood mix. Conifer regeneration is common on well drained sites, and hardwoods occur in the poorly drained sites. Irrigation withdrawals in this region can potentially dewater streams. The Western Cascades Lowlands and Valleys are characterized by large streams flowing through canyons where waterfalls are common. Soils range from deep clay loams to cobbly loams and the geology consists of lava flows. Conifers are common in the riparian zones and the upland vegetation is a mix of Douglas-fir, western hemlock, western red cedar, vine maple, and western red alder forests.

The Western Cascade Montane Highlands consist of steep dissected mountains with moderate to high gradient streams. Soils are the same as those in the Western Cascades Lowlands with deep silt loam to very cobbly loam. Conifer regeneration is common in the riparian areas and upland vegetation consists of Pacific silver fir, western hemlock, Douglas-fir, mountain hemlock, noble fir, subalpine fir, grand fir, and white fir.

CHAPTER 2. FISHERIES

Spring chinook and winter steelhead are two anadromous fish native to the South Santiam River watershed. Consequently, this fisheries assessment concentrates on these species. Several factors complicated conducting a fisheries assessment in the South Santiam River watershed. These factors included:

- The very complex and detailed history of the fisheries
- Lack of continuity to issues, actions, and protocols
- A lot of valuable information is the direct experience of residents and of fishery biologists within the watershed, which is mostly uncompiled and unpublished

The South Santiam fishery resides within the Upper Willamette River Evolutionary Significant Unit as defined by the National Marine Fisheries Service (Busby et al. 1996). The Evolutionary Significant Unit (ESU) occupies the Willamette River and its tributaries upstream from Willamette Falls. The South Santiam fishery is put into context among this entire unit area because the entire Upper Willamette watershed is significant to the evolution of the fishery. Within this unit, the North Santiam River, the McKenzie River, and the Molalla River are recognized currently as the most significant contributors to anadromous fish production (ODFW 1998). According to ODFW, the Mollala, North Santiam, and South Santiam basins are primary producers of indigenous wild winter steelhead in the Upper Willamette ESU (ODFW 1997a).

The National Marine Fisheries Service concluded that the Upper Willamette winter steelhead ESU is neither presently in danger of extinction, nor likely to become endangered in the foreseeable future (Busby et al. 1996). However, a minority concluded that the small numbers and declining trend in the native stock, coupled with other risk factors, indicate a likelihood of becoming endangered. NMFS stated that “while historical information regarding this ESU is lacking, geographic range and historical abundance are believed to have been relatively small compared to other ESUs, and current production probably represents a larger proportion of historical production than is the case in other Columbia River Basin ESUs” (Busby et al. 1996).

Even though NMFS concluded there was no great concern to the steelhead ESU (hatchery and wild strains), NMFS recognized that native winter steelhead within this ESU have been declining on average since 1971, and have exhibited large fluctuations in abundance (Busby et al.

1996). There is widespread production of hatchery winter steelhead as well as the introduced summer steelhead within the range of this ESU, predominantly of non-native summer and early-run winter steelhead. The recent counts at Willamette Falls show that both summer and winter steelhead are declining in the Upper Willamette ESU. ODFW suggests that the South Santiam winter steelhead may be very close to not being able to sustain itself. In fact, ODFW stated they are concerned about the fate of the upper Willamette ESU than any of the other ESUs in Oregon (ODFW 1997a). The Mollala, North Santiam, and South Santiam basins are primary producers of wild winter steelhead in the Upper Willamette ESU (ODFW 1997a).

Table 2.1. Historic Fish Presence in the South Santiam watershed

Species	Source
Spring chinook	ODFW (Wevers et al. 1992)
Winter steelhead	ODFW (Wevers et al. 1992)
Rainbow trout	ODFW (Wevers et al. 1992)
Bull trout	Meehan & Bjornn 1991
Cutthroat trout	Nicholas 1978
Oregon chub	ODFW (Wevers et al. 1992)
Squawfish	WNF 1996
Sand rollers	ODFW (Wevers et al. 1992)
Shiners	WNF 1996
Sculpins	WNF 1996
Dace	WNF 1996

2.1 Historic and Current Fish Presence

Winter steelhead and spring chinook salmon occurred historically above the Willamette Falls and are the only two anadromous fish native to the South Santiam watershed. Both of these species have recently been listed as threatened under the endangered species act. Summer steelhead, fall chinook salmon, kokanee, and coho salmon did not historically occur above the falls, but were introduced through hatchery programs at different times during the century. Of these introduced species, only coho have failed to establish in the watershed. Coho are not present today. Table 2.1 presents species that historically have occurred in the watershed. Not only have hatchery runs been introduced but a warm water fishery has entered the South Santiam watershed where historically, there was no warm water fishery (WNF 1995).

2.2 Spring Chinook

Spring chinook (*Oncorhynchus tshawytscha*) is blue-green on the back and top of the head with silvery sides and white bellies, black spots on the upper half of its body, and gray/black mouth coloration. They measure up to 58 inches in length and weigh up to 129 pounds. Important habitat for chinook salmon includes freshwater streams and estuaries. When young, chinook feed on terrestrial and aquatic insects, amphipods, and other crustaceans. When older, chinook primarily feed on other fish. Eggs are laid in deeper water with larger gravel than steelhead, and need well-oxygenated water to survive. Mortality of chinook salmon in the early life stages is usually high due to natural predation and human induced changes in habitat, such as siltation, high water temperatures, low oxygen conditions, loss of stream cover and reductions in river flow (ODFW 1997b). Figure 2.1 shows the life history of spring chinook within the watershed.

Spring Chinook exhibit a fluctuating population in the South Santiam watershed (Table 2.2). Currently, spring chinook primarily occur in the mainstem South Santiam.

Table 2.2. Results of Aerial Surveys for Spring Chinook Salmon Redds in the South Santiam River 1970-1993(ODFW 1995)

Year	Total Redds counted[a]	Redds above Lebanon Dam[b]
1970	559	61
1971	348	31
1972	269	10
1973	780	no survey
1974	2578	50
1975	1054	no survey
1976	1881	no survey
1977	2310	no survey
1978	2102	25
1979	792	37
1980	454	91
1981	457	59
1982	2318	68
1983	1273	41
1984	no survey	no survey
1985	no survey	no survey
1986	711	52
1987	282	53
1988	333	144
1989	380	25
1990	no survey	no survey
1991	925	138
1992	1712	119
1993	1028	134

[a] Mainstem only
Most likely spring chinooks

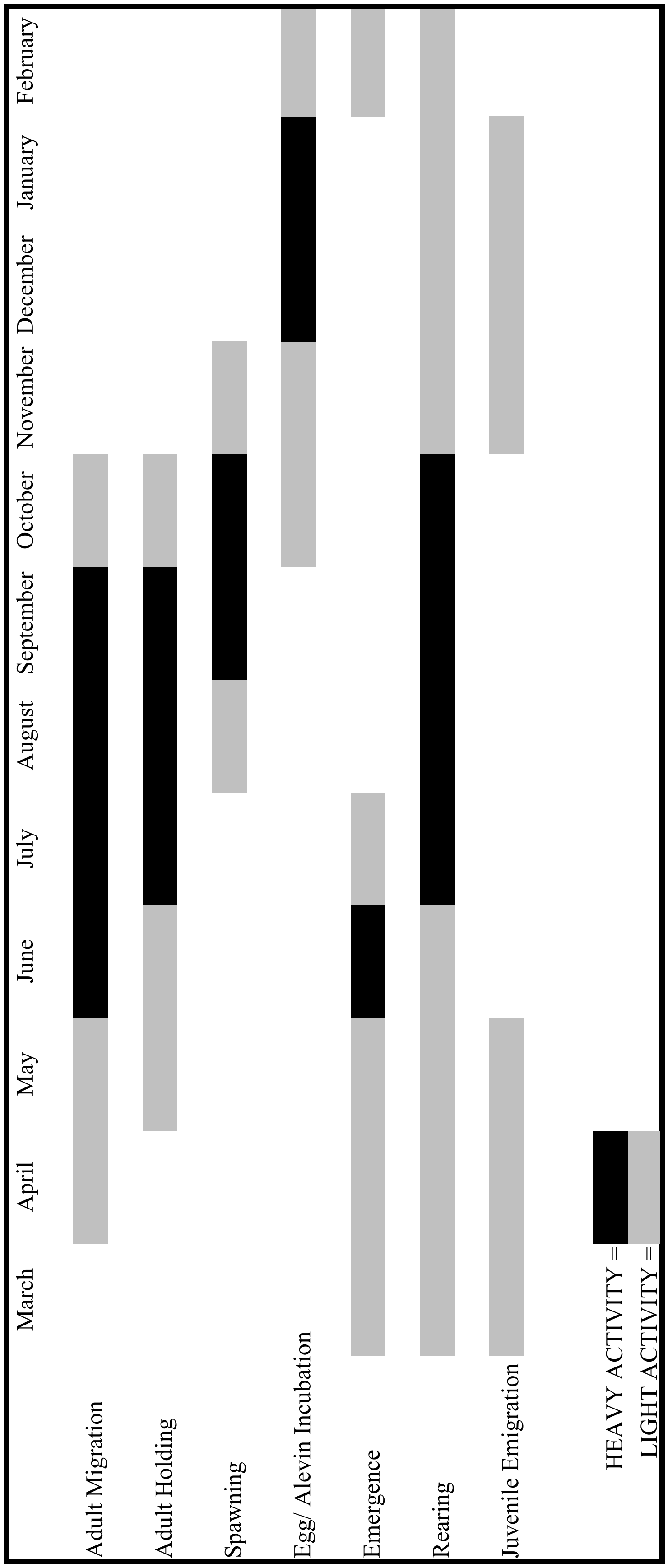


Figure 2.1. Spring chinook freshwater life history in the Santiam River Basin (ODFW 1990)

2.3 Winter Steelhead

Steelhead (*Oncorhynchus mykiss* previously known as *Salmo gairdneri)* appears bluish from above and silvery from below in the sea. They have small black spots on their back and most fins. Steelhead can grow up to 45 inches in length and weigh 40 pounds, although they usually weigh less than 10 pounds. Native steelhead of this basin are late-migrating winter steelhead, entering fresh water primarily in March and April (Howell et al. 1985). Other populations of west coast winter steelhead most commonly enter fresh water beginning in November or December.

Steelhead rely on streams, rivers, estuaries and marine habitat during their lifecycle. In freshwater and estuarine habitats, steelhead feed on small crustaceans, insects and small fishes. Eggs are laid in small and medium gravel and need good water flow (to supply oxygen) to survive. After emerging from the redd (nest) they remain in streams and rivers for 1 to 4 years before migrating through the estuaries to the ocean. Steelhead need cool, well-oxygenated water for survival. Because young steelhead spend a significant portion of their lives in rivers and streams, they are particularly susceptible to human induced changes to water quality and habitat threats as well as angling pressures. Poor timber and agricultural management practices can lead to siltation in streams, which may ruin spawning beds or smother the eggs (ODFW 1995).

The South Santiam Watershed is home to the remnants of a run of wild winter steelhead which, prior to construction of Green Peter and Foster dams, numbered in excess of 2600 returning adult fish (WNF, 1996). The sixty percent of the run which spawned in the Middle Santiam no longer exists, as no adults pass over Green Peter. Of the other 40% of the historic run only two to three hundred adults pass over Foster and into the South Santiam watershed to spawn each year. Counts of winter steelhead from 1973 to 1996 at Foster Dam suggest a relatively stable population below Foster Dam, with the exception perhaps of the last several years. This population of winter steelhead has been relatively free from the influence of hatchery fish except during a period of time from 1982-88 when late-run hatchery fish from the North Santiam (Marion Forks Broodstock) returned to the basin (ODFW 1997a).

ODFW conducted a spawner-recruit model then performed a regression analysis for the winter steelhead population of the South Santiam watershed. The data suggested that with very little additional stress, South Santiam steelhead will not be able to sustain themselves (ODFW 1997a). ODFW wrote to NMFS, "Our analysis suggests that one of the primary wild populations in this ESU, South Santiam winter steelhead, may be very close to not being able to sustain itself, even at very low densities where theoretically it should be the most robust. While this analysis was based upon a population that may not be representative of the ESU, it is a clear warning sign of a conservation crisis."

2.4 Stocking History

The definition of a wild fish includes two basic criteria :

- It must be a species of Salmon, trout, whitefish, or sturgeon native to Oregon. Some native, non-game fish are also included under this definition
- It must be naturally spawned and directly descended from a population that was present in the same geographical area prior to the year 1800

The genetic impact of hatchery fish on wild populations poses a significant risk to the anadromous fishery(ODFW 1998). However, there are two major areas of uncertainty (Busby et al. 1996). First, the degree of interaction between hatchery and natural stocks is unknown, since there is no specific information regarding potential spawning separation. Second, some trends for these populations are based on angler catch data, which may not be a good indicator of actual trends in population. In light of these uncertainties, ODFW implemented a set of strategies with the Wild Fish Management Policy (WFMP) to reduce the percentage of hatchery steelhead in natural spawning populations to either 10% or 30% depending upon the origin and characteristics of the hatchery stock (ODFW 1992). Both Thomas and Crabtree Creeks are currently being managed by ODFW for natural production of steelhead.

2.4.1 Stocking History in the Upper Willamette ESU

Current hatchery programs in the Upper Willamette ESU were initiated or expanded to mitigate the loss of natural spawning and rearing areas lost due to the construction of dams in the 1950s and 1960s (Cramer et al. 1996). Due to the large and persistent artificial propagation programs in the Willamette River system, wild populations are thought to be small and "vastly dominated by hatchery fish" (Kostow 1995). Hatchery fish have been observed spawning in the wild and appear to be successfully reproducing (Cramer et al. 1996).

Artificial propagation in the Upper Willamette River ESU began when the state of Oregon began operating a hatchery on the McKenzie River in 1902 (Olsen et al. 1992). Eggs were collected between 1909 and 1942 from spring-run adults returning to the Santiam and Middle

Fork Willamette Rivers, incubated at the state's Bonneville Hatchery, and then the fry were returned to the Willamette River Basin (Howell et al. 1985). Egg collections from the four primary state-run stations on the Willamette River Basin (North Santiam, South Santiam, McKenzie, and Middle Fork Willamette River stations) totaled 668 million eggs during the 1918-42 period (Craig and Townsend 1946). These eggs were largely the source for the 382 million fingerlings released into the basin during that time period. There were introductions of non-native fish into this ESU during the first half of this century; however, the vast majority of the eggs used originated from fish returning to the upper Willamette River (Howell et al. 1985, Olsen et al. 1992).

2.4.2 Stocking History in the South Santiam Basin

General

Since the turn of the century, the South Santiam watershed has contributed to hatchery programs throughout the region. There were numerous non-state sponsored stocking of various species since the 1880's including large mouth bass and eastern brook trout. The watershed has served as a source for broodstocks of hatchery fish for other basins and has also been a location for the placement of many different hatchery spawned species. A detailed description of hatchery development in the Willamette River watershed is available from Cramer et al. (1996).

Currently, the South Santiam fisheries are managed under the Wild Fish Management Plan (WFMP). The stated goal of the program is to keep "the best of our remaining native stocks while serving Oregon's present and future economic and recreation needs" (ODFW 1992). Table 2.3 presents the species that have been stocked in the watershed. For some species, their arrival in the watershed has occurred from individuals planting them in the watershed or from straying from other streams in the ESU.

Winter and Summer Steelhead

Table 2.4 presents the locations and total number of released steelhead in the South Santiam watershed since 1980, illustrating the recent geographical distribution of hatchery steelhead of the South Santiam broodstock. Based upon upstream migrant trapping at the Stayton ladder, the latest estimate (1994) for percentage of hatchery winter steelhead in the North Santiam is 14%. Hatchery smolt releases of winter steelhead into the Mollala have been reduced from 90,000 in

Table 2.3. Historical and present species stocked in the South Santiam watershed.

Species	Current or Historical	Source
Spring chinook	Historical, Current	ODFW 95
Coho	Historical	Busby 1996
Fall chinook	Historical	ODFW 95
Sockeye(Kokanee)	Historical	ODFW 95
Summer steelhead	Historical	ODFW 95
Winter steelhead	Historical	ODFW 95
Rainbow trout	Historical, Current	ODFW 95
Large/smallmouth bass	Plant/stray	ODFW 95
Cutthroat trout	Historical	ODFW 95
Crappie	Plant/stray	ODFW 95
Bluegill	Plant/stray	ODFW 95
Pumpkinseed	Plant/stray	ODFW 95
Brown and yellow bullhead	Plant/stray	ODFW 95

Table 2.4 Hatchery steelhead releases of South Santiam broodstock, listed by ESU. The period of record indicates the time frame of available data; actual release during that period did not necessarily occur annually (Busby 1996, ODFW 1994).

Release location	Summer or Winter Steelhead	Period of Record	Total number released
South Santiam River	S	1980-1994	5,595,712
South Santiam River	W	1982-1986	150,356
Southwest Washington: Gnat Cr.	S	1980-1991	85,786
Clatskanie River	S	1981	5,010
Lower Columbia River	S	1980-1989	435,597
Clackamas River	S	1980-1994	2,625,792
Sandy River	S	1980-1994	256,710
Hood River	S	1980-1994	1,399,343
Molalla River	S	1980-1994	692,589
McKenzie River	S	1980-1985	615,390
Willamette River	S	1980-1994	622,425
Salmon River	S	1980-1994	940,954

the early 1980's to no releases in 1997. These factors should lower the percentage of hatchery fish in the South Santiam basin. The fish ladders constructed at Willamette Falls in 1885 facilitated introduction of Skamania stock summer steelhead and early migrating Big Creek stock winter steelhead to the upper basin. Another effort to expand steelhead production in the upper Willamette River was the stocking of native steelhead in tributaries not historically utilized by that species (Busby et al. 1996).

Hatcheries will continue to play a significant role in fish production in Oregon (Wevers et al. 1992). In the 1992 Fish Management Plan for the Santiam and Calapooia Subbasin, ODFW presents several policies toward conserving wild fish. Since 1992 all caught wild winter steelhead are to be released. Additionally, ODFW makes a unique effort to protect wild native steelhead in a program they term 'recycling'. Under the 'recycling' program, summer steelhead, which run during the winter steelhead run are trapped at Foster Dam and trucked back downstream for fishermen to have another opportunity at catching.

Spring Chinook

Most of the historical geographic range of spring-run chinook salmon in the Willamette River Basin has received introductions of hatchery fish (Cramer et al. 1996). Hatchery practices have reduced the early and late segments of the spring chinook spawning cycle in the Upper Willamette ESU. Historically, the wild populations of spring-run chinook salmon in the Willamette River spawned sometime between mid-July and late October. Current Willamette River populations, both wild and hatchery, spawn during September. The majority of natural spawners are thought to be of recent hatchery origin(Cramer et al. 1996). In addition, hatchery strays are thought to have a significant impact on population dynamics in this ESU. It has been estimated that the straying rate of adults returning from releases of trucked juveniles can be as high as 75% (Cramer et al. 1996). These strays are thought to contribute to the naturally spawning population (Kostow 1995).

The impact of introduced fall-run chinook salmon is greatly unknown. One review reported that between 16% and 46% of the adult fall-run chinook salmon in the upper Willamette River were of natural origin. This suggests at least a moderate amount of successful reproduction by straying hatchery fall-run chinook salmon (Howell et al. 1985). Spawning of fall-run chinook salmon in the upper Willamette River has been observed to occur primarily during September

(Howell et al. 1985), which closely overlaps the spawning period of spring chinook salmon. However, the genetic or ecological interactions between fall-and spring-run chinook salmon in the upper Willamette River is unknown (Myers et al. 1998).

New fish regulations for 1999 have been adopted for the spring chinook sport fishery. Oregon Department of Fish and Wildlife staff are forecasting a 46,500 spring chinook return to the Willamette River this spring. Nearly 90 percent are bound for hatcheries, while the remainder are wild spawners headed for the McKenzie and Clackamas Rivers. Starting in 2002, all returning Willamette River hatchery spring chinook will be marked with a fin clip, allowing fishery managers to set more liberal seasons focused on hatchery chinook. Anglers will be required to release all non-finclipped salmon like current wild steelhead. Biologists expect only 15 percent of 1999's returning salmon to be finmarked.

2.5 Potential Species Interactions

The fisheries interactions in the Willamette Basin are complex due to difficulties in identifying distinct populations. Connection with the Columbia River as well as historical connections with coastal basins through stream capture and headwater transfer events contributes to this complexity (Minckley et al. 1996). Hatchery programs and fish ladders constructed as early as 1885 at Willamette Falls to aid the passage of anadromous fish have complicated native anadromous fish presence even further (Bennett 1987, PGE 1994). Table 2.5 shows a comparative life history of several key species within the watershed. There may be undue competition due to overlapping life cycles.

Table 2.5. Life cycles of South Santiam salmonids.

	Migration	Spawning	Emergence
Mar	Ws	Ct, Ss	
Apr	Ws, Ss	Rb, Ct, Ws	Ss, Sc
May	Ws, Ss	Rb, Ct, Ws	Rb, Ss, Sc
June	Ss, Sc		Rb, Ws, Sc
July	Ss, Sc		Rb, Ws
Aug	Ss, Sc		
Sept	Ss, Sc, Fc	Sc	
Oct	Fc	Sc, Fc	
Nov	Ct		Fc
Dec	Ct		Fc
Jan	Ct	Ct, Ss	
Feb	Ct	Ct, Ss	

Ct= Cutthroat Trout; Rb= Rainbow Trout; Ws= Winter Steelhead, Sc= Spring Chinook; Fc= Fall Chinook; Ss=

2.6 Habitat Summary

Long term habitat changes have affected the salmonid fishery. Bottom et al. (1985) identified specific factors affecting salmon habitat in various areas of Oregon that apply to the South Santiam watershed. They include streamflow and temperature problems, riparian habitat losses, and instream habitat degradation. Bottom et al. (1985) contend that in the Willamette Valley temperatures and streamflows reach critical levels for salmonids in places where there are significant water withdrawals or removal of streamside vegetation. They also conclude that splash dams, debris removal and stream channelization have caused long-term damage to salmonid habitats.

Historically, spawning by native winter steelhead in the entire Upper Willamette River was concentrated in the North and Middle Santiam River Basins (Fulton 1970). As much as eighty-five percent of the historical spawning area in the Middle Santiam for native winter steelhead was blocked by the construction of Green Peter Dam (WNF 1995).

In addition, the flood control dams have changed the hydrology of the South Santiam River. Flows have increased in the late summer and fall, changing water temperatures. Spring and early summer temperatures are colder, which delays juvenile chinook growth, while fall temperatures are warmer, which accelerates egg development and advances emergence times. These changes are thought to have decreased egg-to-smolt survival of spring chinook naturally spawning in the mainstem South Santiam River (ODFW 1995).

One of the tools available for evaluation of habitat in the watershed is a summary of habitat conditions from stream surveys. ODFW habitat benchmarks are presented in Table 2.6.

Benchmark values are best applied to the evaluation of conditions in individual streams or stream reaches. The benchmarks provide a context for interpretation and a starting point for more detailed and meaningful analysis. For each habitat variable that meets or fails to meet desirable habitat benchmarks, the investigation and analysis should focus on both proximal and historic causes. An important part of this work is to interpret channel and riparian condition in a broader landscape context. It must be remembered that even under pristine conditions a certain percentage of a watershed may always be classified as below desirable condition.

Table 2.6. ODFW Aquatic Inventory and Analysis Habitat Benchmarks		
	Undesirable	Desirable
Pools		
Pool Area (percent total stream area)	<10	>35
Pool Frequency (channel widths between pools)	>20	5-8
Residual Pool Depth (meters)		
Low Gradient (slope<3%)or small (<7m width)	<0.2	>0.5
High Gradient (slope >3%) or large (>7m width)	<0.5	>1
Riffles		
Gravel (percent area)	<15	>35
Large Woody Debris		
Pieces (per 100m)	<10	>20
Volume (m^3 per 100m)	<20	>30
"Key" Pieces (>60cm dia. & >10cm long per 100m)	<1	>3

CHAPTER 3. WATER QUALITY

3.1. Beneficial Uses and DEQ Standards

The state of Oregon has recognized a number of beneficial uses of instream water such as drinking water, aquatic life, swimming, and boating. The State Water Quality Standards require the protection of the most sensitive of these beneficial uses. These sensitive beneficial uses of water drive the evaluation of water quality and the establishment of best management practices within any given watershed. The South Santiam Watershed has the following beneficial uses of water:

Public and private domestic water supply	Fishing
Industrial water supply	Boating
Irrigation	Water contact recreation
Livestock watering	Aesthetic quality
Anadromous fish passage	Hydro power
Salmonid fish rearing and spawning	Resident fish and aquatic life
Wildlife and hunting	

Associated with the sensitive beneficial uses of water, the Oregon Department of Environmental Quality (ODEQ) has established water quality standards in an effort to protect these beneficial uses. Table 3.1 shows these standards for those water quality parameters of interest in the South Santiam watershed.

The South Santiam River supports cold water fisheries and salmonid spawning and rearing (which is also a cold water fishery, however DEQ has applied more stringent standards to salmonid spawning and rearing areas). Consequently, the dissolved oxygen (D.O.) standard that applies is 8 mg/L. However, specific spawning areas that have yet to be identified by ODFW will follow the D.O. standard of 11 mg/L. Habitat and Flow Modification can be detected using Biotic Indices; however, these will not be dealt with in this report. Turbidity is compared against values before any activity occurred which is often difficult to determine since little baseline data is available for many sites.

Table 3.1.Water quality standards established by ODEQ applicable to the South Santiam watershed.

Parameter	Beneficial Use Affected	Standards or Criteria
Dissolved Oxygen	Resident Fish and Aquatic Life; Salmonid Spawning and Rearing	D.O. shall not be less than 11 mg/L for Salmonid Spawning; D.O. shall not be less than 8 mg/L for Cold Water Aquatic Resources
Habitat Modification	Resident Fish and Aquatic Life; Salmonid Spawning and Rearing	Biotic Communities are impaired as compared to a reference community
Flow Modification	Resident Fish and Aquatic Life; Salmonid Spawning and Rearing	Biotic Communities are impaired as compared to a reference community
Turbidity	Resident Fish and Aquatic Life; Water Supply; Aesthetics	No greater than a 10% increase in turbidity due to an operational activity
Temperature	Resident Fish and Aquatic Life; Salmonid Spawning and Rearing	Seven day moving average of the daily maximum shall not exceed 64ºF (17.8ºC); in waters supporting salmonid spawning, the seven-day moving average of the daily maximum shall not exceed 55°F.
pH	Resident Fish and Aquatic Life; Water Contact Recreation	pH shall be in the rage of 6.5 to 8.5 for the Willamette Basin and not more that 10% exceedance
Nutrients	Aesthetics or related parameters	No standards set for South Santiam basin
Bacteria: E. Coli and Fecal Coliform	Water Contact Recreation	10% of samples exceed 406 organisms/100 ml or a 30-day log mean of 126 organisms; 10% of samples exceed 400 MPN/100 ml or a geometric mean > 200MPN/100 ml

3.2 Water Quality and Land Use

Land use can be used in watershed assessments to screen for possible pollutants and associated water quality issues. For example, cattle grazing may be associated with fecal coliform contamination and forest harvest is often associated with increases in turbidity and suspended sediments. By first looking at land use categories within a watershed, we can identify where the most probable types of pollution may occur and focus our efforts on these water quality issues. Table 3.2 demonstrates some of the land use categories and their associated pollutants.

Table 3.2. Potential pollutant categories associated with land use (GWEB 1997).		
Potential Source	Primary Process	Pollutant Category
Non-irrigated cropland	Surface erosion Chemical application	Turbidity, nutrients, contaminants
Irrigated cropland	Surface erosion Chemical application Flow modification	Turbidity, nutrients, contaminants
Pasture Land	Overland flow	Bacteria, nutrients
Concentrated animal feeding operations	Surface erosion	Turbidity, bacteria, nutrients
Forest Management	Surface erosion Mass wasting	Turbidity
Road construction/maintenance	Surface erosion Mass wasting	Turbidity
Metals mining	Surface erosion Mass wasting Acid mine drainage	Turbidity, contaminants
Aggregate mining	Surface erosion Mass wasting	Turbidity
Industrial mining (phosphate, gypsum, etc.)	Surface erosion Mass wasting	Turbidity, contaminants
Streamside recreation	Surface erosion	Turbidity
Urban/suburban runoff	Surface erosion	Turbidity
Urban/industrial runoff	Contaminants	Bacteria

The South Santiam River watershed is a complex mix of different land use types. Generally, the upper South Santiam watershed management is dominated by both federal and industrial forest practices. Management in the lower South Santiam watersheds is dominated by agriculture, urban and rural areas, as well as forestry practices.

There have been several studies on water quality in the Willamette River watershed that address the issue of land use and their associated pollutants (Tetra Tech 1993). Some studies have estimated loading coefficients for associated land uses in the Willamette River watershed, which includes the South Santiam as a subbasin. Using this approach, the Santiam watershed, including the South Santiam, contributes large amounts of Total Nitrogen (5.34 kg/ha), Total Phosphorus (0.84 kg/ha), and Total Suspended Solids (780 kg/ha) to the Willamette River (Tetra Tech 1993). However, it is important to note that these values were generated as part of a modeling exercise, and are intended solely to give some perspective on using land use to identify potential water quality issues in the South Santiam watershed. Water quality issues and their associated land use categories will be further explored in subsequent sections.

SECTION IV. LOWER SOUTH SANTIAM WATERSHEDS

CHAPTER 1. BACKGROUND

1.1 Climate and Topography

Four fifth field watersheds define what this project is calling the lower South Santiam watersheds, namely the Wiley Creek, Crabtree Creek, Thomas Creek, and Mainstem South Santiam (formerly Hamilton Creek/South Santiam) watersheds. The Lower South Santiam subwatershed includes the mainstem South Santiam River from Foster Dam to its confluence with the North Santiam River. Tributaries include Hamilton Creek, McDowell Creek, Ames Creek, Noble Creek and Onehorse Slough (Figure 1.1, Table 1.1). The Crabtree Creek watershed is north of the Mainstem South Santiam watershed and the tributaries include Beaver Creek, Roaring River, and Green Mountain Creek. The Thomas Creek watershed is the northern most tributary to the South Santiam River and includes the tributaries of Indian Prairie Creek, Ella Creek, Criminal Creek, Hall Creek, Neal Creek, and Burmester Creek. The Wiley Creek watershed represents the southern most watershed comprising the lower South Santiam watersheds. The Wiley Creek watershed includes the tributaries of Little Wiley Creek, Jackson Creek, and Farmers Creek.

Table 1.1. Physical characteristics of the lower South Santiam watersheds.

Watershed	Area (ac)	Mean Annual Average Precipitation* (in)	Minimum Elevation (ft)	Maximum Elevation (ft)
Lower South Santiam	119,000	52	220	4,055
Crabtree Creek	99,856	64	269	4,469
Thomas Creek	92,446	66	230	4,389
Wiley Creek	40,577	69	558	4,498

* based on Daly et al. (1994)

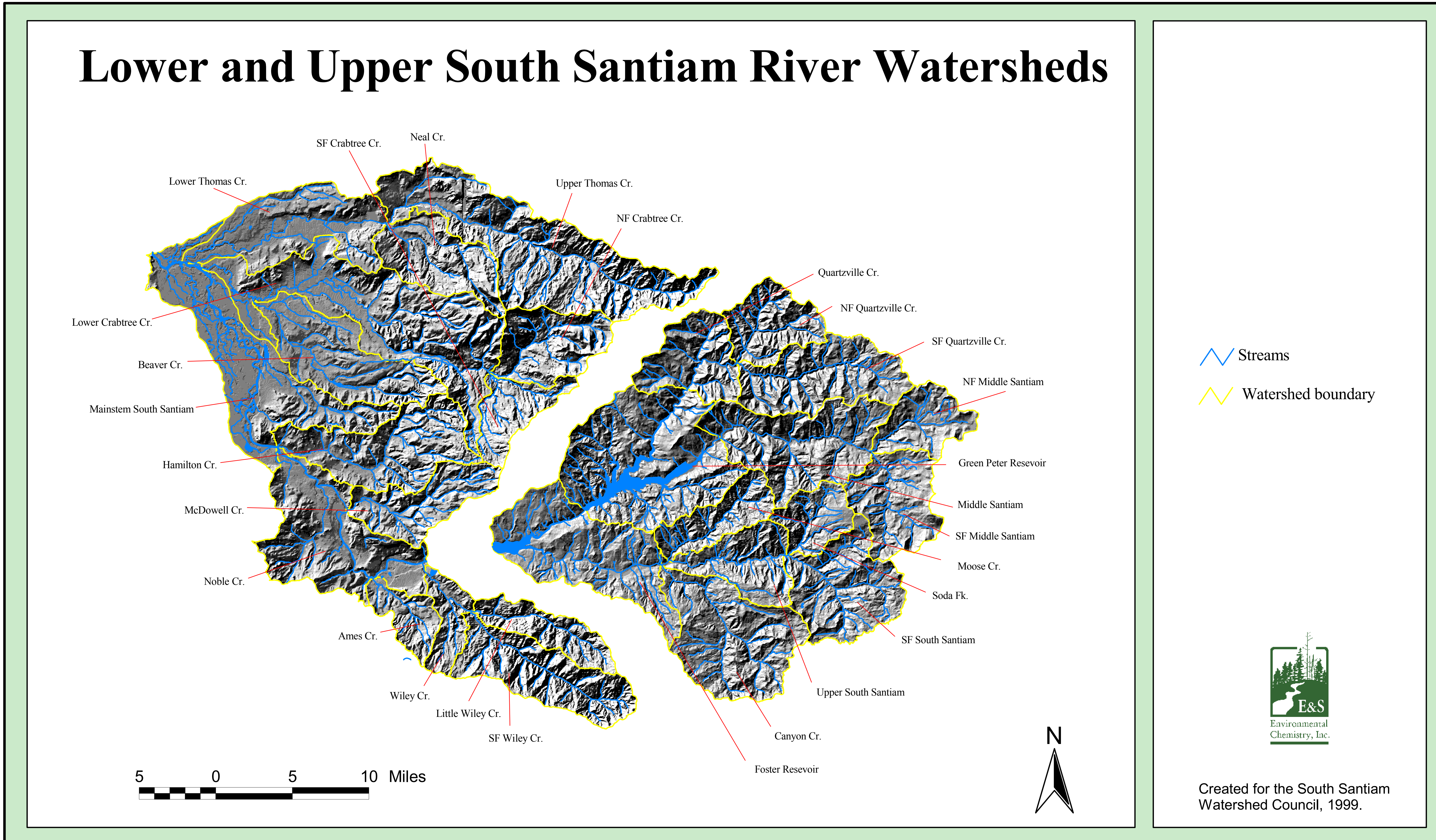


Figure 1.1. Delineated subwatershed boundaries for the South Santiam watershed. The break in the watershed illustrates the delineation between the upper and lower portions of the watershed.

All of the watersheds were divided into subwatersheds based on priority areas identified by the South Santiam Watershed Council, hydrography features, land use and watersheds identified by the Water Resources Department (Figure 1.1).

Four ecoregions occur in the lower South Santiam watershed, namely Western Cascades Lowlands and Valleys, Western Cascades Montane Highlands, Willamette Valley Foothills, and Willamette Valley Plains.

The climate in these watersheds is characterized by warm dry summers and cool wet winters. Annual precipitation is usually in the form of rain in the lowlands and snow in the highlands. There is a large portion of the watershed that is in the intermittent zone where there is a potential for rain-on-snow events. Annual rainfall ranges from 44 inches in the Willamette Valley plains to 84 inches in the Western Cascade Montane Highlands (GWEB, 1999).

Vegetation in the higher elevations of the Thomas Creek, Crabtree Creek, and Lower South Santiam subwatersheds is characterized by white oak, Douglas-fir, big leaf maple, Oregon ash and red alders in the western part of the valley, with Douglas fir, western hemlock, and western red cedar occurring from the valley bottom to approximately 3,000 feet (BLM 1996). Above 3,000 feet, the vegetation is composed of mixed stands of noble and silver fir, Douglas fir, and western hemlock (BLM 1996). The lower elevations are characterized by heavy agricultural use, predominantly grass seed farming.

1.2 Land use

Land use was broken down for each of the sixth field subwatersheds delineated for this study (Figure 1.2, Table 1.2). Land use in the lower sections of the lower South Santiam watersheds is the most diverse in the entire watershed. Land use in this watershed is comprised of large portions of urban and rural residential areas, agricultural areas, pastureland, and private timberlands in the headwaters. Land use in the Crabtree Creek watershed is dominated by private forest lands in higher elevations and agriculture in the lower elevations. The BLM owns approximately half of the North Fork Crabtree Creek subwatershed with the remaining portion being private timber lands. The Beaver Creek subwatershed has the most diverse land use with BLM and private timber in the higher elevations and agriculture dominating the lower elevations. The lower levations of the Beaver Creek subwatershed also exhibit a broad range of land use with private timber, BLM and agriculture dominating the watershed. The dominant land use in

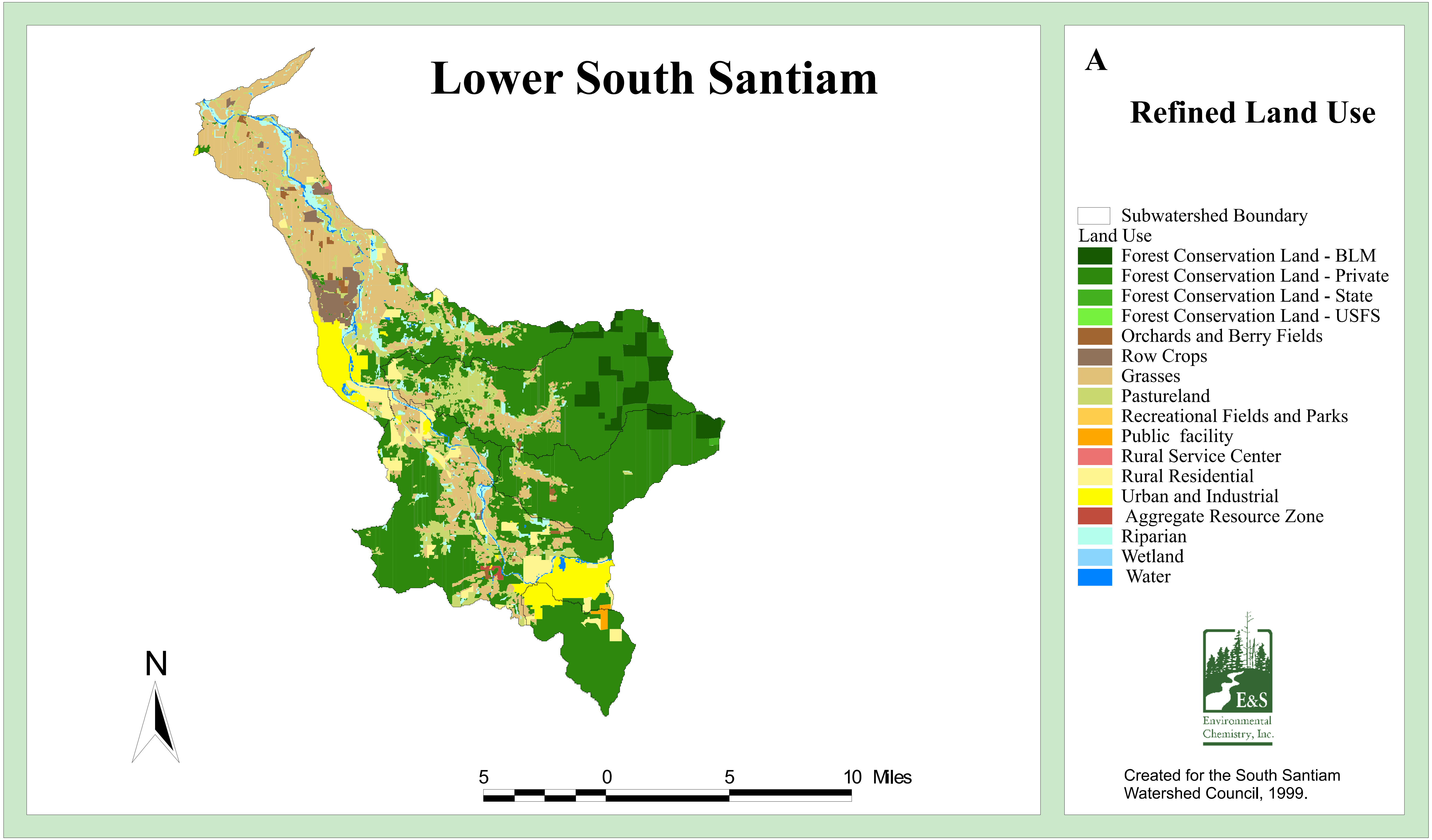


Figure 1.2. Land use in the Lower South Santiam watershed illustrating the spatial complexity in these three lower basins. (A) Land use in the Lower South Santiam basin. (B) Land use in the Crabtree Creek basin. (C) Land use in the Thomas Creek basin.

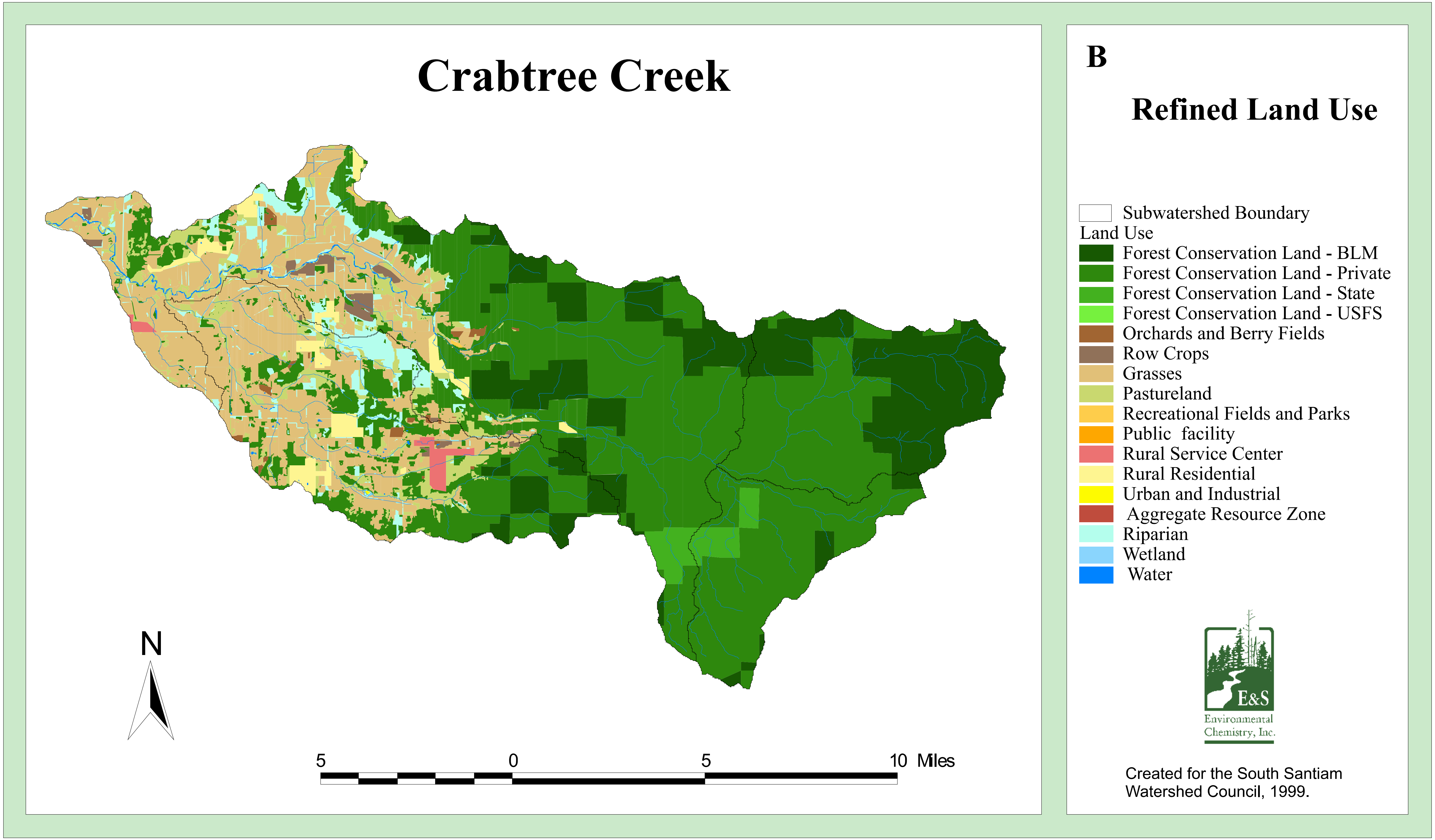


Figure 1.2. Continued.

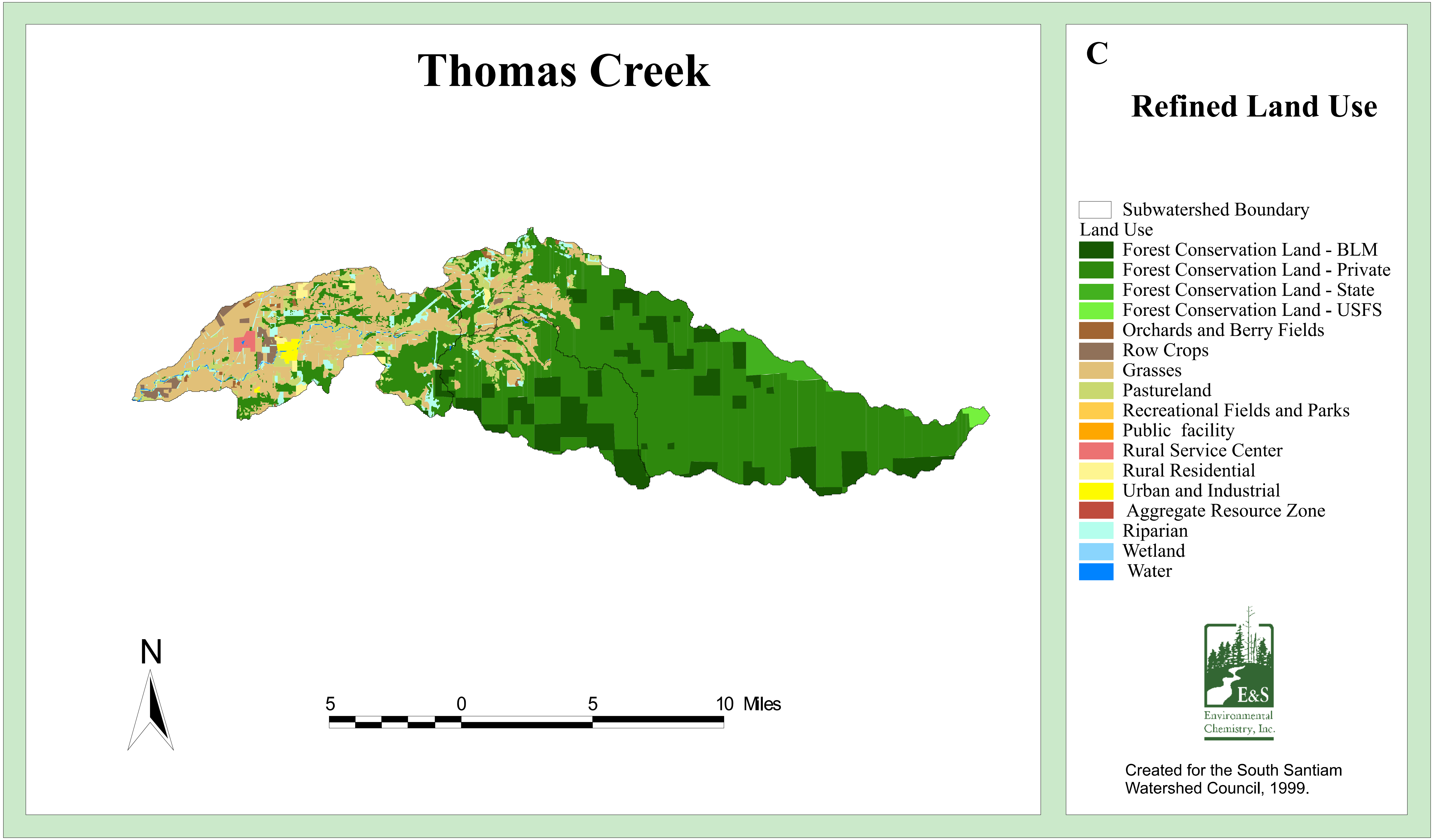


Figure 1.2. Continued.

Table 1.2. Percent land use for the lower South Santiam River watersheds.

	Forestry				Agriculture			Water				
Subwatershed	Private	State	BLM	USFS	Grasses	Row Crops	Pasture	Water	Riparian	Rural Service Center	Urban and Industrial	Rural Residential
Crabtree Creek												
South Fork, Crabtree Creek	85	9	6									
North Fork	48		52									
Lower	13				66	2	12	2	3	2		1
Beaver	31		8		39		9		6	2		4
Mainstem	53	2	16		16	1	5		5			2
Totals	48	2	18		20	1	5		4	<1		2
Hamilton Creek Watershed												
Noble	50				17		10	2	3		8	9
Mc Dowell	86		7		4		2					
Lower South Santiam	19		<1		42	6	11	2	7		7	4
Hamilton	64		14		9		11		1			1
Ames	82				1						10	4
Totals	50		4		21	2	9	1	3		5	4
Thomas Creek Watershed												
Upper	71	4	14	<1	7		2		1			
Neal	56		30		10		3		1			
Lower	25		1		50	3	9	1	6	1	1	2
Totals	55	2	13		19	1	4		3			<1
Wiley Creek Watershed												
Wiley	91		1		1			1			3	4
North Fork	97			3								
Little Wiley	89			6								
Totals	93			3								<1

the Thomas Creek watershed is private forest industry. The lower elevations in the western portions of the Thomas Creek watershed are characterized by agricultural lands (grass seed farming and row crops) and some pasture. The higher elevations in the eastern portions of the watershed are characterized by private timber industry and BLM lands with small amounts of agriculture.

1.2.1 Ownership

Most of the land in the lower South Santiam watersheds is privately owned, with the headwaters being primarily timberlands and the lower elevations primarily agricultural lands (Table 1.3). The BLM owns significant portions of the lower South Santiam headwaters including land in the Upper Thomas, Neal, NF Crabtree, and Hamilton Creek watersheds. There is very little USFS land in the lower South Santiam watersheds. The cities of Lebanon and Sweet Home are part of the Lower South Santiam subwatershed.

Table 1.3. Land ownership for the lower South Santiam watersheds.

Watershed	Private Timber	Private	BLM	USFS	State Forest	Other Federal	Unknown
Lower South Santiam	30	66	4		<1		<1
Crabtree Creek	37	43	18		2		<1
Thomas Creek	39	44	13	<1	2		<1
Wiley Creek	91	6		3			

CHAPTER 2. CHANNEL HABITAT TYPES

The percentage of total river length for each channel habitat type (CHT) are listed by subwatersheds in Table 2.1. A description of the channel habitat types and their associated fish usage is provided in the Background section (Section II, Chapter 2, Table 2.1). The tributaries to the lower South Santiam River below Foster Dam (Ames, McDowell, and Hamilton) have large percentages of MH and FP3 stream reaches. FP3 reaches are characterized by low gradients with an associated flood plain and supply important steelhead rearing and spawning habitat. MH reaches are characterized by moderate gradients and represent potential steelhead spawning and rearing if the reaches are accessible. It is important to note that the location of these reaches will need to be assessed and that these classes represent only the potential of streams to provide habitat based on their geomorphologic characteristics. For example, much of the Ames Creek FP3 reaches are in the urban portions of the watershed. These reaches have the potential to provide essential fish habitat, although other impacts such as stream simplification due to

Table 2.1 Channel habitat types in the lower South Santiam watersheds. Channel Habitat Type descriptions are located in the Background section, Section II, Chapter 2, Table 2.1).

Subwatershed	FP1	FP2	FP3	L	LC	MC	MH	MM	MV	SV	VH	WC
Wiley Cr.	-	17%	2%	-	1%	-	44%	3%	6%	24%	4%	1%
Little Wiley Cr.	-	-	-	1%	10%	7%	16%	8%	2%	43%	13%	-
NF Crabtree Cr.	-	-	1%	-	-	3%	20%	8%	5%	38%	14%	12%
SF Crabtree Cr.	-	-	-	-	-	1%	27%	6%	5%	48%	14%	-
Beaver Cr.	-	16%	44%	-	3%	-	27%	-	-	8%	1%	-
Lower Crabtree Cr.	-	16%	26%	-	4%	-	23%	2%	1%	23%	5%	1%
Upper Thomas Cr.	-	4%	10%	-	3%	3%	17%	21%	1%	36%	20%	1%
Lower Thomas Cr.	-	29%	29%	-	-	-	25%	2%	-	12%	3%	-
Ames Cr.	-	-	16%	-	-	-	63%	-	-	18%	2%	-
Noble Cr.	-	-	39%	-	-	-	41%	1%	-	16%	3%	-
McDowell Cr.	-	9%	-	-	1%	-	48%	6%	4%	27%	3%	2%
Hamilton Cr.	11%	-	-	-	2%	-	50%	2%	1%	25%	6%	1%
Lower S. Santiam	-	-	76%	-	-	-	20%	-	-	2%	-	2%
NF Wiley Cr.	-	-	-	-	12%	7%	14%	-	1%	32%	33%	1%
Neal Cr.	-	12%	8%	-	-	-	37%	6%	-	27%	7%	-

urbanization may have degraded the ability of the stream to provide this habitat. The data does suggest that the tributaries have a high potential to provide key habitat for steelhead spawning and rearing. The highest potential for fish habitat is in the lower portions of the watersheds, since the steep headwaters of Hamilton, McDowell, and Ames Creeks (classed as SV and VH) represent only limited spawning and rearing habitat.

The highest subwatersheds of Crabtree Creek (NF Crabtree and SF Crabtree) are predominately MH and SV, suggesting limited habitat for potential steelhead rearing. SV categories are characterized by small, steep and constrained streams which, if accessible, support limited rearing for anadromous fish and limited resident spawning and rearing. The lower subwatersheds, Beaver Creek and Lower Crabtree, contain most of the FP3 reaches where the important steelhead rearing and spawning habitat is located. The highest potential for fish habitat is in the lower portions of the watersheds, since the steep headwaters of Crabtree Creek (classed as SV and VH) represent only limited spawning and rearing habitat.

The headwaters of Thomas Creek (Upper Thomas) are predominately MH and SV suggesting limited to potential steelhead rearing while the lower subwatershed, Lower Thomas Creek, contains high percentages of FP2 (29%) and FP3 (29%) where important steelhead and resident rearing and spawning and resident overwintering habitat is located. The highest potential for fish habitat is in the lower portions of the Thomas Creek watershed since the upper subwatershed's steep headwaters (classed as SV and VH) represent only limited spawning and rearing habitat.

Two subwatersheds of the Wiley Watershed, Wiley and Little Wiley, are dominated by MH and SV which provide potential to limited steelhead rearing and spawning and important to limited resident rearing and spawning. The third subwatershed, NF Wiley, is predominately SV and VH which will only support limited habitat for steelhead or residential fish. The highest potential for fish habitat is located mainly in the Wiley and Little Wiley subwatersheds since the steep headwaters (classed as SV and VH) represent only limited spawning and rearing habitat.

CHAPTER 3. FISHERIES

3.1 Fish Distribution

Table 3.1. Compilation of anadromous fish distribution in the lower South Santiam watersheds.

	1961[a]	1963a[b]	1969[c]	1994[d]	1995[e]	1998a[f]	1998b[g]	1999[h]
Crabtree Creek								
Camp Cr.						X		
Crabtree Cr.	C,S	C,S	C,S	C,S		X	X	X
Bald Peter Cr.						X	X	X
SF Crabtree Cr.	S						X	X
Roaring River	S	C,S	S	S			X	X
Cruiser Cr.						X		
Bald Barney Cr.						X		
Lower South Santiam								
Hamilton Cr.	S		S				X	X
Morgan Cr.						X		
McDowell Cr.	S	S	S	S		X	X	X
Ames Cr.						X		
Scott Cr.	S							
Thomas Creek								
Thomas Cr.	C,S	C,S	C,S	C,S			X	X
Neal Cr.	S	S	S	S			X	X
Jordan Cr.			S					
SF Neal Cr.			S					
Wiley Creek								
Wiley Cr.	C,S	C,S	C,S	C,S		X	X	X
Little Wiley Cr.	S	S	S	S			X	X
Jackson Cr.						X	X	

[a] State Water Resources Board 1963. Middle Willamette River Basin.
[b] Oregon State Game Commission 1963
[c] Willamette Basin Comprehensive Study, Willamette Basin Task Force 1969.
[d] Healthy Native Stocks of Anadromous Salmonids in the Pacific Northwest and California, Huntington et al. 1994.
[e] South Santiam Watershed Assessment, United States Forest Service 1995. (WNF 1995)
[f] Linn County Anadromous Fish Distribution Map, United States Fish and Wildlife 1998.
[g] Willamette River and Sandy River Guide to Restoration Site Selection, Oregon Department of Fish and Wildlife 1998 (Thom and Talabere 1998).
[h] ODSL 1999. Essential Salmon Habitat

C=chinook S=steelhead X=anadromous

3.2 Migration Barriers

Migration barriers are a major consideration when evaluating salmonid habitat. There are several natural barriers in the form of waterfalls (Table 3.2). Some of these, such as the Hamilton Creek waterfall, may be passable by steelhead under high flow conditions. Several of the waterfalls separate populations of cutthroat and steelhead.

Table 3.2. Known migration barriers in the lower South Santiam watersheds.

Location	Barrier Type	Source
Lebanon Dam	Dam, passage	ODFW 1995
Lebanon-Albany Canal	No Screen	WBTF 1969
Foster Dam/Green Peter Dam	Dam, passage	ODFW 1995
Crabtree/Lacomb Dam	Gravel dam	WBTF 1969
Thomas Creek	Waterfall	WBTF 1969
Wiley Creek	Dam, passage	WBTF 1969

3.3 Habitat Conditions

The information presented as habitat condition values should be used to draw attention to a specific problem for consideration, for example lack of large woody debris. Individual stream survey records could then be reviewed, site visits made, and opportunities for improvement identified. For example, targets may include improving conditions involving large woody debris. Placement of large woody debris in the stream would facilitate pool development, increasing pool frequency, and percent pools. Long term investment in riparian areas would create a sustainable source of large woody debris. It is also important to note that significant flooding occurred in the South Santiam watersheds in 1996 and that many of the habitat conditions have changed, including but not limited to percent pools, LWD, and pool frequency.

Pieces and volume of large woody debris are lacking in most of the streams surveyed (Table 3.3). Exceptions were South Fork Crabtree Creek, and its tributaries, Dorgan Creek, and Shafer Creek. Ames Creek had the most desirable habitat conditions according to the ODFW habitat benchmarks, and it too is lacking in LWD. Crabtree Creek, South Fork Crabtree Creek and its tributaries have a broad range of conditions. Generally, the undesirable conditions are recognized as involving large woody debris, pool frequency, and percent pools.

Table 3.3. ODFW Habitat Benchmarks - lower South Santiam watersheds. Values shaded in dark gray indicate undesirable conditions while light gray indicates values associated with desirable conditions. Unshaded values are in-between.

	Reach	Miles	Gradient	Pool Frequency	Percent Pools	Residual Pool Depth	Gravels in Riffles	Woody Debris Pieces/100m	Woody Debris Volume(m^3)/100m	Key Pieces /100m
Ames Cr	1	1.08	0.5	10.5	80.2	0.3	66			
	2	0.96	0.7	3.7	61.2	0.5	81			
	3	0.57	1.4	5.9	45.5	0.3	70			
Crabtree Cr	1	7.75	0.4	6.4	37	0.7	37	1	1.4	0
	2	5.06	1	4.6	18.4	0.9	33	3	2.3	0
	3	5.37	1.7	8.1	14.6	0.9	18	5	6.4	0
	4	4.16	3.5	6	9.8	0.9	30	13	11.1	0
	5	2.82	6.1	9.7	7.9	0.4	25	10	14.8	1
	6	1.94	1.9	7.1	18.3	0.6	65	7	8.3	0
	7	0.72	10.6	15	16.1	0.7	60	17	27.9	2
	8	1.20	2.4	42.4	88	0.3	32	11	13.8	0
Dorgan Cr	1	1.23	6.5	18.6	6.1	0.3	20	19	34.5	1
	2	1.69	4.7	16.2	22.8	0.3	29	38	125.5	4
Hunter Cr	1	0.80	6.9	NA	0	NA	20	8	18.9	1
Neal Cr(lower)	1	0.52	2.6	6.6	31.1	0.5	9			
	2	0.36	4.9	3.3	37.8	0.6	28			
	3	0.35	2.2	11.3	10.5	0.2	25			
Neal Cr(upper)	1	0.08	2.3	6.3	10.3	0.2	30			
	2	0.04	8.5	1.4	38.7	0.4	95			
	3	0.23	7	7.7	11.7	0.2	95			
	4	0.33	5.4	17	12.9	0.2	33			
	5	0.56	0.6	15.4	90	0.6	34			
Shafter Cr	1	0.46	3.6	65.4	2.6	0.4	32	13	30.6	2
	2	0.74	11.1	99.1	2.7	1.1	3	14	46.5	2
SF Crabtree Cr	1	2.34	4.9	7.2	20.6	0.4	15	5	56.7	1
	2	4.67	7.9	13.3	11.5	0.5	58	10	27.9	1

Table 3.3. Continued.

	Reach	Miles	Gradient	Pool Frequency	Percent Pools	Residual Pool Depth	Gravels in Riffles	Woody Debris Pieces/100 m	Woody Debris Volume(m^3)/ 100m	Key Pieces /100m
Thomas Cr	1	6.40	1.2	4.2	34.4	0.7	40	3	9.2	
	2	3.85	1.9	5.5	41.5	1.5	46	4	15.9	
	3	2.23	3	3.9	28.9	1	26	7	18.4	
SF Crabtree Trib 1	1	0.48	7.9	11.5	36.9	0.5	0	41	99.7	3
SF Crabtree Trib 2	1	0.60	14.9	108	9.2	0.5	0	31	95.7	2
SF Crabtree Trib 3	1	0.75	18	6.9	16.3	0.4	20	35	119.1	5
Wiley Cr	1	2.28	1.8	10.5	23.3	1.3	28	2	4.9	
	2	0.80	1.8	6.2	47.1	1.2	35	5	18.5	
	3	0.27	3.4	10.7	22.4	0.9	40	3	10.8	
	4	2.55	2.9	6.9	24	0.9	29	3	9.6	
	5	2.59	4	9.6	9.7	0.6	21	4	14.9	
	6	0.49	6.6	14	11.9	0.6	30	1	2.6	
	7	0.40	6.3	7.4	12.2	0.4	40	10	18.2	
	8	0.21	7.5	6.8	14	0.6	28	11	33	
	9	0.40	6.7	14	7.7	0.4	28	6	11.8	
	10	0.30	12.3	13.2	8.8	0.3	36	10	22.9	
Wiley Cr Trib 1	1	0.08	24.5	7.3	22.1	0.6	20	10	13.5	
Wiley Cr Trib 2	1	0.11	13	5.1	14.2	0.6	19	15	14.6	
Wiley Cr Trib 3	1	0.71	10.5	19.8	8	0.4	25	18	40.7	

Desirable =
Undesirable =

CHAPTER 4. CHANNEL MODIFICATION ASSESSMENT

The Lower South Santiam and Crabtree Creek subwatersheds had the highest frequency of documented channel modifications with more than half of the total (140; Table 4.1). A majority of the impacts are a result of mining, gravel extraction, and/or flood protection measures constructed by the Army Corps of Engineers in the form of rip-rap. Crabtree Creek had more impacts in the form of diversions and channelized streambanks. Noble Creek and Ames Creek had the next highest quantity of channel modifications. Noble Creek had a large percentage of activity in mining and diversions. Ames Creek has a high frequency of bridge crossings and bank stabilization.

Table 4.1. Channel modification occurrences in the lower South Santiam watersheds.

Subwatershed	*Sand/Gravel Removal*	*Channelized Streambank*	*Mining*	*Revetment*	*Rip-rap*	*Diversion*	*Dam*	*Channel Stabilization*	*Other*	***Total***
Lower South Santiam	13	0	18	7	25	0	1	0	2	82
Crabtree Cr.	0	12	3	0	7	19	1	0	10	58
Noble Cr.	1	1	9	0	2	10	0	0	1	25
Ames Cr.	0	0	0	0	1	1	1	7	2	22
NF Wiley Cr.	0	1	1	0	1	0	0	0	0	8
Lower Thomas Cr.	0	0	7	0	0	0	0	0	1	8
Upper Thomas Cr.	0	0	1	0	0	1	1	0	0	8
NF Crabtree Cr.	0	1	0	0	0	0	0	0	1	4
Hamilton Cr.	0	1	1	0	0	0	0	0	0	2
Neal Cr.	0	0	1	0	0	0	0	0	0	1
McDowell Cr.	0	0	0	0	0	0	0	0	1	1
Little Wiley Cr.	0	0	0	0	0	0	0	0	0	0
SF Crabtree Cr.	0	0	0	0	0	0	0	0	0	0
Beaver Cr.	0	0	0	0	0	0	0	0	0	0
Wiley Cr.	0	0	0	0	0	0	0	0	0	0
Total	14	16	41	7	36	31	4	7	18	219

CHAPTER 5. RIPARIAN

5.1. Vegetation

The higher elevations of the lower South Santiam watersheds are mainly mature, dense forest, while the lower elevations are mainly grass/shrub and mature, sparse forest. Ames, McDowell, and Hamilton Creeks exhibited the largest proportions of mature, coniferous and mixed (coniferous and hardwood) vegetation (Table 5.1). However, Hamilton Creek also had a large proportion of grass/shrub most likely associated with the urban and agricultural uses in the watershed (25%). The Lower South Santiam, Noble Creek, and Hamilton Creek subwatersheds both had large proportions of grass shrub riparian areas along with mature sparse riparian areas representing approximately a quarter of the subwatersheds.

Vegetation in the South Fork and North Fork subwatersheds of Crabtree Creek are dominated by mature dense conifer stands (67% and 50%, respectively) or mature, mixed stands (22% and 12%, respectively; Table 5.1). In the lower elevations of Crabtree Creek, there are areas of grass/shrub riparian conditions mostly associated with the agricultural lands of the watershed. The White Rock Creek area has several segments of riparian wetland vegetation that may be important winter fish habitat.

The majority of riparian areas in the Thomas Creek watershed are dominated by mature, dense forest with a significant amount of young riparian forest. Only the Lower Thomas Creek subwatershed had a notable amount of grass/shrub dominated riparian areas. The BLM riparian reserve assessment states that current riparian vegetation is characterized by varied age classes which are heavily skewed towards stands less than 80 years old resulting in a general lack of mature to late succession dominated riparian vegetation (BLM 1997).

5.2. Continuity

Road crossings are the main reason for lack of continuity in the lower South Santiam watersheds with the most discontinuous watersheds being the lower elevations of Noble Creek, Hamilton Creek, and the Mainstem South Santiam watersheds (Table 5.2). The BLM estimated the road density at 4.25 miles per section in the Hamilton Creek watershed analysis area (BLM 1995) which covers the upper halves of the Hamilton and McDowell Creek subwatersheds. The Ames Creek subwatershed has much better continuity than the rest of the watershed with 63% in

Table 5.1. Riparian vegetation classes and percent of the total watershed for the lower South Santiam watersheds.

	Mature[a] Dense			Mature Sparse			Young[b] Dense			Young Sparse			Riparian Wetland	Grass/ Shrub	Urban	No Info
	C	H	M	C	H	M	C	H	M	C	H	M				
<u>Mainstem South Santiam</u>																
Lower S. Santiam	2	1	21	0	7	32	1	1	1	1	3	0	0	27	3	0
Noble Cr.	0	0	34	0	6	24	0	2	0	0	1	0	0	20	0	14
Hamilton Cr.	23	0	21	1	5	6	4	1	3	7	2	2	0	25	0	0
McDowell Cr.	33	1	24	2	1	17	1	0	0	4	0	1	1	13	0	1
Ames Cr.	52	0	21	0	3	16	0	0	0	0	0	0	0	0	8	0
<u>Crabtree</u>																
Lower Crabtree Cr.	26	3	29	2	6	7	6	0	1	5	0	1	3	10	0	0
Beaver Cr.	18	4	30	0	9	16	0	2	0	1	2	3	0	17	0	0
SF Crabtree Cr.	67	0	22	0	0	0	6	0	0	5	0	0	0	1	0	0
NF Crabtree Cr.	50	0	12	2	0	0	16	0	0	18	0	0	1	0	0	0
<u>Thomas</u>																
Lower Thomas Cr.	0	7	25	0	15	17	0	0	1	0	1	2	0	32	0	0
Neal Cr.	36	0	30	0	5	5	4	0	0	16	0	0	0	2	0	0
Upper Thomas Cr.	31	1	21	0	1	2	26	0	2	13	1	0	0	3	0	0

C = conifer H = hardwood M = mixed
[a] Mature = closed canopy
[b] Young = open canopy

Table 5.2. Continuity Class for riparian zones in the lower South Santiam watersheds			
Subwatershed	% Poor	% Fair	% Good
Noble Cr.	53	35	12
Lower South Santiam	50	34	16
Hamilton Cr.	38	32	30
McDowell Cr.	26	51	22
Lower Thomas Cr.	20	39	40
Upper Thomas Cr.	11	50	39
Ames Cr.	10	27	63
Beaver Cr.	8	42	50
Lower Crabtree Cr.	6	45	49
Neal Cr.	7	25	68
NF Crabtree Cr.	4	51	45
SF Crabtree Cr.	0	54	46

good condition.

The continuity in the the Crabtree Creek watershed is split evenly between the good and fair categories with only a small percent rated as poor. Breaks in continuity are mainly due to road and utility crossings.

Most of the Thomas Creek riparian zones are somewhat continuous with one or fewer interruptions per mile. The majority of the riparian interruptions are due to road and utility crossings. The BLM estimated that road densities range from 3.5 to 6.2 miles per section in the Thomas Creek watershed (BLM 1996). They counted 2,368 road/stream intersections in the Thomas Creek watershed analysis area, which is an average of 160 intersections for every square mile of riparian habitat (BLM 1996). The BLM watershed analysis area begins where Richardson's Gap Road crosses Thomas Creek at the Shimanek Bridge and extends east to the headwaters of Thomas Creek, covering approximately three-quarters of the Thomas Creek watershed.

5.3. Buffer Width

The majority of narrow buffers occurred in the lower elevation subwatersheds (Lower Thomas Creek, Noble Creek, Lower South Santiam) where the greatest amount of agriculture occurs. The Lower Thomas Creek subwatershed is the only watershed in the Thomas Creek watershed that has narrow riparian buffer width (Table 5.3). The Lower Crabtree and Beaver Creek watersheds have significant portions in the fair category (27% and 50% fair respectively), mostly associated with the agricultural lands in the watershed. However, it is important to note that only a small portion of these watersheds is in poor condition (4% and 3% respectively).

Table 5.3. Riparian width class in the lower South Santiam watersheds. The benchmark width used was 30 m.

Subwatershed	% Poor	% Fair	% Good
Lower Thomas Cr.	20	51	29
Noble Cr.	17	46	37
Lower South Santiam	12	58	30
McDowell Cr.	11	22	67
Hamilton Cr.	9	21	70
Lower Crabtree Cr.	4	27	69
Beaver Cr.	3	50	47
Upper Thomas Cr.	2	10	89
Ames Cr.	0	40	60
Neal Cr.	0	12	88
NF Crabtree Cr.	0	0	100
SF Crabtree Cr.	0	0	100

The headwaters of Crabtree Creek, Thomas Creek, Hamilton Creek, McDowell Creek, and Ames Creek have good width conditions with all of the reaches having a buffer width of greater than 30 meters (Table 5.3). Approximately 89% and 88% of the riparian areas in the Upper Thomas Creek and Neal Creek watersheds have at least a 30 m (98.4 ft.) buffer with the majority being forested. Most of these areas occur in the higher elevations and headwaters.

5.4 Overall Riparian Condition

The poor riparian areas are mainly in the lower elevations of the watersheds where there is the largest amount of agricultural land use (Table 5.4). These riparian areas are characterized by narrow, discontinuous riparian zones that are often dominated by grass/shrub vegetation. Over

Table 5.4. Riparian condition summary for the lower South Santiam watersheds.

Subwatershed	Buffer Score*	Buffer Classification	Continuity Score*	Continuity Classification	Vegetation Score*	Vegetation Classification	Overall Score*	Overall Classification
SF Crabtree Cr.	10	Good	8	Good	10	Good	28	Good
NF Crabtree Cr.	10	Good	8	Good	8	Good	27	Good
Neal Cr.	9	Good	8	Good	9	Good	26	Good
Upper Thomas Cr.	9	Good	8	Good	8	Good	26	Good
Lower Crabtree Cr.	8	Good	8	Good	8	Good	24	Good
Ames Cr.	8	Good	8	Good	8	Good	23	Fair
McDowell Cr.	8	Good	7	Fair	8	Good	23	Fair
Beaver Cr.	6	Fair	8	Good	7	Fair	21	Fair
Hamilton Cr.	8	Good	6	Fair	7	Fair	21	Fair
Lower Thomas Cr.	5	Fair	7	Fair	6	Fair	18	Fair
Lower South Santiam	6	Fair	6	Fair	6	Fair	17	Fair
Noble Cr.	6	Fair	5	Fair	6	Fair	17	Fair

* scores presented and mean values weighted by length. Scoring system is described in Section II, Chapter 3.

half of the Lower South Santiam subwatershed and approximately two-thirds of the Noble Creek subwatershed have narrow or no riparian buffer and an abundance of grass/shrub or urban vegetation in the lower tributaries such as Mill Creek, Spring Creek, and One Horse Slough where there is heavy influence of agricultural practices on landscape features (Table 5.4). The lower portions of the Hamilton Creek and McDowell Creek subwatersheds are largely agricultural lands and are characterized by relatively narrow buffers dominated by grass/shrub and sparse hardwood vegetation. The mainstem of the South Santiam River also has short segments of narrow buffers and grass/shrub riparian vegetation.

The lower half of the Lower Crabtree subwatershed is similar in that it has areas of narrow buffers or little or no riparian buffers scattered throughout and has a discontinuous riparian zone. About a fifth of the Beaver Creek subwatershed is dominated by grass/shrubs, mainly in the tributaries and along the Lacomb Ditch.

Many of the tributaries and short sections of the mainstem of Thomas Creek have narrow buffers or little or no riparian buffer. The tributaries in the lower three-quarters of the Lower Thomas Creek subwatershed are dominated by grass/shrub riparian vegetation while the riparian area along the mainstem of Thomas Creek is dominated by mature, sparse vegetation.

The headwaters of the tributaries are generally in good condition (Table 5.4). The upper portions of Hamilton, McDowell, Neal, Beaver and Ames Creeks and the headwaters of Thomas and Crabtree Creeks are forest land characterized by wide buffers and riparian areas dominated by dense, closed canopy forest. However, several of the small, headwater tributaries have short segments of clearcut with no apparent buffer. The portion of Ames Creek that runs through the city of Sweet Home is in poor condition, characterized by narrow buffers dominated by grass/shrub or urban riparian vegetation (weeds, brush, occasional trees, and hardened banks).

Overall, the riparian conditions in the lowland areas typically associated with agricultural land use are in poor to fair condition due to removal or thinning of the riparian vegetation and decreased riparian width. The headwater regions typically associated with managed forest lands are in good condition with wide buffers and mature stands of conifers and hardwoods. However, there were several clearcuts where the riparian area did not appear to remain intact.

5.5 Future Potential for Large Woody Debris

The future potential for LWD delivery is high in approximately half of the Lower South Santiam subwatershed (Table 5.5). The areas with moderate or low potential are dominated by grass/shrub vegetation, urban areas, or young woodlands. These areas tend to be clustered in the lower portions of the tributaries and in several small segments along the mainstem of the South Santiam River (Table 5.5). The future potential for LWD delivery in the Noble Creek subwatershed is high in 56% of the subwatershed. Much of the lower portion of the Hamilton Creek subwatershed is young, sparse woodland or grass/shrub riparian vegetation and thus has a moderate or low potential for future LWD. The upper portion of the subwatershed is largely forested and shows high potential for LWD recruitment in the future. Most of the McDowell Creek subwatershed is mature forest and has high potential for future recruitment of LWD. Approximately a quarter of the McDowell Creek subwatershed has moderate or low potential for future LWD recruitment due to the grass/shrub and young woodland riparian vegetation scattered throughout the lower part of the watershed and the unbuffered clearcuts in the headwaters. The BLM Hamilton Creek Watershed Analysis reported similar potential LWD recruitment: 56%

Table 5.5. Future potential for large woody debris in the lower South Santiam watersheds.

Subwatershed	% Low	% Moderate	% High	Need More Info
Lower Crabtree Cr.	6	19	75	0
Beaver Cr.	5	27	68	0
SF Crabtree Cr.	0	12	88	0
NF Crabtree Cr.	0	27	73	0
Lower South Santiam	16	33	51	0
Noble Cr.	11	20	56	14
Hamilton Cr.	20	24	56	0
McDowell Cr.	9	13	77	1
Ames Cr.	3	10	87	0
Lower Thomas Cr.	19	24	57	0
Neal Cr.	1	23	76	0
Upper Thomas Cr.	2	38	60	0

high potential; 39% moderate potential; and 4% low potential (BLM 1995). It is important to note that the BLM analysis only covered the upper halves of the Hamilton Creek and McDowell Creek subwatersheds. Due to the large percentage of the Ames Creek subwatershed that is mature, dense forest, the future potential for LWD is very high. The areas classified as having moderate and low potential are in the lower section of the subwatershed in and around the city of Sweet Home. In these areas the riparian vegetation is dominated by urban vegetation consisting of weeds, brush, occasional trees, and hardened banks.

Three quarters of the Lower Crabtree subwatershed has high potential for future LWD recruitment. The areas classified as having low potential are those dominated by grass/shrub and riparian wetland vegetation. These areas are located mainly in the lower half of the subwatershed. The future potential for LWD is high overall in the Beaver Creek subwatershed. The small percentage of area classified as low potential corresponds to the grass/shrub dominated areas along Lacomb Ditch and in the lower tributaries to Beaver Creek. Approximately half the subwatershed is mature, dense forest and another quarter is mature, sparse forest providing high potential for LWD recruitment in the future. Due to the dominance of mature, dense forest the potential for future LWD is very high in the South Fork Crabtree subwatershed. The 12% of the subwatershed that is classified as moderate potential corresponds to the areas of young forest. The future potential for LWD recruitment is also very high in the North Fork Crabtree subwatershed. Approximately 27% of the subwatershed is classified as moderate potential due to the young riparian forest scattered throughout the subwatershed.

The future potential for LWD is high for much of the mainstem of Thomas Creek and most of the upper tributaries in the subwatershed. However, since much of the riparian vegetation is dominated by hardwoods the LWD will likely be smaller and will not last as long in the stream. The potential for future LWD recruitment is low in most of the lower tributaries due to the dominance of grass/shrub riparian vegetation. The future potential for LWD recruitment is high in the Neal Creek subwatershed. The riparian vegetation is dominated by conifer and mixed, mature, dense forest. Approximately 20% of the subwatershed is dominated by young riparian vegetation which has a moderate potential for future LWD recruitment. The future potential for LWD is high in just over half the Upper Thomas Creek subwatershed. There is also a large percentage of riparian area with moderate potential for future LWD recruitment due to the abundance of young riparian vegetation in the Upper Thomas Creek subwatershed. The 2% that has low potential for future LWD recruitment corresponds to the areas dominated by grass/shrub vegetation.

5.5.1 Stream Shading and Water Temperatures

Elevated temperatures is a widespread problem throughout the lower South Santiam watersheds. Thirteen sites were monitored for summer temperatures in the lower South Santiam watersheds by the South Santiam Watershed Council in 1998. All sites had temperature exceedences (7-day moving average of daily maximum temperatures greater then 64°F).

Ames, Hamilton, and McDowell Creeks all exhibited temperature exceedences in July, August and parts of September (Figure 5.1). Two sites were monitored on both Hamilton and McDowell Creeks and significant warming occurred as the water traveled from the midway sites to the mouth. Poor stream shading probably contributed to increased stream temperatures. Temperatures need to be monitored at the forest/agriculture interface to determine the extent of warming and whether stream temperatures are already exceeding standards. All of the current high-temperature sites are in the agricultural parts of the watersheds where stream shading is classified as poor.

Thomas Creek, Crabtree Creek, and Beaver Creek all exceeded temperature standards, with exceedences occurring well into late September (Figure 5.2). Sites need to be expanded on both Crabtree and Thomas Creeks to elucidate stream reaches that contribute heavily to stream warming. Currently, these sites are located in the lower portions of the watershed where there is poor stream shading as a result of riparian loss. Additional data at the forest/agriculture interface will also help evaluate stream temperatures as they move out of well shaded areas.

Four sites were monitored for temperature on Wiley Creek. Two were right next to each other, and consequently data from only three will be presented here. Significant warming occurred (approximately 4-6 °F) from the headwater site versus the mouth of Wiley Creek (Figure 5.3). The middle site was similar the headwater site, suggesting that a large amount of warming occurred between the middle site and the mouth. All three sites exceeded temperature standards, although the mouth maintained the temperature exceedance for a longer duration. The riparian areas of Wiley Creek were not evaluated as a part of this assessment. Consequently, there is no way to determine the effects of stream shading on stream temperatures. Both sites on Little Wiley Creek exceeded temperature standards. The mouth of Wiley maintained its

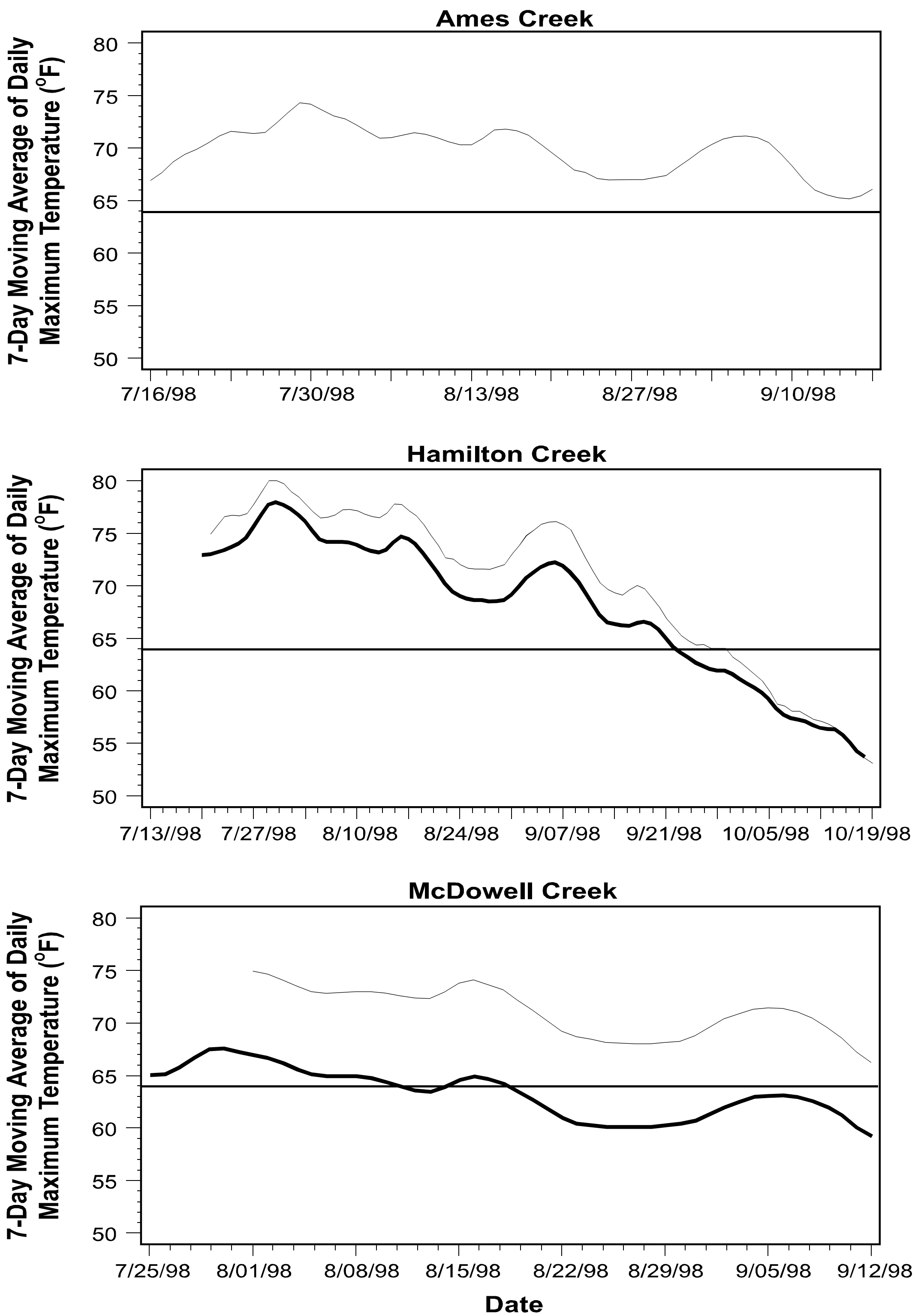
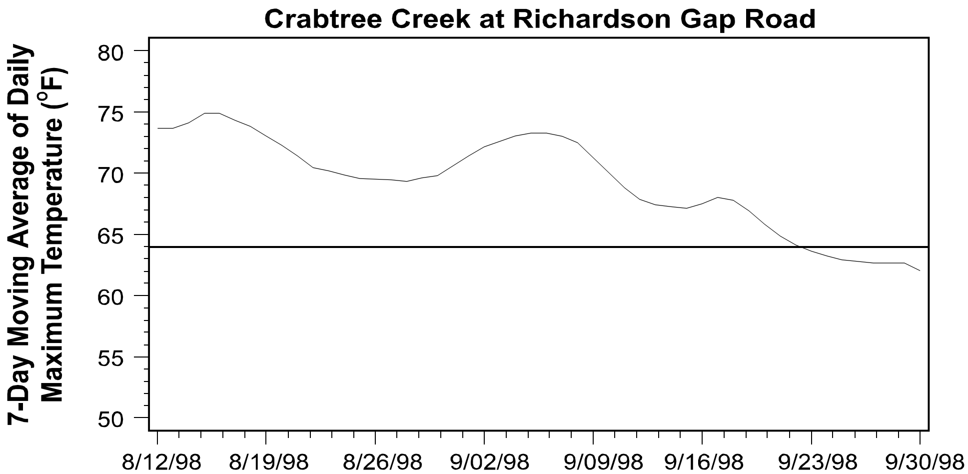
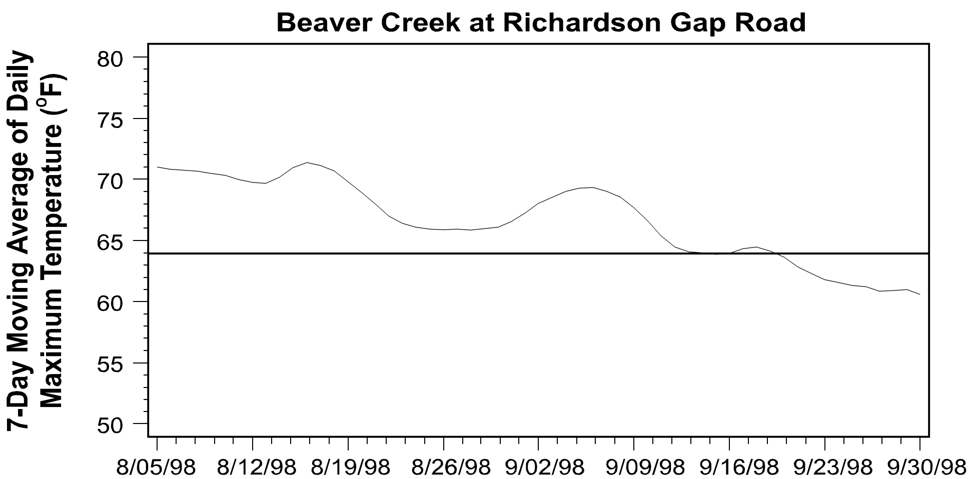


Figure 5.1. The 7-day moving average of daily maximum temperature (°F) on Ames Creek (a), Hamilton Creek (b), and McDowell Creek (c). The lighter weight line represents the most downstream site. The solid line represents the DEQ standard for cold water fisheries (64°F).





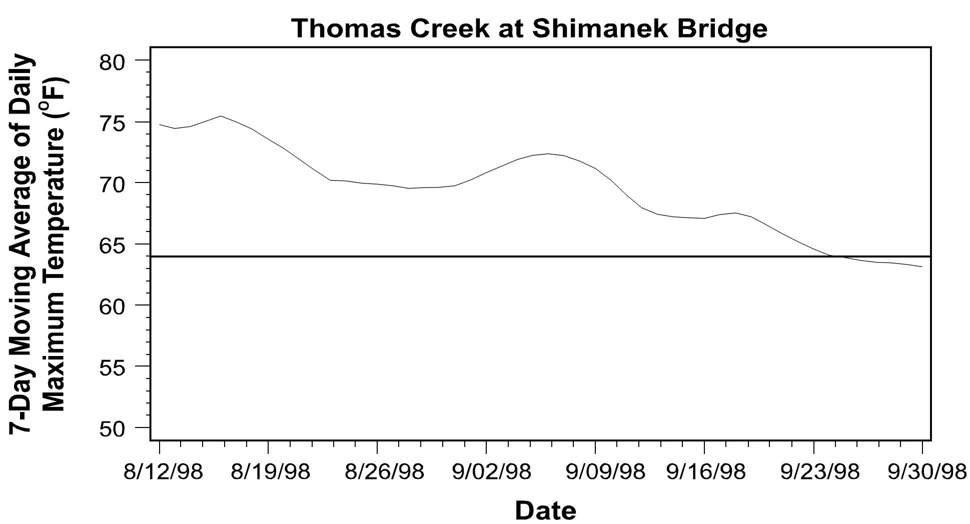
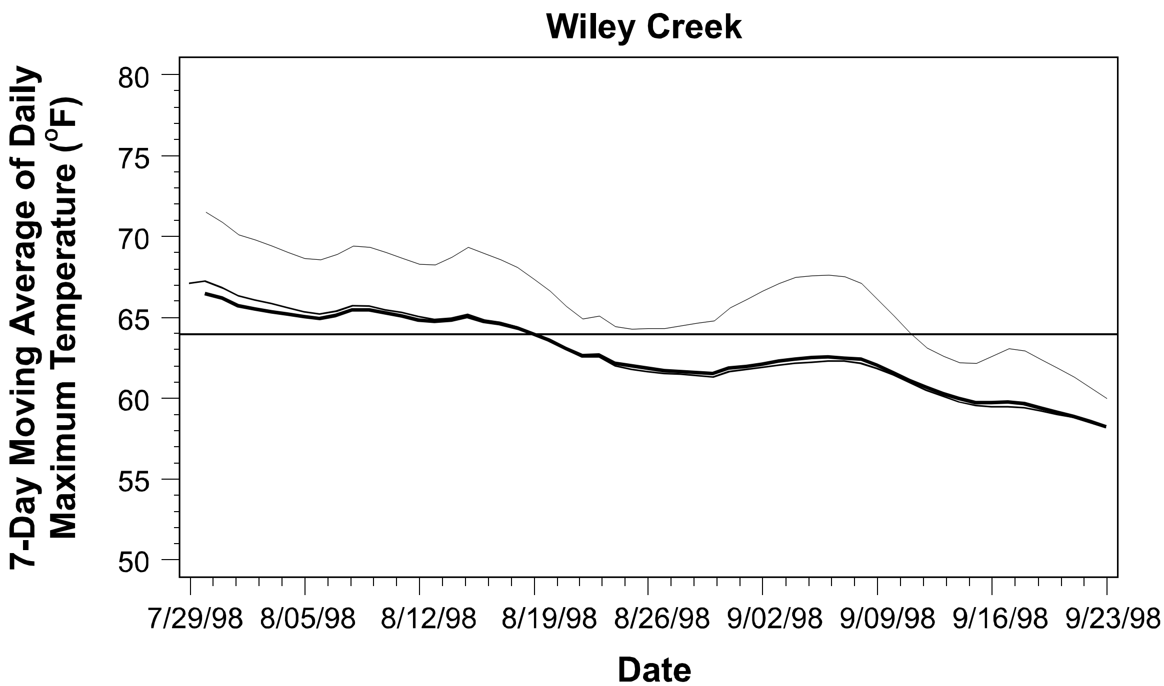


Figure 5.2. The 7-day moving average of daily maximum temperature (°F) on Crabtree Creek (a), Beaver Creek (b), and Thomas Creek (c). Only one site was monitored on each of these creeks. The solid line represents the DEQ standard for cold water fisheries (64°F).



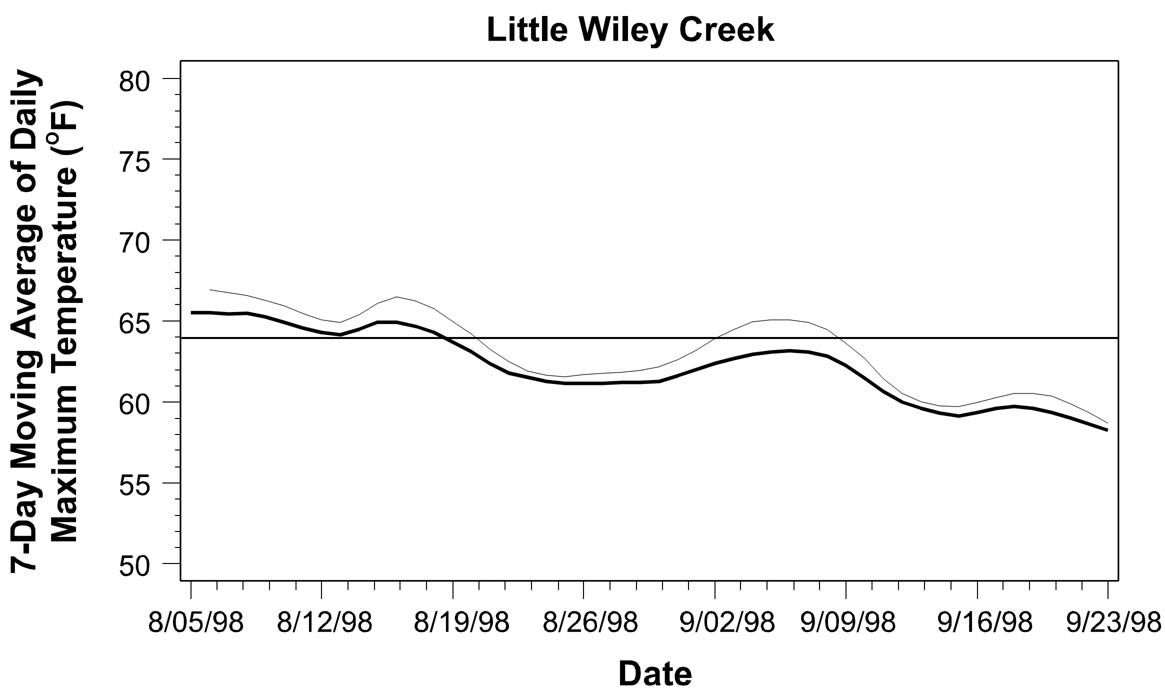


Figure 5.3. The 7-day moving average of daily maximum temperature (ºF) on Wiley Creek (a) and Little Wiley Creek (b). The lighter weight line represents the most downstream site and the dashed line is the middle site. The solid line represents the DEQ standard for cold water fisheries (64ºF).

temperature exceedance for a longer period of time and generally ran about 1-2 degrees warmer than the upper Little Wiley Creek site.

Temperature exceedence is a widespread problem through the lower watersheds. There is some evidence that stream temperatures may already exceed standards before flowing through the poorly shaded portions of the watershed. Wiley Creek exceeded standards in the headwaters, where stream shading is assumed to be high. A study is necessary to further understand historical stream temperatures and specific reaches that may contribute significantly to stream temperature increases.

5.5.2 Data Confidence

Based on the current vegetation composition, 62% of the Thomas Creek watershed has high potential for future LWD recruitment, 32% has moderate potential and 8% has low potential. However, the BLM Thomas Creek watershed analysis gives a somewhat different picture of future potential for LWD. The BLM categorized 66% of the watershed analysis area as having low potential to provide future LWD, 26% as having moderate potential, and 8% as having high potential (BLM, 1996). This discrepancy is due to different classification systems. The BLM only classifies riparian areas dominated by conifers older than 80 years as having high potential for future LWD recruitment. The OWAM takes a more general approach and looks at longer term potential for LWD recruitment. Table 5.6 illustrates the differences in the two classification systems.

Table 5.6. Future Potential for LWD: BLM Classification versus OWAM Classification.

Age Class (years)	Acres	BLM Classification	OWAM Classification
Conifer < 40	7,765	Low	Moderate
Conifer 40 - 80	3,326	Moderate	High
Conifer > 80	1,292	High	High
Hardwood < 40	661	Low	Moderate
Hardwood 40 - 80	554	Moderate	High
Hardwood > 80	29	Moderate	High
Non-forest	1,666	Low	Low

CHAPTER 6. WATER QUALITY

6.1 Applicable Water Quality Standards

Oregon Administrative Rules (Chap. 350, Div. 41, DEQ) designated beneficial uses for the waters of the State. Often these uses are watershed specific, however all of the beneficial uses designated apply to the South Santiam River except for Navigation. Consequently, virtually all of the water quality criteria apply including dissolved oxygen, temperature, pH, coliform bacteria, habitat modification, and toxics. For further discussion on the designated beneficial uses and their associated water qualify criteria see the introduction section on water quality (Section II, Chapter 2).

6.2 Description of Current Water Quality

The DEQ 1998 Section 303(d) decision matrix lists stream segments that have been checked for water quality and have not been listed (Table 6.1). Much of the data is from the South Santiam Watershed Council volunteer water quality monitoring program, as well as DEQ, USGS, BLM, and USFS data.

Table 6.1. Streams listed as OK by DEQ after potential concern and data collection.

Stream Segment	Parameter	Season	Criteria	Supporting Data
Thomas Cr. Mouth to Neal Cr.	pH		Willamette Basin (6.5 to 8.5)	SSWC data
South Santiam - Mouth to McDowell Cr.	D.O.	Sept. 1 - July 31	Cold Water Aquatic Life (<8mg/L or 90% saturation)	DEQ data
	pH	Summer	Willamette Basin (6.5 to 8.5)	DEQ data
	pH	Fall-Spring	Willamette Basin (6.5 to 8.5)	DEQ data
	Bacteria	Summer	Water Contact Recreation	DEQ data
	Chlorophyll a	Summer		DEQ data
	D.O.	August	Cold Water Aquatic Life (<8mg/L or 90% saturation)	DEQ data
South Santiam McDowell Cr. to Foster Reservoir	Bacteria	Summer	Water Contact Recreation	DEQ data
	Temperature	Summer	Rearing 64°F (17.8°C)	USGS Data

Table 6.1. Continued.				
McDowell Mouth to Deer Creek	D.O.	Summer	Cold Water Aquatic Life (<8mg/L or 90% saturation)	SSWC data
	pH		Willamette Basin (6.5 to 8.5)	SSWC data
Hamilton Mouth to ?*	D.O.	Summer	Cold Water Aquatic Life (<8mg/L or 90% saturation)	SSWC data
	pH		Willamette Basin (6.5 to 8.5)	SSWC data
Crabtree Cr. Mouth to White Rock Cr.	D.O.	Summer	Cold Water Aquatic Life (<8mg/L or 90% saturation)	SSWC data
	pH		Willamette Basin (6.5 to 8.5)	SSWC data
*The DEQ document indicated Deer Creek, which is incorrect. The correct location is not known.				

The mainstem South Santiam River below McDowell Creek met established criteria for pH, dissolved oxygen, chlorophyll *a*, and summer bacteria based on DEQ data. The McDowell Creek to Foster Dam reach of the South Santiam River met criteria for summer bacteria concentrations and temperatures. However, the South Santiam below McDowell Creek is on the 303(d) list for temperatures suggesting significant warming of the water as it moves down the mainstem South Santiam (Table 6.2). The South Santiam River is also on the 303(d) list for year- round bacteria, suggesting significant increases in bacteria during the high flow months.

Table 6.2. Water Quality Limited Streams (303d) for the lower South Santiam watersheds.

Stream Segment	Parameter	Criteria	Season	Supporting Data
Thomas Cr. Mouth to Neal Cr.	Temperature	Rearing 64ºF (17.8ºC)	Summer	SSWC data; USGS data
South Santiam Mouth to McDowell Creek	Temperature	Rearing 64ºF (17.8ºC)	Summer	DEQ data 1986-1995
	Bacteria	Water Contact Recreation	Year Round	DEQ data 1986-1995
McDowell Mouth to Deer Creek	Temperature	Rearing 64ºF (17.8ºC)	Summer	SSWC data
Hamilton Cr. Mouth to ?	Temperature	Rearing 64ºF (17.8ºC)	Summer	SSWC data
Crabtree Cr. Mouth to White Rock Cr.	Temperature	Rearing 64ºF (17.8ºC)	Summer	USGS data near Scio, OR; SSWC data
*The DEQ document indicated Deer Creek, which is incorrect. The correct location is not known.				

Data collected by the SSWC suggests that many of the tributaries met D.O. and pH criteria including Crabtree Creek, Hamilton Creek, McDowell Creek, and Thomas Creek (pH only). Many of the tributaries have significant temperature problems including Thomas Creek (Mouth to Neal Creek), Crabtree Creek (mouth to White Rock Creek), Hamilton Creek (Mouth to Deer Creek) and McDowell Creek (Mouth to Deer Creek) which are 303(d) listed for temperature (Table 6.2).

The STORET database is a water quality database maintained by the Environmental Protection Agency (EPA) which contains water quality data from many government agencies such as the Department of Environmental Quality, EPA, and Water Resources Department. There are over 75 sampling sites in the STORET database for the South Santiam River and its tributaries. However the majority of these sites have a sampling frequency of less than five, and many have only one or two samples taken. The South Santiam River at Highway 226 is the only site that has been maintained to date. The remaining sites were sampled in the 1960's and 1970's with a few exceptions. We have attempted to use relevant data to characterize the water quality in the South Santiam River. However it is difficult to assess the quality of data from this type of database. Differences in data can often be artifacts of analytical differences, differences in period of record, or other factors of which we are unaware. Analytical methods have improved over the decades increasing the possibility of artifacts resulting from improved analytical techniques. Consequently, differences in data may not reflect actual differences in water quality.

6.2.1 Mainstem South Santiam

Seasonal mean water quality data for the South Santiam River site at Highway 226 are presented in Table 6.3. Apparent trends in some of these conventional water quality parameters suggest improved water quality since the 1950's. However, many of these increases can be attributed to the construction of Green Peter and Foster Dams in the late 1960's, when many water improvements began. Both dissolved oxygen concentration and percent saturation has increased since the 1960's (Figure 6.1). Much of this may be attributed to cold water releases

Table 6.3. Water Quality in the South Santiam River collected at the Highway 226 crossing from 1949 to 1998. The data were obtained from EPA's STORET database.

Parameter	Fall					Spring				
	N	MIN	MAX	MEAN	STD	N	MIN	MAX	MEAN	STD
Water temperature (ºC)	79	5.5	22.0	13.7	3.5	66	6.7	18.0	10.6	2.8
Turbidity (Hach FTU)	31	1.0	12.0	2.6	2.1	34	2.0	24.0	6.7	5.9
Color (units)	39	0.0	70.0	10.0	12.6	38	0.0	58.0	14.2	13.5
Conductivity (:M)	40	33.0	122.0	56.2	24.1	38	28.0	59.0	40.6	6.9
Dissolved Oxygen (mg/L)	76	0.2	13.0	9.0	3.0	66	8.1	12.8	11.2	1.1
BOD (mg/L)	79	0.2	56.0	3.2	6.9	63	0.2	5.1	1.8	1.0
pH (s.u.)	71	6.3	8.1	7.0	0.4	63	6.7	7.8	7.2	0.3
Total Alkalinity (mg/L)	30	14.0	23.0	16.7	2.2	32	13.0	21.0	16.1	2.0
NH_4^+ (mg/L)	39	0.0	4.0	0.2	0.6	41	0.0	1.2	0.1	0.2
NO_3^- (mg/L)	31	0.0	0.2	0.0	0.0	34	0.0	0.3	0.1	0.1
Total Phosphorus (mg/L P)	30	0.0	0.1	0.0	0.0	34	0.0	0.2	0.0	0.0
Calcium (mg/L)	20	3.4	4.9	4.1	0.4	19	3.4	4.7	4.0	0.4
Magnesium (mg/L)	20	0.7	1.1	0.9	0.1	19	0.8	1.3	1.0	0.1
Sodium (mg/L)	23	1.5	2.9	2.4	0.3	21	1.8	2.9	2.4	0.3
Potassium (mg/L)	20	0.3	0.5	0.4	0.1	19	0.1	2.5	0.6	0.5
Chloride (mg/L)	13	0.8	4.3	2.0	1.1	15	0.6	2.0	1.4	0.4
Sulfate (mg/L)	13	0.9	21.5	4.3	5.6	15	0.1	5.0	1.7	1.2
Fecal Coliform (cfs/100 ml)	34	2.0	7000.0	369.5	1207.5	39	3.0	24000.0	1049.1	3925.6
Parameter	Summer					Winter				
	N	MIN	MAX	MEAN	STD	N	MIN	MAX	MEAN	STD
Water temperature (ºC)	118	6.3	26.5	18.9	3.3	59	0.00	10.00	6.43	1.9
Turbidity (Hach FTU)	35	1.0	5.0	2.2	1.0	32	3.0	39.00	11.09	8.9
Color (units)	45	1.0	33.0	7.0	6.1	36	1.00	70.00	21.47	15.8
Conductivity (:M)	44	40.0	112.0	60.3	19.8	36	30.00	55.00	39.42	6.10
Dissolved Oxygen (mg/L)	114	0.3	12.0	7.9	2.7	60	10.10	13.20	11.78	0.7
BOD (mg/L)	106	0.1	19.3	2.5	2.8	58	0.60	6.30	1.78	1.0
pH (s.u.)	109	6.2	8.2	7.0	0.5	59	6.5	7.50	7.01	0.29
Total Alkalinity (mg/L)	38	14.0	20.0	17.0	1.6	32	11.00	19.00	15.03	2.0
NH_4^+ (mg/L)	65	0.0	1.0	0.1	0.2	37	0.02	0.42	0.06	0.1
NO_3^- (mg/L)	57	0.0	0.4	0.1	0.1	33	0.08	0.35	0.17	0.1
Total Phosphorus (mg/L P)	51	0.0	0.2	0.0	0.0	33	0.02	0.13	0.05	0.0
Calcium (mg/L)	22	3.7	5.3	4.4	0.4	18	3.00	4.70	4.00	0.50
Magnesium (mg/L)	22	0.7	1.2	1.0	0.1	18	0.70	1.20	0.95	0.16
Sodium (mg/L)	22	1.9	3.6	2.6	0.3	22	1.2	3.00	2.32	0.43
Potassium (mg/L)	19	0.1	0.7	0.4	0.1	20	0.20	0.80	0.43	0.13
Chloride (mg/L)	17	0.5	3.5	1.5	0.7	12	1.10	2.50	1.53	0.45
Sulfate (mg/L)	17	0.5	9.3	2.0	2.0	12	0.50	3.80	1.91	1.06
Fecal Coliform (cfu/100 ml)	46	3.0	28000.0	1224.1	4566.4	35	7.00	7000.0	631.63	1267.57

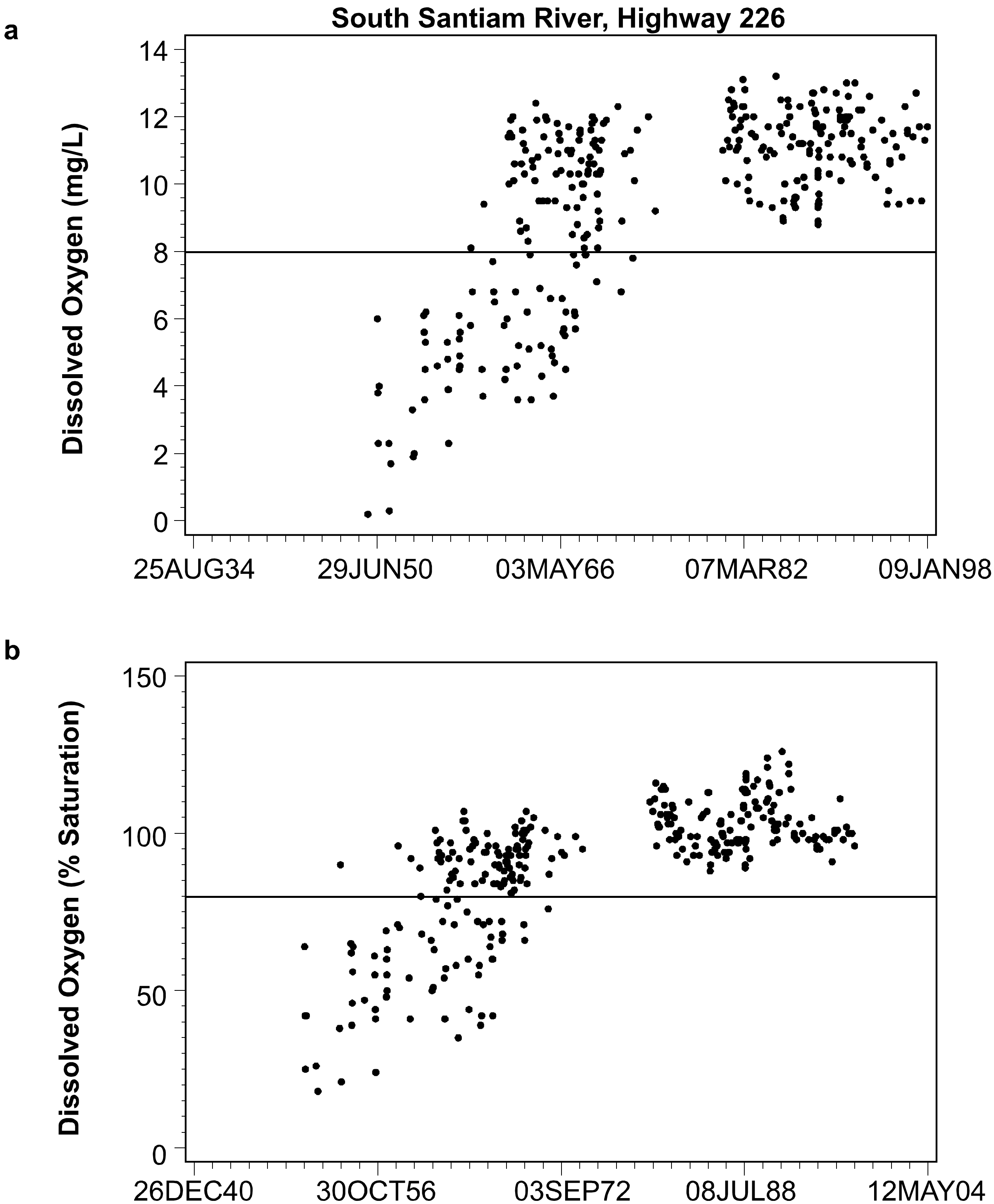


Figure 6.1. Dissolved oxygen as both (a) concentration (mg/L) and (b) percent saturation in the mainstem South Santiam River at the Highway 226 crossing from 1949 to 1998. The solid line represents the DEQ standard for cold water fisheries.

from the bottom of Foster Reservoir. Cold water holds more oxygen and increased flows can result in greater mixing of water with atmospheric oxygen in rapids. Temperature values at the monitoring site show a decreasing trend, further corroborating that cold water releases have increased oxygen concentrations (Figure 6.2). Biological oxygen demand (5-Day BOD) does appear to have a decreasing trend since 1960 which may also play a role in increased oxygen levels (Figure 6.3). Decreased BOD levels may be attributed to improvements in wastewater treatment and septic systems, decreasing the amount of effluent and associated oxygen demanding substances to surface waters. The closing and clean-up of the Crown-Zellerbach Mill in Lebanon, OR may also have contributed to an increase in D.O. in the mainstem South Santiam River.

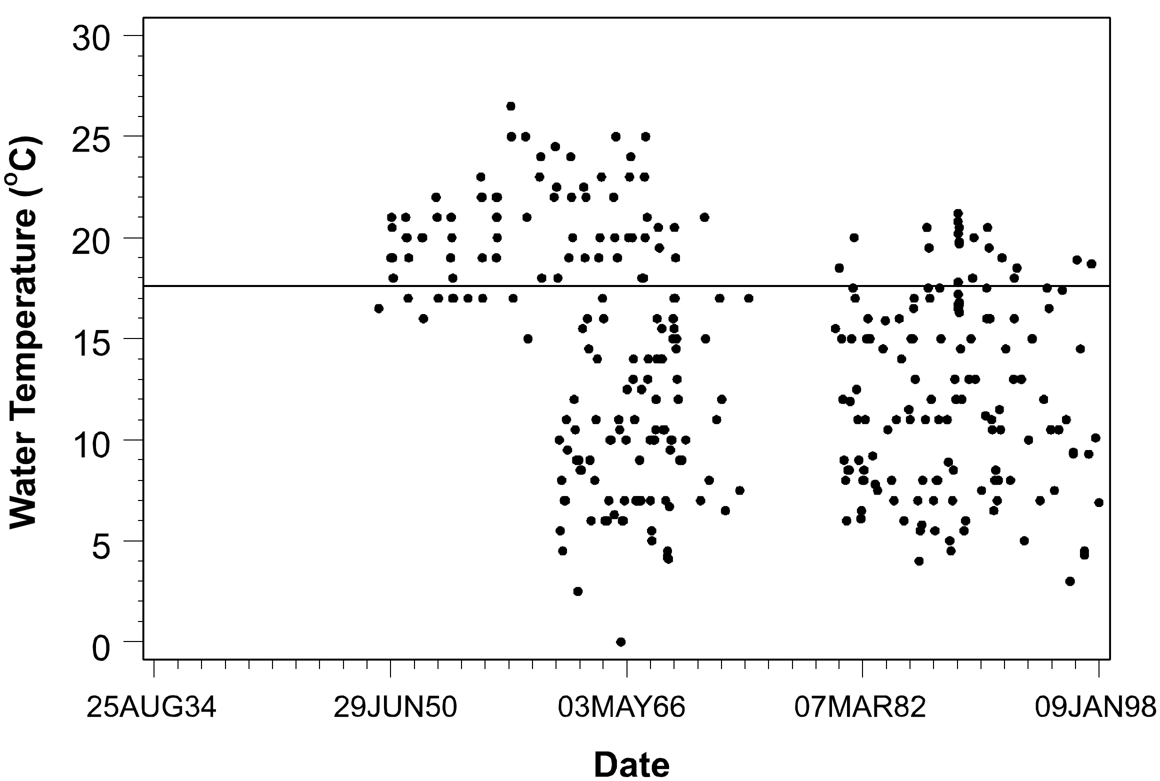


Figure 6.2. Temperature (°C) from the STORET database in the mainstem South Santiam River at the Highway 226 crossing from 1949 to 1998. The solid line represents the DEQ standard for temperature.

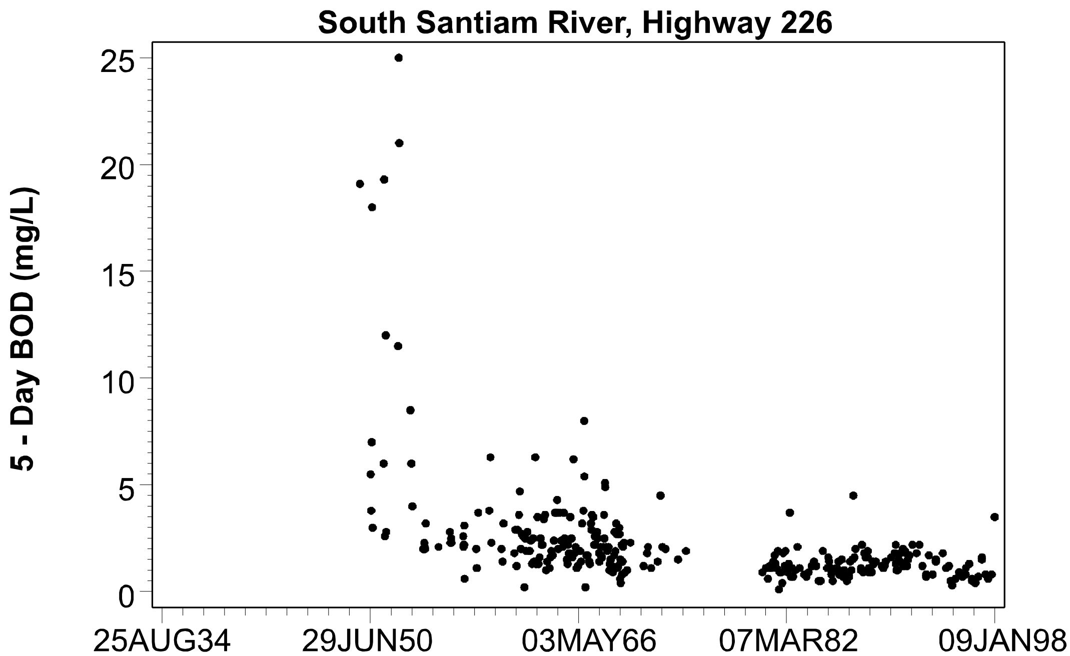


Figure 6.3 Five-day biological oxygen demand (BOD, mg/L) in the mainstem South Santiam River at the Highway 226 crossing from 1949 to 1998.

Although water quality conditions have improved for dissolved oxygen and water temperatures, there are some indications for increased primary productivity in the mainstem South Santiam River. pH can be an indicator of increased primary productivity (photosynthesis removes CO_2 from the water causing an increase in pH), and there has been an increase in river pH, that appears to have begun around the same time as the installation of Foster and Green Peter Dams (1967; Figure 6.4). Increased values meet the current pH standards set for the Willamette Basin, however, and consequently is of no real concern. There is no apparent trend in chlorophyll *a* for the South Santiam River suggesting that there is no significant increase in productivity and increased pH may be attributed to other factors (Figure 6.5). Both nitrate and total phosphorus show no apparent trend with values in the moderate range (Figure 6.6). Ammonium values indicate a decreasing trend with concentrations less than 0.1 mg/L since 1980 (Figure 6.7).

The South Santiam River is on the 303(d) list for fecal coliform bacteria from the mouth to McDowell Creek. Historically, the South Santiam River has had high concentrations of fecal

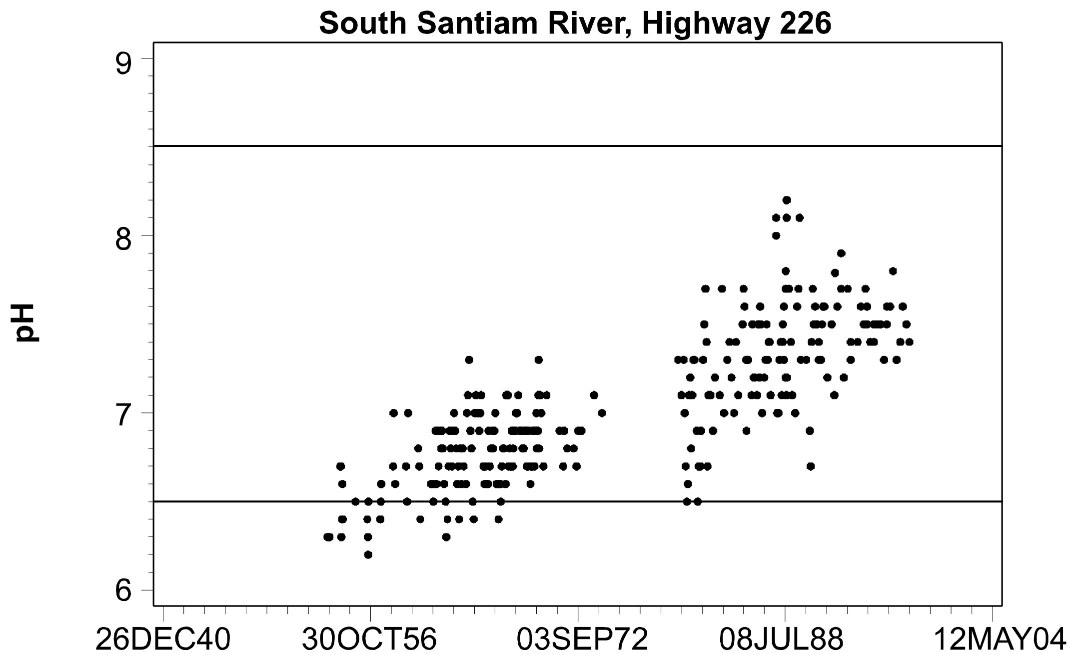


Figure 6.4. Field pH (standard units) in the mainstem South Santiam River at the Highway 226 crossing from 1949 to 1998. The solid lines represent the maximum and minimum state standards set by DEQ.

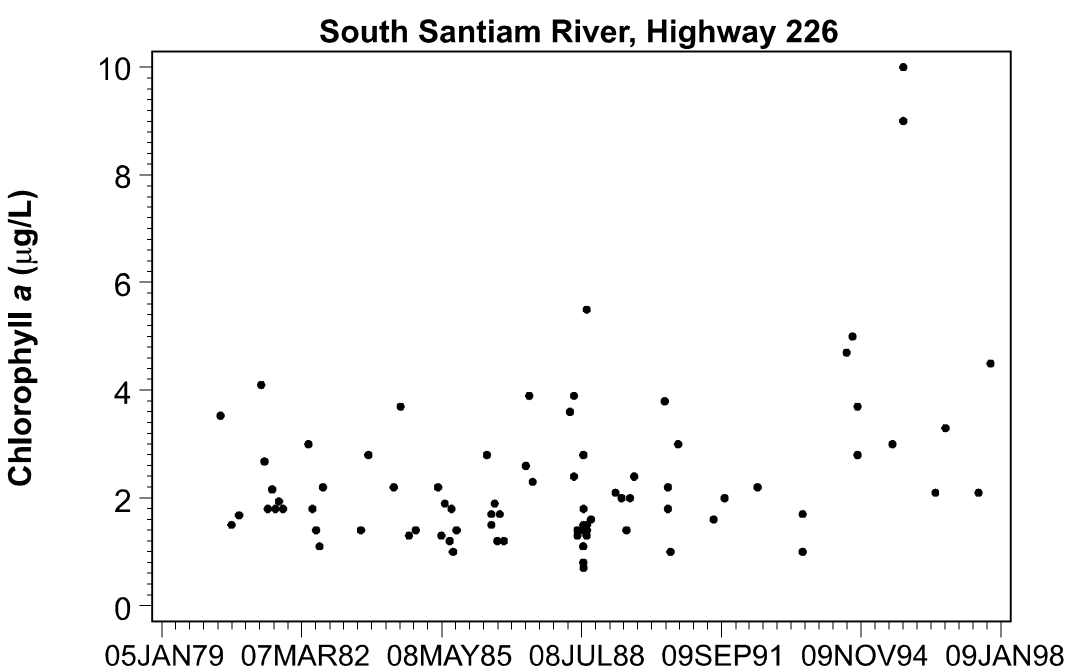
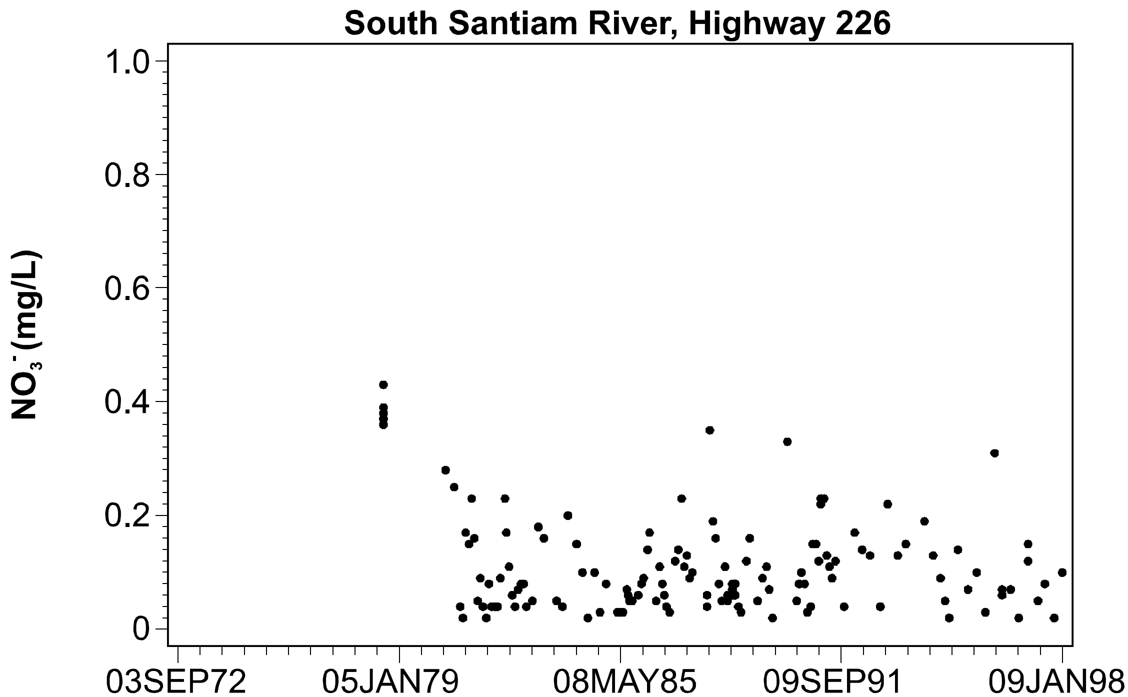


Figure 6.5 Chlorophyll *a* (: g/L) in the mainstem South Santiam River at the Highway 226 crossing from 1979 to 1998.

a



b

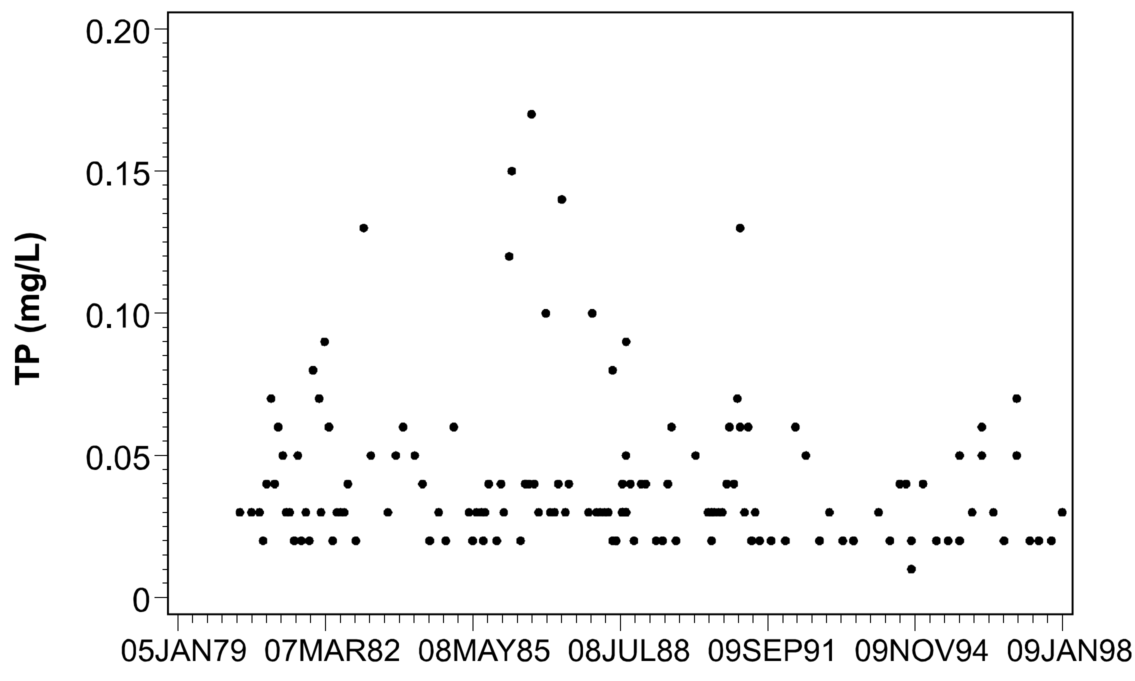


Figure 6.6. (a) Nitrate (mg/L) and (b) total phosphorus (mg/L) in the mainstem South Santiam River at the Highway 226 crossing from 1979 to 1998.

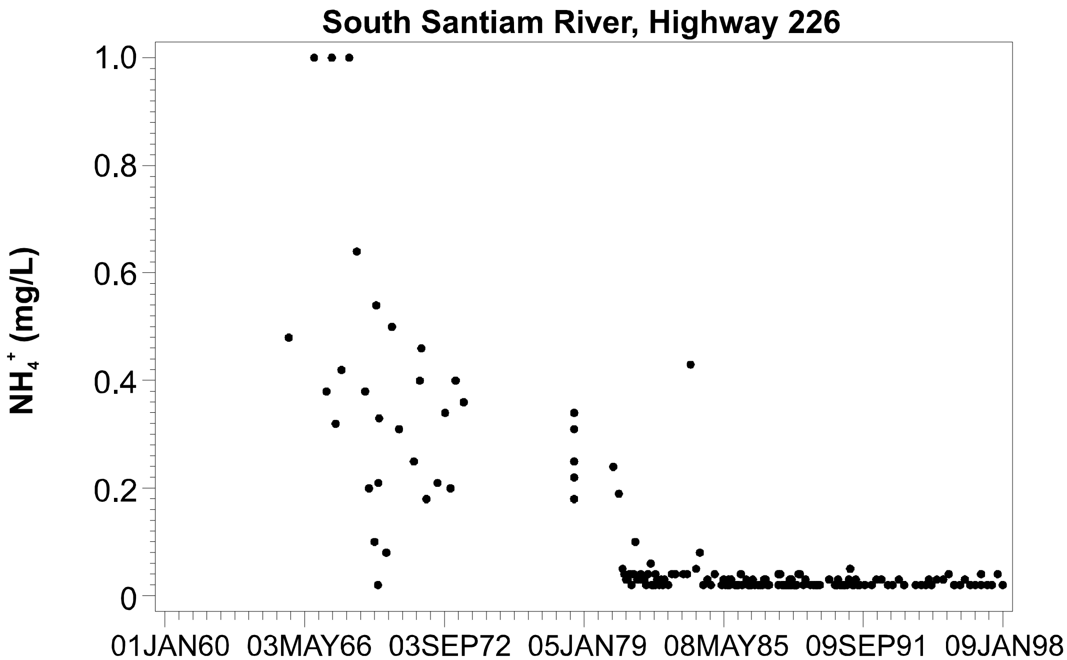


Figure 6.7. Ammonium (mg/L) in the mainstem South Santiam River at the Highway 226 crossing from 1963 to 1998.

coliform bacteria, with values often exceeding 2,000 cfu/100 ml, which is well above the legal limit of 400 cfu/100 ml (Figure 6.8). Summer concentrations have decreased and have not exceeded the legal limit since 1984, prompting the listing to cover year round fecal coliform and not summer concentrations. Fecal coliform bacteria is highly episodic in nature, and discharge at the time of sampling is unknown. Summers in this region tend to be relatively dry. However, summer storms can increase fecal coliform concentrations as is illustrated by a high summer maximum (Table 6.3) and has been shown in other studies in Oregon (Sullivan et al. 1998a, 1998b; Bischoff et. al. 1999). Additionally, sources of fecal coliform bacteria has been shown to include pastures, septic systems, and urban areas, which are spread throughout the lower South Santiam watersheds. Samples taken from Mark's Slough, which runs through the city of Lebanon, in the early 1970's (N=8) show very high fecal coliform concentrations (mean= 591,306 cfu/100 ml) suggesting that fecal coliform contributions from urban areas may be significant. Further investigation is warranted to elucidate specific land use practices and river reaches that contribute fecal coliform to surface waters and the timing of these contributions.

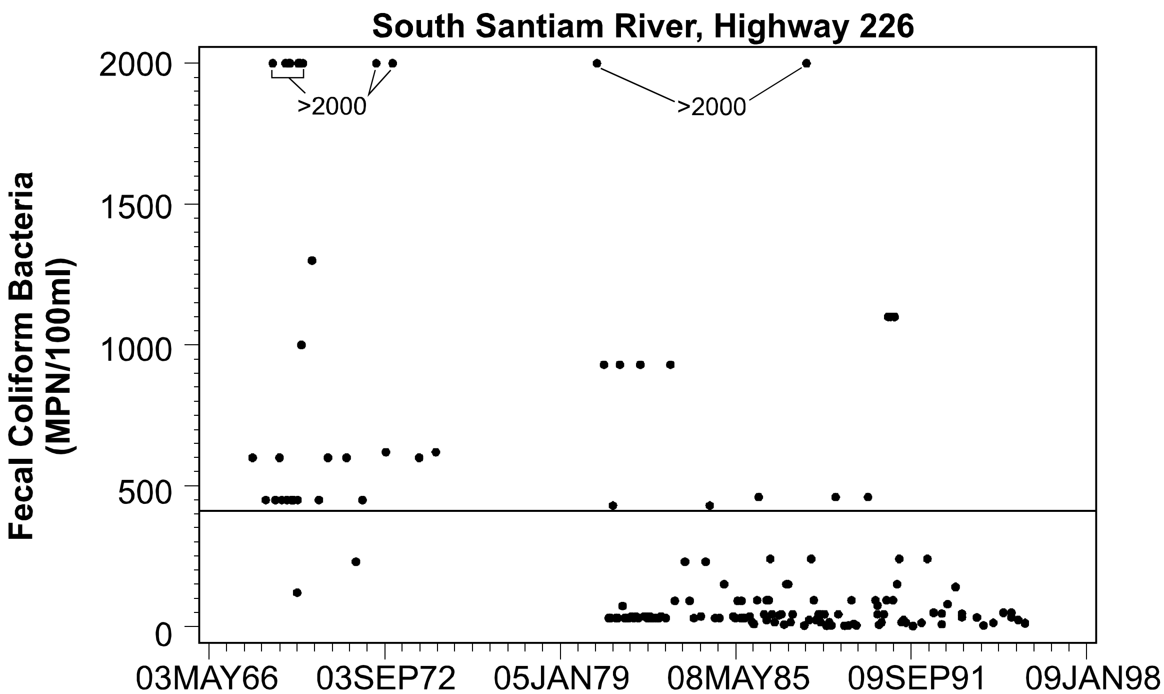


Figure 6.8 Fecal coliform bacteria (cfu/100 ml) in the mainstem South Santiam River at the Highway 226 crossing from 1963 to 1998. The solid line represents the state standard for fecal coliform set by DEQ.

6.2.2 Thomas Creek

There is very little water quality information available for Thomas Creek. One site was sampled several times in the summer of 1978 for temperature and dissolved oxygen (Table 6.4). Temperatures were high in Thomas Creek, ranging from 21 to 24.5 ºC, far exceeding the temperature standard of 17.8ºC. Dissolved oxygen was low, ranging from 7 to 10 mg/L and was similar to concentrations reported by the SSWC volunteer monitoring program. Thomas Creek is on the 303(d) list for temperature and as a potential concern for dissolved oxygen. Continued monitoring of both dissolved oxygen and temperature is needed to evaluate current conditions of Thomas Creek. However, it is likely that low dissolved oxygen concentrations are a direct result of high stream temperatures.

Table 6.4. Water quality data for Thomas Creek collected at River Mile 4.8 in 1978. The data were obtained from EPA's STORET database.

Parameter	N	MIN	MAX	MEAN	STD
Water Temperature (°C)	13	21.00	24.50	22.01	0.95
Dissolved Oxygen (mg/L)	13	7.40	9.70	9.15	0.60
NH_4^+ (mg/L)	1			0.20	
NO_3^- (mg/L)	1			0.13	

6.2.3 Crabtree Creek

Crabtree Creek was sampled during the summer between 1974 and 1978 at River Mile 1.6 for temperature, dissolved oxygen, and one sample for nitrogen species. Crabtree Creek was similar to Thomas Creek in that water temperatures were high and dissolved oxygen concentrations were low. However, D.O. did meet DEQ standards. More recent information needs to be collected to better understand the current conditions of Crabtree Creek.

Table 6.5. Water quality data for Crabtree Creek collected at River Mile 1.6 from 1974 to 1978. The data were obtained from EPA's STORET database.

Parameter	N	MIN	MAX	MEAN	STD
Water Temperature (°C)	11	20.00	24.00	22.05	1.34
Dissolved Oxygen (mg/L)	11	8.00	9.00	8.75	0.27
NH_4^+ (mg/L)	1			0.07	
NO_3^- (mg/L)	1			0.17	

6.2.4 Wiley Creek

Wiley Creek was sampled between 1969 and 1973 at Highway 20 (Table 6.6). Without knowing the season or discharge at the time of sampling, it is difficult to interpret these data. However, these data suggest that general water quality in Wiley Creek is good. Temperatures did exceed water quality standards (17.8 °C).

Table 6.6. Water quality data for Wiley Creek collected at Highway 20 from 1969 to 1973. The data were obtained from EPA's STORET database.

Parameter	N	MIN	MAX	MEAN	STD
Water Temperature (ºC)	7	7.00	20.00	15.36	5.76
Turbidity (Hach FTU)	5	1.00	4.00	2.20	1.30
Color (units)	5	0.00	5.00	3.60	2.19
Conductivity (:M)	5	35.00	58.00	47.80	9.39
Dissolved Oxygen (mg/L)	7	8.40	11.70	9.70	1.34
Dissolved Oxygen (%)	7	93.00	100.00	96.86	2.27
BOD (mg/L)	7	0.30	1.40	0.86	0.39
pH (s.u.)	7	6.90	7.10	6.99	0.07
NH_4^+ (mg/L)	5	0.01	0.12	0.08	0.04
Chloride (mg/L)	5	1.30	2.70	1.72	0.56
Sulfate (mg/L)	5	0.70	5.50	3.16	2.09
Fecal Coliform (cfu/100 ml)	2	45.00	60.00	52.50	10.61

6.2.5 Watershed Council Monitoring

The South Santiam Watershed Council has been monitoring water quality on the South Santiam River and many of its tributaries since May of 1997. Approximately 12 sites have been monitored for water quality parameters including Hamilton, McDowell, Ames, Beaver, Thomas, and Crabtree Creeks as well as the Mainstem South Santiam River at the Lebanon Dam (Table 6.7). Temperature data and sites will be dealt with in a separate section. It is important to note that the water quality monitoring program is in its initial stages, and therefore the amount of data is limited. There is not enough data to assess differences between seasons or river flows. Additionally, the QA/QC plan has not been fully implemented (SSWC 1997) because not enough samples have been collected to fully evaluate the quality of the data. The quality of some of the data has been reported as suspect, particularly some measurements of dissolved oxygen and fecal coliform bacteria. These data are most useful for giving a general idea of where there may be water quality problems and where further investigations may be warranted.

Table 6.7. Water quality in the lower South Santiam watersheds collected at various sites by the SSWC volunteer monitoring program.

	N	MAX	MIN	MEAN	STD	N	MAX	MIN	MEAN	STD
PH AND DISSOLVED OXYGEN	pH					D.O. (mg/L)				
Ames Cr. - Above Duck Pond	4	6.99	5.86	6.51	0.56	4	13.00	9.33	10.83	1.64
Ames Cr. - Below Duck Pond	2	6.86	6.60	6.73	0.19	1	11.50	11.50	11.50	
Beaver Cr. - Richardson Gap	2	6.39	6.09	6.24	0.21	2	18.00	10.83	14.42	5.07
Crabtree Cr. - Richardson Gap Road	11	8.60	6.09	7.48	0.74	11	11.67	8.00	9.77	1.27
Crabtree Cr. - Hoffman Bridge	10	7.76	6.03	7.17	0.59	12	12.00	8.68	10.29	0.96
Hamilton Cr. - Bellinger Scale Road	13	8.13	6.32	7.05	0.57	15	11.88	9.17	10.61	0.70
Hamilton Cr. - Udell's	6	7.16	6.50	6.80	0.29	4	11.39	9.50	10.68	0.84
Hamilton Cr. - Berlin Road	12	7.60	5.95	6.71	0.57	13	11.96	9.99	10.95	0.62
McDowell Cr. - McDowell Rd. Bridge	12	7.90	6.10	6.90	0.62	10	12.67	9.33	11.37	1.26
South Santiam - Lebanon Dam	10	6.63	6.01	6.30	0.23	11	12.26	10.22	11.42	0.57
Thomas Cr. - Shimanek Bridge	10	8.20	6.22	7.37	0.63	9	12.17	7.00	9.55	1.81
Thomas Cr. - Gilkey Bridge	9	8.44	6.66	7.41	0.61	10	11.83	8.17	10.44	1.25
NUTRIENTS	NO_3 (mg/L)					TP (mg/L)				
Hamilton Cr. - Bellinger Scale Road	7	3.00	0.00	1.00	1.00	8	5.00	0.00	1.50	1.60
Hamilton Cr. - Berlin Road	8	2.00	0.00	0.63	0.74	6	6.00	1.00	2.17	1.94
South Santiam - Lebanon Dam	9	1.00	0.00	0.56	0.53	5	3.00	0.00	1.20	1.30
SEDIMENTS	Turbidity (Hach FTU)					TSS (mg/L)				
Ames Cr. - Above Duck Pond	4	11.80	7.23	8.86	2.13					
Ames Cr. - Below Duck Pond	2	16.50	8.01	12.26	6.00					
Beaver Cr. - Richardson Gap	2	70.07	16.03	43.05	38.21					
Crabtree Cr. - Hoffman Bridge	12	21.83	3.50	10.12	6.58					
Crabtree Cr. - Richardson Gap Road	11	39.97	0.91	10.25	14.95					
Hamilton Cr. - Udell's	6	34.43	10.13	17.21	9.62					
Hamilton Cr. - Bellinger Scale Road	15	51.70	4.16	16.90	16.35	7	50.00	26.00	31.86	8.63
Hamilton Cr. - Berlin Road	13	40.93	4.60	16.89	11.86	7	53.00	27.00	33.86	9.39
McDowell Cr. - McDowell Rd. Bridge	12	21.80	2.45	13.11	6.47					
South Santiam - Lebanon Dam	9	25.50	3.20	9.35	6.83	9	29.00	20.00	24.11	2.57
Thomas Cr. - Shimanek Bridge	10	12.97	0.99	4.50	3.99					
Thomas Cr. - Gilkey Bridge	11	17.37	1.49	5.58	5.02					
BACTERIA	Fecal Coliform (CFU/100 ml)					E. Coli (MPN/100 ml)				
Crabtree Cr. - Hoffman Bridge	5	660	252	492	148	5	441	183	339	95
Crabtree Cr. - Richardson Gap Road	2	510	169	340	241	2	344	117	231	161
Hamilton Cr - Udell’s	2	3050	112	1581	2077	2	2030	78	1054	1380
Hamilton Cr. - Berlin Road	4	765	137	400	315	4	560	137	259	201
Hamilton Cr. - Bellinger Scale Road	7	9600	112	1746	3469	7	1000	92	403	310
McDowell Cr. - McDowell Rd. Bridge	3	505	340	407	87	3	344	242	279	56
South Santiam - Lebanon Dam	6	2100	12	769	1038	6	2100	12	583	862
Thomas Cr. - Gilkey Bridge	6	675	27	283	248	6	452	18	202	172
Thomas Cr. - Shimanek Bridge	4	123	0	79	54	4	86	0	57	39
CONDUCTIVITY	Conductivity (:S)									
Hamilton Cr. - Bellinger Scale Road	8	75	50.00	65.25	8.94					
Hamilton Cr. - Berlin Road	6	93	57.00	67.50	12.91					
McDowell Cr. - McDowell Rd. Bridge	2	56	26.00	41.00	21.21					
South Santiam - Lebanon Dam	5	54	42.00	49.20	4.76					
Thomas Cr. - Shimanek Bridge	3	57	42.00	48.67	7.64					

Consequently, the authors do not suggest that the water quality measurements are absolute values, but rather general approximations of water quality.

Mean dissolved oxygen ranged from approximately 9 to 11 mg/L with the lowest values in Crabtree and Thomas Creeks. All but one of the values met the Cold Water Fisheries criteria (8 mg/L), although only a few met the salmonid spawning criteria (11 mg/L; Table 6.7). Since cold water holds more oxygen and percent saturation values ranged from 70% to 115% (SSWC, 1997), decreased oxygen concentrations may be a function of increased water temperatures. Many of these streams are temperature limited resulting in a lower capacity of holding oxygen. Improving stream temperatures should increase dissolved oxygen concentrations.

pH values in the lower South Santiam watersheds ranged from a minimum of 6 on the mainstem South Santiam to a maximum of 8 on Thomas and Hamilton Creeks. Some of the values fell outside of the DEQ standards of 6.5 to 8.5, including samples taken for Hamilton, McDowell, Thomas, Crabtree, and Beaver Creeks as well as the mainstem South Santiam River. The pH was highest in Thomas, Crabtree, and Hamilton Creeks, most likely as a result of heavy agricultural use of these lands (pH can be an indicator of increased productivity). However, high pH does not appear to be a major problem in any of the streams.

Nutrient values (NO_3 and TP) were sampled on Hamilton Creek and the mainstem South Santiam River, and appear to have very high concentrations (mean of 2 mg/L and 1 mg/L for NO_3 and 1 mg/L and 0.56 mg/L for TP, respectively). However, these values do not agree with STORET data on the mainstem South Santiam River and may be attributed to analytical methods. Nutrient loading warrants further study.

Turbidity was measured at all sites. Turbidity increases with increased flows, and consequently is often associated with storm events. Ambient sampling of turbidity can skew the values to the low end if all of the samples are taken during low flow periods. These values may represent low end values. However, it would take a more in-depth analysis of turbidity than the scope of this study allows. Many of the samples were collected in the summer months, further supporting that these values represent low-end turbidities (SSWC 1997). On three different dates, turbidity was collected on Crabtree, Hamilton, McDowell and Thomas Creeks, giving some insight into the differences between creeks. Generally, Thomas Creek has the lowest turbidities during the low flow months, but was similar to the rest of the streams in September, probably as a result of higher flows from a rain event. To fully understanding turbidity and sediment loads, it will require storm characterization as well as ambient sampling across a suite of flow regimes. Generally, turbidity was high in all of the streams and needs to be further characterized. More recent turbidity data was collected during December 1998 and January 1999. These data yielded higher maximum values for Hamilton, McDowell, Noble, Billy and Scott Creeks as well as the mainstem South Santiam River (T. Dover, pers. comm.). Total suspended solids was sampled on Hamilton Creek and the mainstem South Santiam River, and was relatively high which is in agreement with turbidity values.

Bacteria samples were high at all sites except at the Shimanek Bridge site on Thomas Creek (Table 6.7). Mean values exceeded legal limits at many of the sites. Bacteria concentrations are highly variable across storm types and season and difficult to interpret. However, there is a large amount of data on the mainstem South Santiam River that has led to its listing as a water quality impaired stream by DEQ (303(d) list, 1998). Monitoring data suggests that the source bacteria is variable across the lower South Santiam watersheds including Thomas Creek, Crabtree Creek, McDowell Creek, and Hamilton Creek, as well as the mainstem South Santiam River. Further investigations are needed to better understand major contributing sources of fecal coliform bacteria and their spatial aggregation in the South Santiam watershed.

Overall, the monitoring data from the South Santiam Watershed Council suggests that water quality exceeds minimum standards throughout the lower South Santiam watersheds. Monitoring data suggests that both bacteria and turbidity are potential concerns throughout the lower South Santiam watersheds and need to be further characterized to better understand sources and variability across storm types (intensity, antecedent moisture conditions). Dissolved oxygen met the cold water fisheries standard, although improvements need to be made to meet salmonid spawning requirements.

CHAPTER 7. WATER USE AND HYDROLOGY

7.1 Watershed Characterization and Precipitation

Elevation in the lowlands of the lower South Santiam watersheds (Mainstem South Santiam, Lower Thomas, Lower Crabtree, Beaver, McDowell, Hamilton and Noble Creeks) ranges from a minimum elevation of 220 feet to a maximum of 4,157 feet (Table 7.1). The topography is typical of Western Cascades Lowlands and Valleys, Willamette Valley Foothills, and Willamette Valley Plains ecoregions where low gradient streams exist with large floodplains and tributaries often reaching into steeper highlands. Mean annual precipitation ranges from 43 to 91 inches. The higher elevation watersheds (North and South Fork Crabtree Creeks, all of Wiley

Table 7.1. Subwatershed Characterization for the lower South Santiam watersheds.

Subwatershed	Drainage Area (acres)	Minimum Elevation (feet)	Maximum Elevation (feet)	Mean Annual Precipitation (inches)
SF Crabtree Cr.	10,448	1,125	4,337	79.6
NF Crabtree Cr.	16,417	1,115	4,469	87.5
Little Wiley Cr.	10,914	837	4,331	67.4
SF Wiley Cr.	22,241	837	4,498	72.9
Wiley Cr.	7,421	558	2,543	58.5
Neal Cr.	17,565	440	4,275	70.5
Upper Thomas Cr.	49,174	440	4,389	80.4
McDowell Cr.	15,387	430	4,045	61.8
Hamilton Cr.	25,782	371	3,054	56.0
Noble Cr.	32,109	367	2,126	50.1
Beaver Cr.	24,236	269	2,579	49.3
Lower Crabtree Cr.	48,756	236	4,157	60.7
Lower Thomas Cr.	25,708	230	1,450	50.4
Mainstem South Santiam River	37,749	220	1,283	45.3
Ames Cr.	7,601	492	2,566	65.5

Creek, Upper Thomas Creek, and Neal Creek) range in elevation from 440 feet to 4,469 feet and is more typical of Western Cascades Lowlands and Valleys and Western Cascade High Montane ecoregions (Table 7.1). Mean annual precipitation ranges from 59 to 88 inches. Precipitation falls predominantly in the form of rain in the lowlands and snow in elevations above 4,000 feet. The transient snow zone (1,500 feet to 3,000 feet as defined by the BLM; BLM, 1996) is a dominant feature of many of these watersheds and describes an area that receives precipitation as both rain and snow with a high risk for winter rain-on-snow events (Figure 7.1).

7.2 Climate

Precipitation, snowfall, and temperature were monitored at Foster Dam from 1961 to 1990 (Table 7.2). The largest amount of precipitation fell during the period of November to February, representing 54% of the total annual precipitation. Mean annual precipitation was approximately 54 inches with less than 1% occurring as snowfall. The highest potential for rain-on-snow events occurred during December through February with mean annual snowfall ranging from 0.32 inches

Table 7.2. Precipitation, snowfall, and temperature as measured at Foster Dam from 1961-1990.

Month	Mean Precipitation (in)	Mean Snowfall (in)	Maximum Precipitation (in)	Mean Temperature (^{O}C)	Maximum Monthly Temperature (^{O}C)	Minimum Monthly Temperature (^{O}C)
1	7.12	0.44	1.9	40.2	47.3	33.1
2	6.06	0.76	12.5	43.3	51.4	35.1
3	5.71	0.01	9.7	46.5	55.9	37.2
4	4.75	0.00	10.5	49.7	60	39.4
5	3.88	0.00	9.2	54.8	66.1	43.4
6	2.58	0.00	8.2	60.4	72.5	48.3
7	0.86	0.00	4.0	65	79.4	50.5
8	1.19	0.00	4.0	65.1	80.1	50.2
9	2.08	0.00	5.4	60.3	74.3	46.4
10	3.91	0.00	8.8	53.2	64.8	41.5
11	8.25	0.05	17.9	45.5	52.9	38.2
12	7.97	0.32	17.8	40.7	47.1	34.2
Annual	54.37	1.59		52		

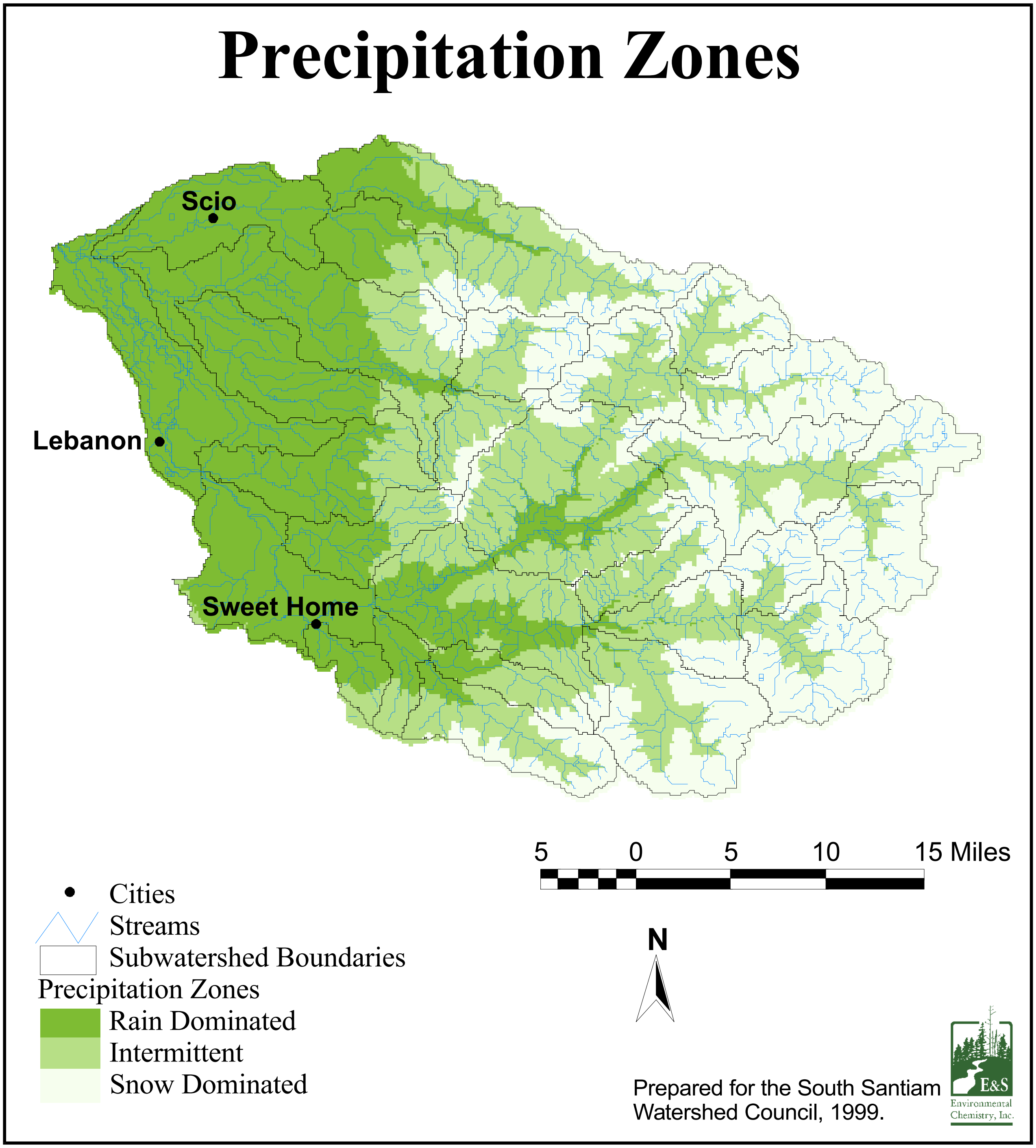


Figure 7.1. Precipitation zones showing rain, intermittent, and snow zones in the South Santiam watershed.

to 0.76 inches. Much of this snowfall is transient due to the elevation of the monitoring station, increasing the potential for rain-on-snow events. Mean monthly temperatures ranged from 40.2 F in January to 65.1 F in August with an annual mean of 52°F.

Climate at the Lacomb monitoring site was similar, with a mean annual precipitation of 57 inches for the period of 1973 to 1990 (Table 7.3). Mean annual snowfall is approximately 3 inches, representing less than 1% of total annual precipitation. Snowfall occurs during the period of November through February, representing the period with the greatest potential for rain-on-snow events. Mean monthly temperatures ranged from a monthly low of 31°F in January and a monthly high of 79°F in August with an annual mean of 51°F. The largest amount of precipitation occurred from October through May representing 79% of the total annual precipitation.

Table 7.3. Precipitation, snowfall, and temperature measured at Lacomb from 1973 to 1990.

Month	Mean Precipitation (in)	Mean Snowfall (in)	Maximum Precipitation (in)	Mean Temperature (°C)	Maximum Monthly Temperature (°C)	Minimum Monthly Temperature (°C)
1	6.97	0.79	12.3	39.0	46.1	31.9
2	6.33	1.21	15.2	42.0	50.4	33.7
3	5.98	0.00	10.7	45.8	55.6	36.0
4	4.98	0.00	10.7	49.4	60.4	38.5
5	4.04	0.00	9.3	54.2	65.9	42.5
6	2.87	0.00	7.0	59.8	72.1	47.4
7	1.15	0.00	5.0	64.0	78.0	49.9
8	1.32	0.00	5.4	64.3	79.1	49.5
9	2.15	0.00	5.5	60.2	74.7	45.6
10	4.42	0.00	9.3	52.4	64.3	40.5
11	8.83	0.18	19.1	44.3	51.9	36.7
12	8.45	0.59	19.4	39.7	46.1	33.3
Annual	57.48	2.77		51.2		

General weather patterns in the lower South Santiam watersheds are characterized by cool wet winters and warm dry summers. Due to the elevation changes in the watersheds, there are rain dominated lowlands moving to snow dominated highlands, and a large portion of the watersheds resides in the rain-on-snow and transient snow zones (Figure 7.1). Precipitation patterns vary largely with elevation changes and this pattern has been characterized by the PRISM model (Daly, 1994). Figure 7.2 shows the precipitation patterns for the lower South Santiam watersheds.

7.3 Snowfall

Two SNOTEL stations are located within the South Santiam Watershed, both of which are situated at approximately 3,500 feet in elevation. Typically, snow melt begins in May and continues through late June and early July (Figure 7.3). Snow water equivalents range from 10 to 30 cm, varying significantly between 1994 and 1998. During late winter and early spring, snow water equivalents increase and decrease suggesting significant snow melt events often followed by accumulation. These data demonstrate the importance of both rain on snow events and snow melt events in the hydrologic characteristics of the South Santiam Watershed.

7.4 Hydrologic Characterization

Eight USGS gaging stations are found in the lower South Santiam watersheds (Table 7.4). The longest period of record is found at the Waterloo site, with a record ranging from 1925 to the present. The Foster Dam gaging site was installed with the construction of Green Peter and Foster Dams and has a period of from 1967 to the present. Gauging stations are periodically

Table 7.4. USGS gaging stations located in the lower South Santiam watersheds.

Station Number	Station Name	Period of Record	Drainage Area	Datum
14186700	South Santiam River At Foster, OR	1967-1972	493	521
14187200	South Santiam River Near Foster,OR	1972-1998	557	560
14187500	South Santiam River At Waterloo, OR	1925-1998	640	370
14188800	Thomas Creek Near Scio, OR	1963-1986	109	380
14187600	Lebanon Santiam Canal Near Lebanon, OR	1991-1998	--	--
14187000	Wiley Creek Near Foster, OR	1988-1998	51	716
14187100	Wiley Creek At Foster,OR	1973-1988	62	590
14188700	Crabtree Creek Near Crabtree, OR	1963-1969	111	280

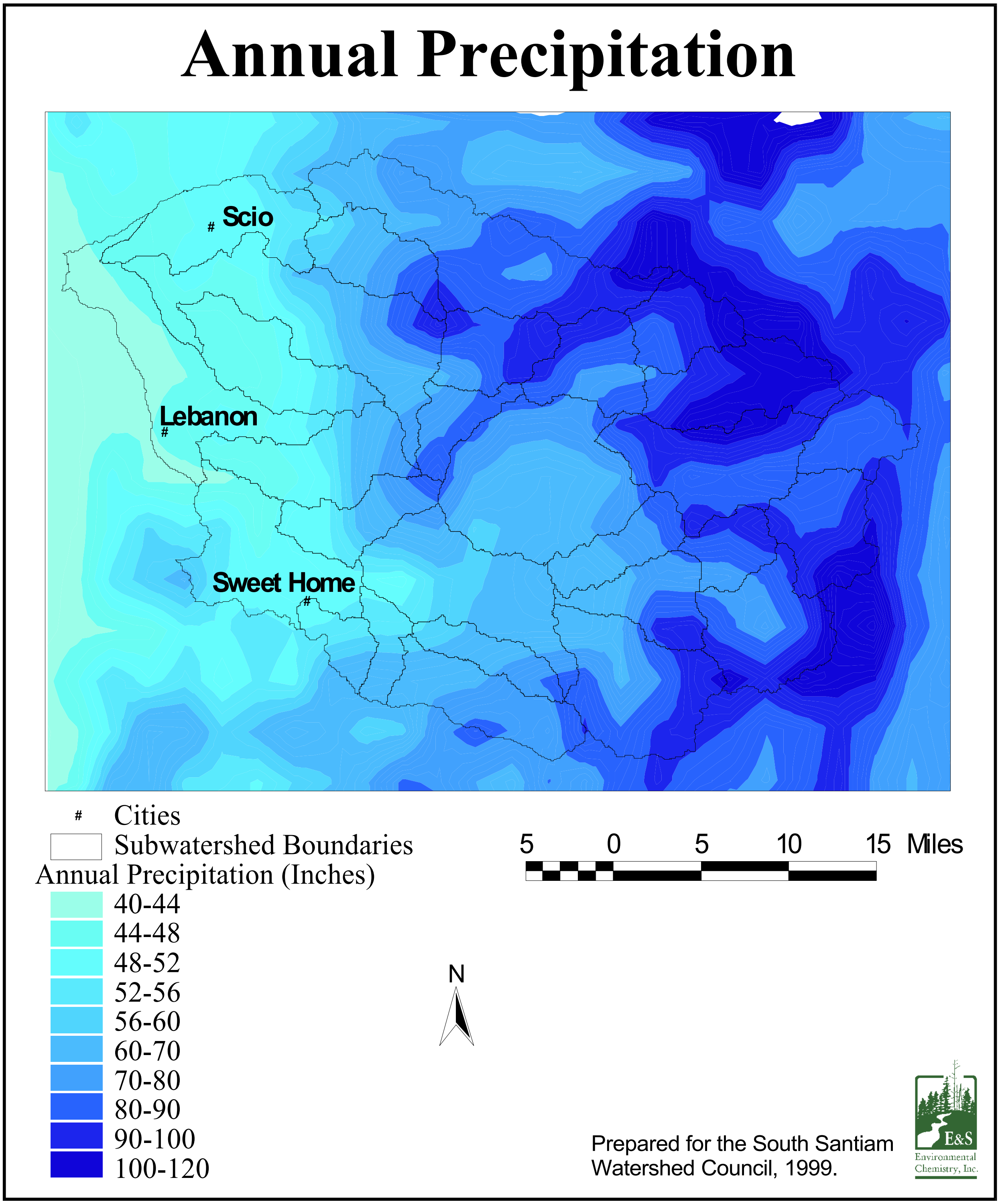
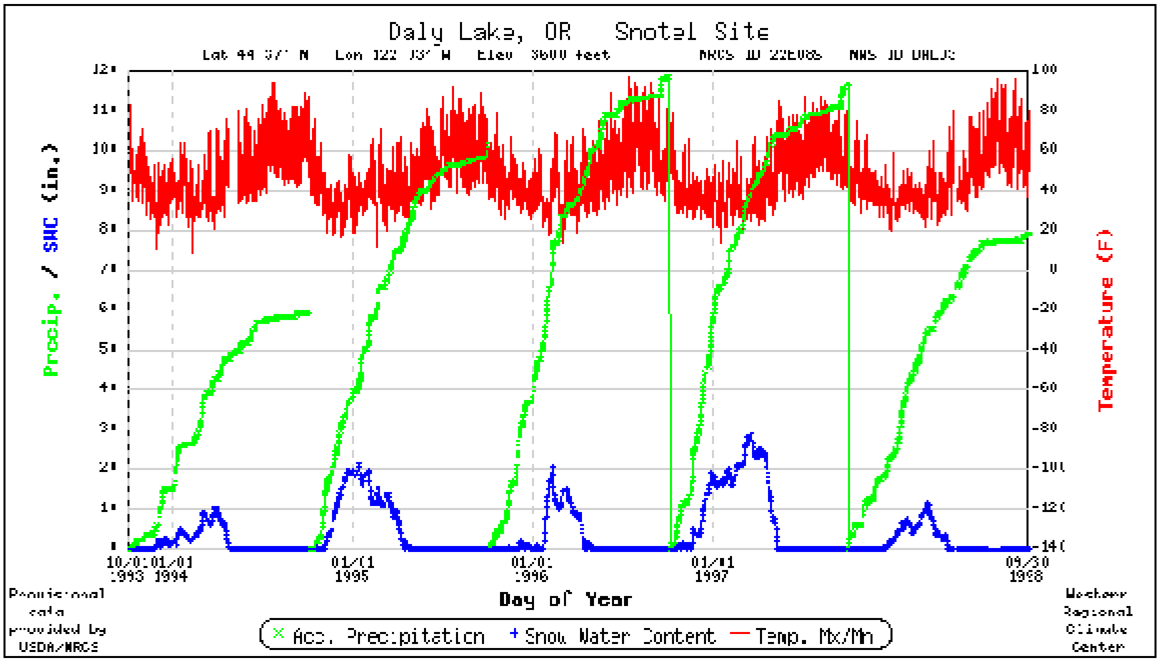


Figure 7.2. Precipitation gradients in the South Santiam watershed based on PRISM outputs (Daly et al. 1994).



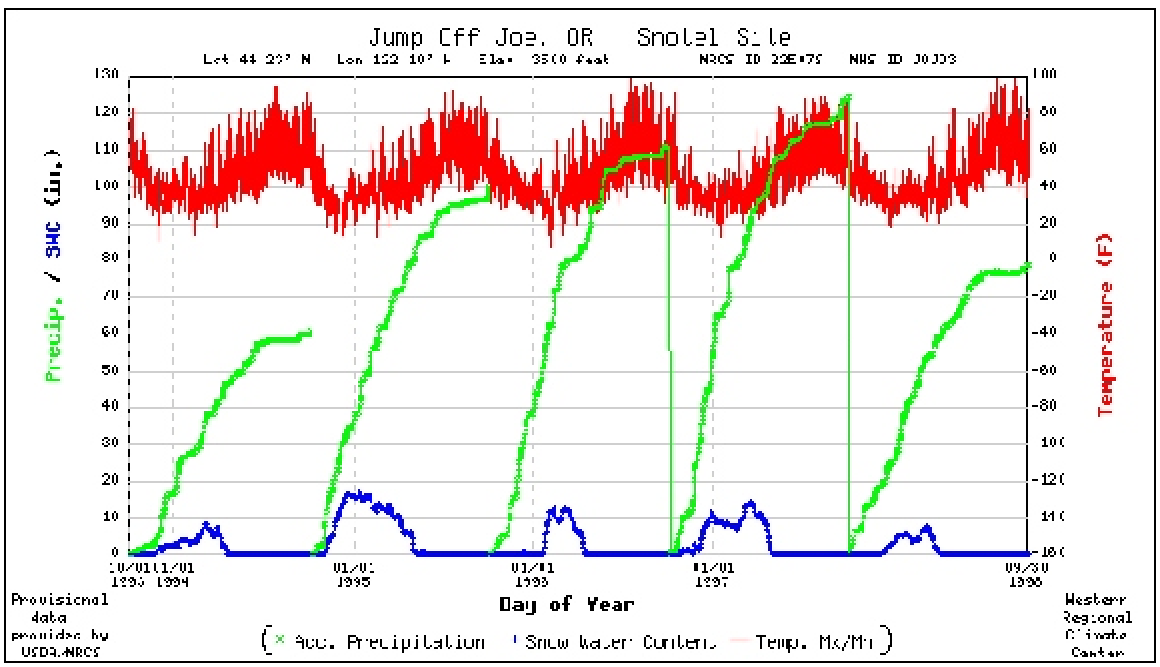


Figure 7.3. Precipitation, snow water equivalents, and temperature for the two SNOTEL stations in the South Santiam watershed.

moved a short distance, although they still characterize the same watershed. This was the case at the Foster gaging station where the equipment was moved a short distance downstream. Monitoring of the Lebanon-Santiam canal began in 1991, maintaining a continuous record to the present. Wiley Creek has been monitored from 1963 to the present. Neither Crabtree Creek nor Thomas Creek are currently being gauged, although they were gauged in the past for the periods of 1963 to 1969 and 1963 to 1986 respectively.

7.4.1 Mainstem South Santiam

Although there are three stations in the mainstem South Santiam River (Waterloo, at Foster, near Foster), only the Waterloo station will be presented here. All of the records were found to be in agreement and data from the other two stations will be included in the appendix (Appendix A). Located about midway between Foster Dam and the confluence of the South Santiam and North Santiam Rivers, the Waterloo site has the longest period of record, starting around 1925 (Table 7.5). Hydrologic data for the South Santiam River at Waterloo has been divided into two periods representing pre and post dam time series (Tables 7.5 and 7.6).

Table 7.5. Streamflow statistics for the South Santiam River at Waterloo for 1925-1965. These statistics represent stream flows prior to the construction of Foster Dam.

Month	Mean Flow (cfs)	Volume (acre feet)	Percent Runoff	Maximum Flow (cfs)	Minimum Flow (cfs)
1	5,047	309,802	15	12,223	898
2	5,277	292,579	14	12,068	1,525
3	4,421	271,331	13	10,528	1,212
4	4,077	242,177	12	7,935	1,056
5	3,018	185,272	9	5,875	862
6	1,693	100,577	5	5,906	437
7	546	33,524	2	1,214	176
8	260	15,952	1	385	126
9	319	18,968	1	1,118	144
10	1,158	71,063	3	4,898	143
11	3,921	232,889	11	9,706	111
12	5,282	324,213	15	15,465	1,068
		2,098,347	100		

Table 7.6. Streamflow statistics for the South Santiam River at Waterloo for 1996-1998. These statistics represent stream flows after the construction of Foster Dam.

Month	Mean Flow (cfs)	Volume (acre feet)	Percent Runoff	Maximum Flow (cfs)	Minimum Flow (cfs)
1	5,536	339,776	16	9,194	713
2	3,917	217,148	10	10,430	597
3	3,180	195,176	9	9,649	865
4	2,956	175,571	8	6,529	1,059
5	2,334	143,249	7	4,148	792
6	1,596	94,785	4	4,300	616
7	786	48,214	2	1,527	470
8	790	48,460	2	1,239	475
9	1,376	81,740	4	2,769	473
10	2,124	130,388	6	5,530	852
11	4,751	282,234	13	9,509	827
12	6,374	391,217	18	12,908	1,126
		2,147,958	100		

Winter mean flows were higher prior to the construction of Foster and Green Peter Dams, ranging from 5,282 cfs to 4,421 cfs. After construction of the dams, winter flows were reduced ranging from 6,374 to 3,180 cfs (Tables 7.5 to 7.6). For example, mean flow in February prior to the construction of the dams was 5,277 cfs which was reduced to 3,917 cfs as a result of dam regulation. Conversely, summer mean flows show an increase as a result of dam regulation. Prior to the installation of the dams summer mean flows ranged from 319 cfs to 546 cfs. After construction of the dams, flows were increased to range of 786 cfs to 1,376 cfs (Tables 7.5 and 7.6).

Historically, the South Santiam River flooded frequently as can be seen in the peak flow history in relation to flood stage (24,700 cfs) at the Waterloo gaging station (Figure 7.4). Many of these floods were most likely associated with large precipitation events, however many of the events may be a result of rain-on-snow events. Annual peak flows in the mainstem South Santiam River were reduced significantly with the construction of Green Peter and Foster Dams (Figure 7.4). Before the construction of the dams, the majority of annual peak flows ranged from 20,000 cfs to almost 80,000 cfs and were an almost annual occurrence. To put this in perspective, the floods of 1996 reached approximately 26,000 cfs and represents the only

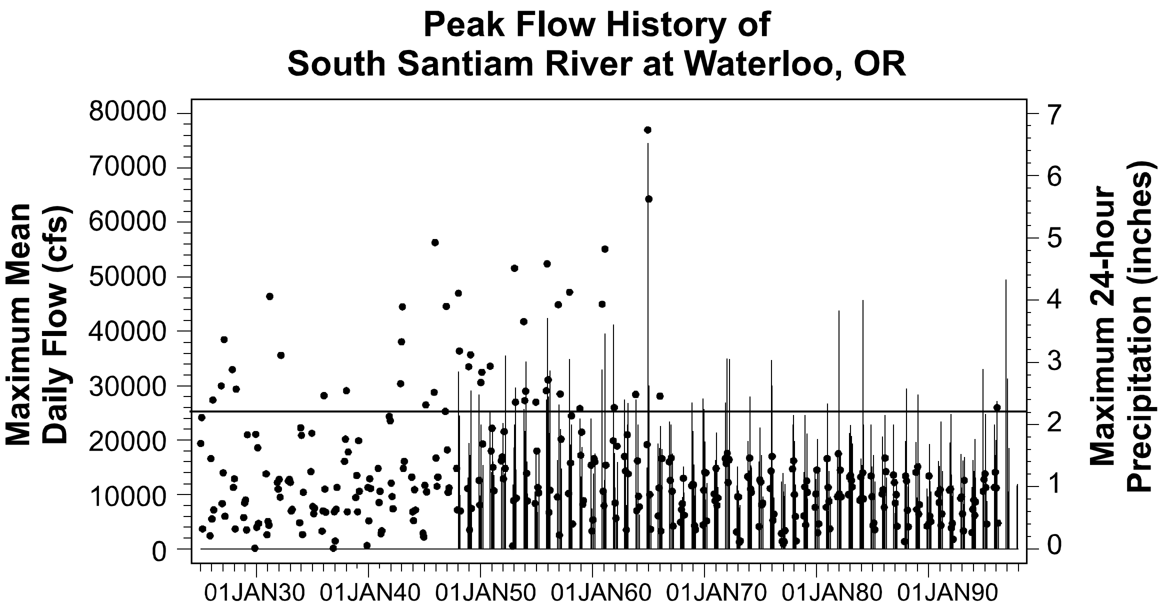


Figure 7.4. Peak mean daily flows (cfs) for the winter high flow period (November-March) for the South Santiam River measured at the Waterloo gaging station. The solid horizontal line represents discharges at floodstage. Precipitation data was collected at the Foster station. (Bars = maximum 24-hr precipitation; C = maximum mean daily flow)

significant flooding event since the construction of the dams. Large rain events have continued to occur since the construction of the dams, although the floods have not been generated due to the mitigating effects of the dam.

Minimum flows for the low flow period on the mainstem South Santiam River are shown in Figure 7.5. Since the construction of Foster Dam and Green Peter Dam, low flows have been regulated to meet instream water needs. Low flows were typically below 200 cfs before the construction of the dams (Figure 7.5). After construction of the dams, low flows have been maintained between 500 cfs and 800 cfs. With the regulated release of water, low flows can be adjusted to mitigate the effects of water withdrawal on fish in the mainstem South Santiam River below Foster Dam. However, it is important to note that low flows cannot be regulated on the tributaries such as Hamilton, McDowell, and Ames Creeks and consequently may still have potential instream effects of dewatering. Also, there is some concern that cold water releases may alter the life history of spring chinook.

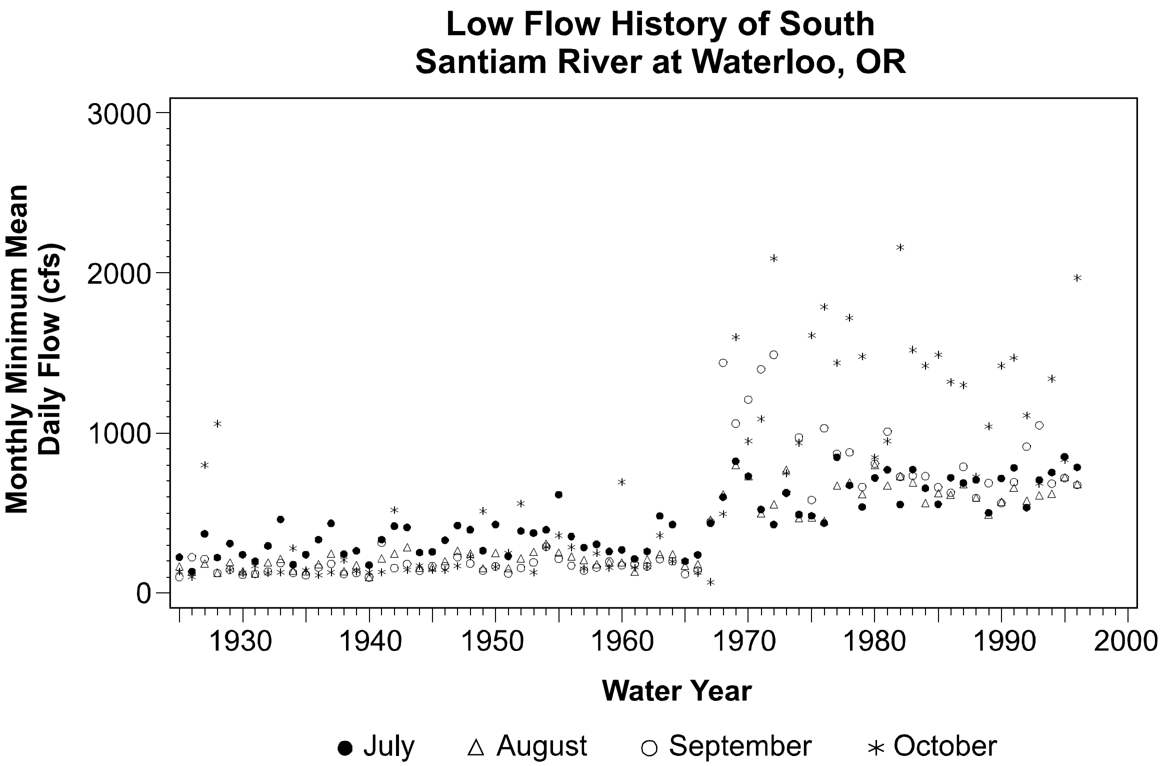


Figure 7.5. Minimum mean daily flows (cfs) for the summer low flow period (July-October) for the South Santiam River measured at the Waterloo gaging station.

7.4.2 <u>Crabtree Creek</u>

Table 7.7 presents the hydrologic characterization of the Crabtree Creek watershed for the period of 1963 to 1969. The characterization of Crabtree Creek flows holds true only for the period of record in which the gaging station was maintained. However, it is our assumption that no significant change has occurred in the watershed and that this characterization is probably similar to today. The largest percentage of runoff occurs during the period of November through March representing 73% of the annual runoff. Mean monthly flows range from 62 to 1,269 cfs with a mean monthly low of 18 cfs in August and a mean monthly maximum of 1,994 cfs in December.

Due to the short period of record for this station, low flow and peak flow histories will not be presented here. Data for this short period of time will not be sufficient to characterize low flows and peak flows and would most likely misrepresent the hydrology of Crabtree Creek.

Table 7.7. Streamflow statistics for Crabtree Creek near Crabtree gaging station for the period 1963 to 1969.

Month	Mean Flow (cfs)	Volume (acrefeet)	Percent Runoff	Maximum Flow (cfs)	Minimum Flow (cfs)
1	1,269	77,875	24	1,682	752
2	671	37,217	11	1,078	406
3	546	33,485	10	839	289
4	453	26,890	8	622	306
5	353	21,639	7	463	210
6	212	12,570	4	431	96
7	85	5,238	2	208	31
8	62	3,812	1	198	18
9	78	4,639	1	275	27
10	217	13,326	4	591	65
11	585	34,748	11	999	269
12	930	57,090	17	1,994	407
Annual	455	328,531	100		

7.4.3 Thomas Creek

The characterization of Thomas Creek flows holds true only for the period of record in which the gaging station was maintained. However, it is our assumption that no significant change has occurred in the watershed and that this characterization is probably similar to today. Annual mean monthly discharge of Thomas Creek at the USGS station near Scio, OR is 497 cfs with a monthly maximum of 1,091 cfs occurring in December and a monthly minimum of 43 cfs occurring in August (Table 7.8). The minimum mean daily flow for the period of record was 14 cfs and a maximum mean daily flow of 2,310 cfs. Nearly 74% of the annual discharge occurs from November through March.

Peak flows for the period of 1963 to 1986 suggest that flooding was a frequent occurrence in the Thomas Creek watershed (Figure 7.6). The estimated discharge at flood stage for the Thomas Creek gaging station is 4,215 cfs. There is no apparent trend in increasing or decreasing flood frequency in the flooding history during this period. However it is important to note that these data only represent monthly extremes and a more detailed analysis of the data is necessary to better understand the flooding history of the watershed, particularly for identifying the effects

Table 7.8. Streamflow statistics for the Thomas Creek near Scio gaging station for the period 1963 - 1986.

Month	Mean Flow (cfs)	Volume (acrefeet)	Percent Runoff	Maximum Flow (cfs)	Minimum Flow (cfs)
1	1,064	65,333	18	1,836	144
2	866	48,009	13	1,666	176
3	711	43,662	12	1,504	245
4	560	33,251	9	888	298
5	379	23,248	6	744	168
6	205	12,183	3	682	74
7	80	4,884	1	407	30
8	43	2,620	1	203	14
9	67	3,986	1	251	18
10	177	10,871	3	633	25
11	726	43,131	12	1,898	128
12	1,091	66,947	19	2,310	104
	497	358,124	100		

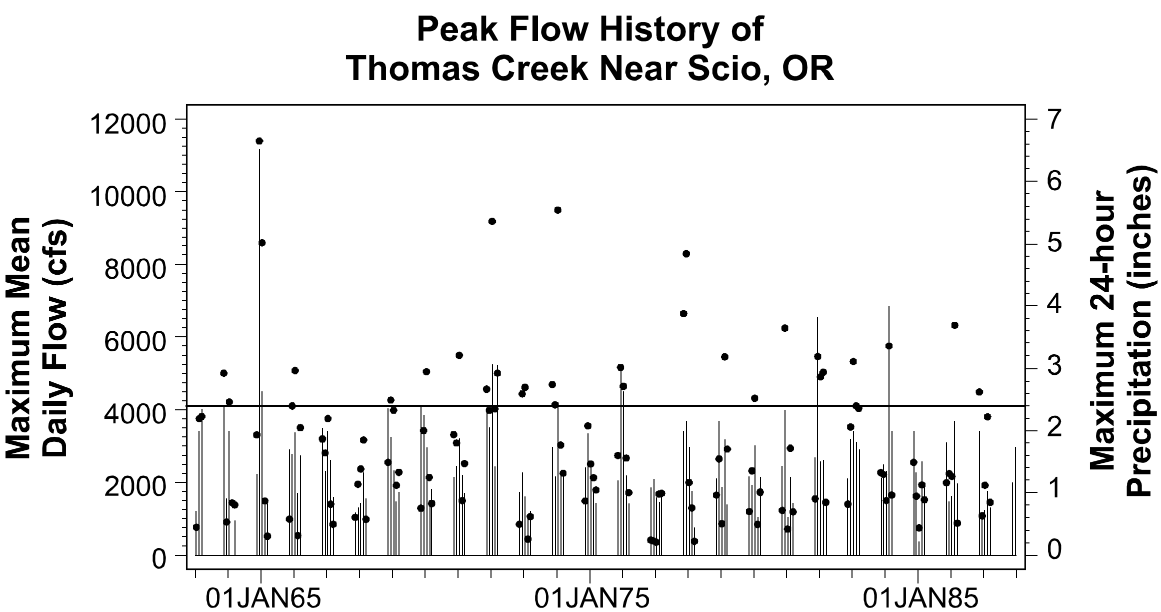


Figure 7.6. Peak mean daily flow (cfs) for the winter high flow period (November-March) for the Thomas Creek gaging station near Scio, OR. The solid horizontal line represents discharge at floodstage. Precipitation data was collected at the Scio station. (Bars = maximum 24-hr precipitation; C = maximum mean daily flow)

of changes in land use practices. These data are only useful in screening for gross changes in the hydrology of the watershed, for example the effects of the construction of a dam or dikes that increase flood frequency and magnitude. However, it does not appear that any gross changes in the hydrology of the Thomas Creek watershed are detectable during the 23 year period of record.

Mean daily flows in Thomas Creek fall below 15 cfs almost annually and typically occur in the months of August and September (Figure 7.7). Mean monthly low flows are 43 and 67 cfs for the months of August and September with monthly mean values being as low as 14 cfs and 18 cfs in extremely dry years. Low flows have never gone below the 10 cfs during the period of record. There is no apparent pattern in the low flow history of Thomas Creek other than natural variation.

7.4.4 Wiley Creek

Wiley Creek flows are characterized for the Wiley Creek USGS station at Foster. Although there was a USGS gage for Wiley Creek providing a period of record before this station, the two

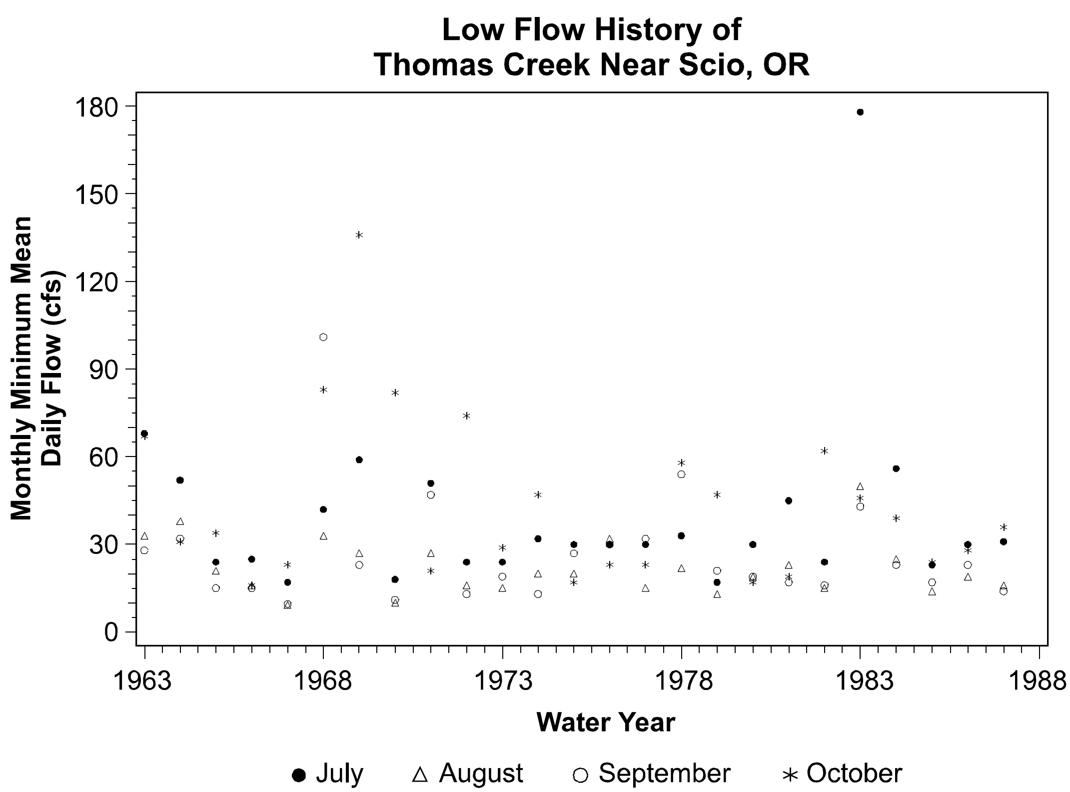


Figure 7.7. Minimum mean daily flow (cfs) for the summer low flow period (July-October) for the Thomas Creek gaging station near Scio.

were found to be in agreement and therefore only the most recent station will be presented here. The other USGS station will be included in the Appendix (Appendix A). Annual mean monthly discharge for Wiley Creek is 184 cfs with a monthly minimum of 10 cfs in September and a monthly maximum of 348 in January (Table 7.9). The greatest amount of discharge occurs in November through April, comprising approximately 81% of the annual discharge.

Flood stage was estimated at 1,716 cfs for the Wiley Creek near Foster station. Historically, flooding was an almost annual event in the Wiley Creek watershed, however flooding has occurred only twice this decade (Figure 7.8). The largest 24 hour precipitation event occurred in November of 1996 but did not result in a flood event suggesting that the February 1996 flooding event may have been caused by a rain-on-snow event or a persistent rain. There is not enough information to discern the cause of the recent lack of floods but it is most likely attributed to natural variations in wet and dry cycles.

Mean monthly flows have been as low as 4 and 5 cfs for the months of August and September respectively (Table 7.9). Discharge below 6 cfs is common during the months of August through October, with mean daily discharge as low as 2 cfs which occurred in 1992, an extremely dry year (Figure 7.9). Flows less than 6 cfs are a common occurrence.

Table 7.9. Streamflow statistics for the Wiley Creek at Foster gaging station for the period of 1993 to 1998.

Month	Mean Flow (cfs)	Volume (acre feet)	Percent Runoff	Maximum Flow (cfs)	Minimum Flow (cfs)
1	348	21,361	16	507	155
2	346	19,156	14	839	161
3	309	18,969	14	614	85
4	287	17,076	13	488	210
5	190	11,680	9	334	65
6	107	6,366	5	286	20
7	28	1,712	1	58	12
8	14	844	1	23	4
9	10	597	0	16	5
10	33	2,033	2	73	8
11	248	14,746	11	401	17
12	289	17,728	13	574	131
Annual	184	132,268	100		

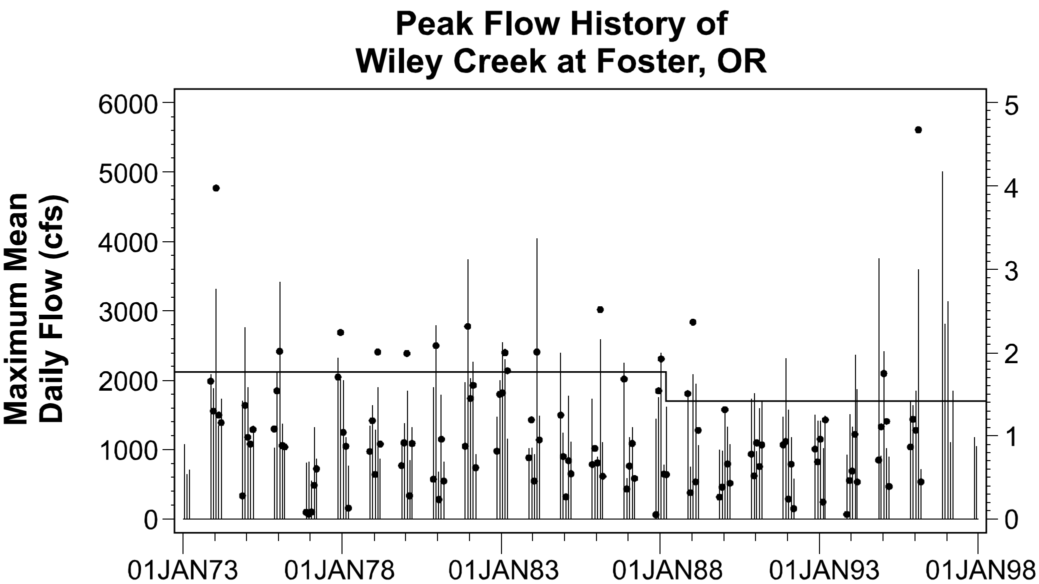


Figure 7.8. Peak mean daily flows (cfs) for the winter high flow period (November-March) for the Wiley Creek at Foster gaging station. The solid horizontal line represents discharge at floodstage. The shift in the solid line represents a change in flood stage due to moving the gage a short distance. (Bars = maximum 24-hr precipitation; C = maximum mean daily flow)

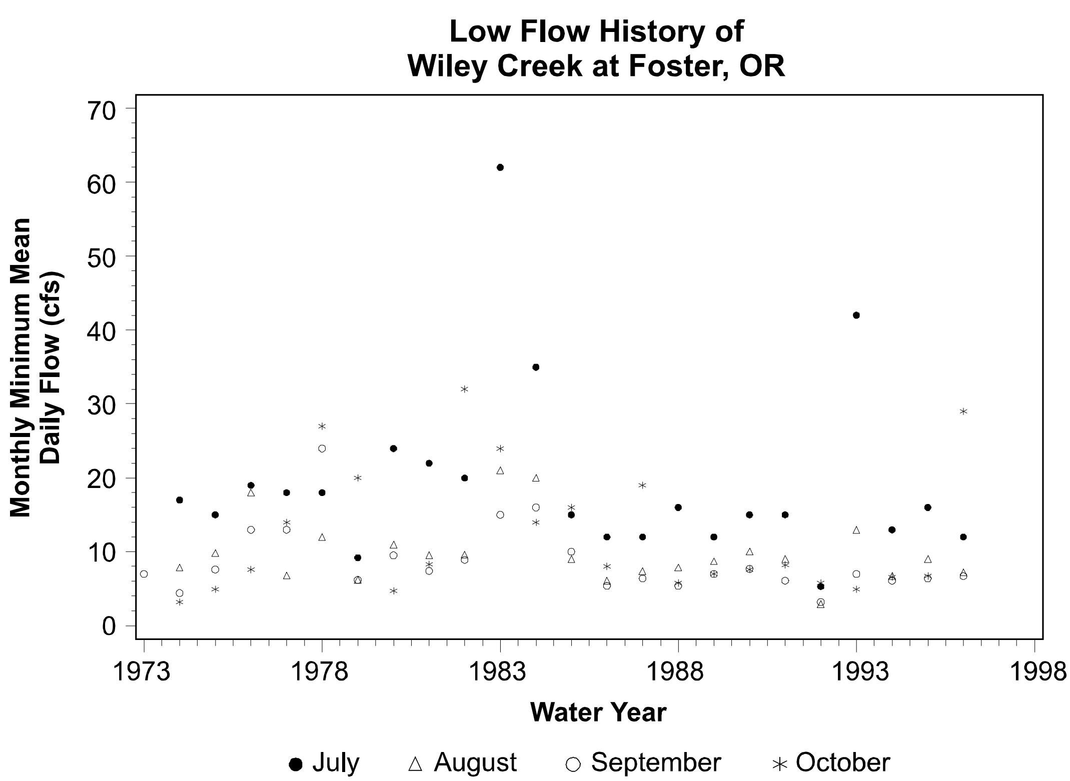


Figure 7.9. Minimum mean daily flows (cfs) for the summer low flow period (July-October) for the Wiley Creek at Foster gaging station.

7.5 Hydrologic Issues and Associated Land Use

Due to the controlled nature of flows, it is difficult to determine land use impacts on the hydrology of the mainstem South Santiam River. Conversely, changes in land use and their associated impacts will have less effects on some stream characteristics due to mitigation of these effects associated with controlled dam release. Mitigation of this sort can have large impacts on stream structure and associated riparian areas, including encroachment of the flood plain by urban, suburban and rural boundaries now that floods can be mitigated. Floods are a natural disturbance that helps to shape stream ecosystems and help maintain the dynamic nature of streams. Stream structures may change with the removal of large flood events that can bring in large woody debris from the flood plains, scour out silt deposits and redeposit gravel important to spawning, as well as other geomorphologic changes associated with episodic flood events.

However, some simple quantification and rankings of watershed level data can give us some insight into potential issues in the lower South Santiam watershed.

7.5.1 Forestry Issues

Peak flows occur in the winter in the South Santiam watershed, suggesting that rain-on-snow events are a likely occurrence. Consequently, the proportion of the watershed that is in the rain-on-snow zone and is managed for timber harvest can give some insight on the potential for increases in peak flows as a result of rain-on-snow events. Quantification of clear cutting activities would further develop this analysis, however this data was not available. Watersheds were characterized by the percentage of forested areas and the proportion of the watershed that is in the rain-on-snow zone and forested (Table 7.10). The headwaters of Crabtree (North Fork and South Fork), Wiley (Little Wiley and South Fork), and Thomas (Upper Thomas) Creeks had the greatest proportion of forested areas in the rain-on-snow zone. These watersheds show the greatest potential for increased peak flows as a result of rain-on-snow events. McDowell Creek, Neal Creek, and the lower sections of Wiley exhibit a moderate proportion of the watershed in the rain-on-snow (32%-36%). The lower elevation watersheds are predominantly agriculture and in the rain dominated zone, however their hydrology will be affected by activities in the headwaters. Consequently, both Crabtree and Thomas Creeks have a large potential for increased peak flows as a result of rain-on-snow events. The Mainstem South Santiam

Table 7.10. Percent of subwatersheds that are forested and in the rain-on-snow zone.

Subwatershed	Percent Subwatershed Forested	Percent of Subwatershed Forested and in the Rain-on-Snow Zone
SF Crabtree Cr.	100	70
SF Wiley Cr.	100	58
Little Wiley Cr.	95	56
NF Crabtree Cr.	100	50
Upper Thomas Cr.	89	49
McDowell Cr.	93	36
Wiley Cr.	92	34
Neal Cr.	86	32
Lower Crabtree Cr.	64	25
Hamilton Cr.	77	23
Ames Cr.	82	21
Beaver Cr.	39	2
Noble Cr.	50	2
Lower South Santiam River	50	0
Lower Thomas Cr.	26	0

watershed is regulated by controlled releases from Foster Dam resulting in mitigation of peak flows.

Forest roads can significantly increase peak flows if a watershed has a road density of greater than 12% (Harr et al. 1975). Forest Road densities were quantified for the lower South Santiam watersheds (Table 7.11). None of the watersheds had a forest road density of greater than 4% based on an average road width of 24 feet.

Table 7.11. Forest road summary in the lower South Santiam watersheds.

Subwatershed	Area (acres)	Area Forested (%)	Miles of Forestry Roads*	Road Area** (acres)	Road Density (%)	Miles of Forestry Roads per Square Mile
SF Crabtree Cr.	10,448	100	130	378	3.7	7.96
McDowell Cr.	15,387	93	165	481	3.13	7.38
NF Crabtree Cr.	16,417	100	170	496	3.0	6.63
Upper Thomas Cr.	49,174	89	441	1238	2.61	6.45
Neal Cr.	17,565	86	135	393	2.24	5.72
Hamilton Cr.	25,782	77	172	499	1.94	5.55
Noble Cr.	32,109	50	183	531	1.65	7.30
Beaver Cr.	24,236	39	122	354	1.46	8.26
Lower Crabtree Cr.	48,756	64	275	802	<1	5.64
Lower Thomas Cr.	25,708	26	80	233	1	7.66
Lower South Santiam River	37,749	50	86	250	<1	2.92
Ames Cr.***	7,601	82	26	76	1	2.67
Wiley Cr.***	7,421	92	24	70	1	2.25
South Fork Wiley Cr.***	22,241	100	70	204	<1	2.01
Little Wiley Cr.***	10,914	95	32	93	<1	1.98

* Road area was calculated based on a road width of 24 ft.
** Forestry roads are defined as all roads in the forestry land use zones.
*** Due to the spatial extent of roads coverages, a more general coverage was used for road data in these watersheds.

7.5.2 Agricultural Issues

Land management practices, such as draining fields for agricultural use can impact peak flows, however, it is a rather difficult process to quantify these effects. The Oregon Watershed Assessment Manual suggests ranking the watersheds by the percent of land that has been recently converted to agriculture. Agricultural practices have dominated the lower portions of the South Santiam watershed since the turn of the century making discerning the effects of agriculture on the hydrology of the watershed very difficult. Complicating the issue, the South Santiam River historically flooded almost annually. The greatest potential for impacts to the hydrology of the

South Santiam watershed by agriculture is the removal of wetlands and disconnection of the floodplain. These issues will not be addressed here because it is beyond the scope of the assessment. However, it is important to note that quantifying the loss of wetlands and floodplain areas will greatly increase our understanding of the current state of the lower South Santiam watersheds' hydrology.

7.5.3 Urban Issues

Urban areas can impact the hydrology of a watershed by reducing the infiltration of water through the construction of impervious surfaces (i.e., streets, parking lots). This results in increased surface runoff which can ultimately increase and change the timing of peak flows. Impervious areas were estimated for the lower South Santiam watersheds where there were significant proportions of urban and rural residential areas (Table 7.12).

Table 7.12. Estimated percentage of subwatersheds that are impervious surfaces (i.e., paved roads, parking lots). Only subwatersheds with urban and rural residential areas are presented.

Subwatershed	% of Subwatershed Urban*	% of Subwatershed Rural Residential**	% of Subwatershed with Impervious Surface
Ames Cr.	10	4	11
Noble Cr.	8	9	10
Lower S. Santiam	7	4	7
Wiley Cr.	3	4	4
Lower Thomas Cr.	1	2	<1
Beaver Cr.	0	4	<1
Lower Crabtree Cr.	0	2	<1
Hamilton Cr.	0	1	<1

* Urban areas were assumed to be 85% impervious surfaces.
** Rural Residential areas were assumed to be 38% impervious surfaces.

Only Ames Creek, Noble Creek, and the lower South Santiam watersheds had significant proportions of their watersheds in urban and rural residential areas as a result of the cities of Sweet Home and Lebanon. Consequently, these watersheds have the greatest potential for increased peak flows as a result of impervious surfaces.

7.6 Water Rights

Water rights and water use were examined for each of the water availability watersheds (watersheds as defined by the Oregon Water Resources Department for the assessment of flow modification), as well as the watersheds delineated for this assessment. Instream water rights were established for the protection of fisheries, aquatic life, and pollution abatement, however many remain junior to most water rights in these watersheds (Table 7.13).

Table 7.13. Instream water rights in the lower South Santiam watersheds.

Stream	Priority	Purpose	Location
South Santiam	6-22-64	Aquatic Life	Above Waterloo
McDowell Cr.	11-3-83	Aquatic Life/Pollution Abatement	McDowell at mouth
Crabtree Cr.	11-3-83	Aquatic Life/Pollution Abatement	Crabtree at mouth
Hamilton Cr.	11-3-83	Aquatic Life/Pollution Abatement	Hamilton at mouth
Thomas Cr.	11-3-83	Aquatic Life/Pollution Abatement	Thomas at mouth
Wiley Cr.	6-22-64	Aquatic Life	River Mile 0 to 1
Little Wiley Cr.	10-18-90	Anadromous and Resident Fish Rearing	River Mile 0 to 8
Neal Cr.	10-18-90	Anadromous and Resident Fish Rearing	River Mile 0 to 6
Wiley Cr.	10-18-90	Anadromous and Resident Fish Rearing	River Mile 0 to 5
Ames Cr.	4-5-93	Fish Habitat (resident)	River Mile 0 to 3

7.7 Consumptive Water Use

The Lower South Santiam subwatershed was combined with the Foster Reservoir watershed since much of the water withdrawals in the lower South Santiam River can be mitigated by storage and controlled release of water from the Foster Reservoir. Consequently, effects of water withdrawals on the mainstem South Santiam River below the Foster Reservoir will be minimal when considering dewatering because scheduled water releases can mitigate the withdrawal effects. This is true for the mainstem South Santiam only. Many of the tributaries (i.e., Thomas, Crabtree, Hamilton) are seriously dewatered in dry years. Essentially, the Foster Reservoir acts as a storage tank for downstream users. There still may be screening issues for the points of diversion.

7.7.1 Irrigation

By far, the greatest amount of water is appropriated for irrigation purposes (Table 7.14), with the greatest concentration occurring in the lower elevations of the watershed, including Thomas Creek, Crabtree Creek and the Mainstem South Santiam watersheds (Figure 7.10). Irrigation withdrawals have the greatest potential to affect instream conditions during the low flow months (June through October), since this is when the greatest amount of irrigation occurs. Water withdrawals from the mainstem South Santiam River for the purposes of irrigation have the least potential to affect instream conditions due the controlled releases from Foster Dam. However, withdrawals from the tributaries still have a large potential for dewatering, especially during the low flow months where irrigation withdrawals are the greatest. Due to the lack of controlled releases, Crabtree and Thomas Creeks have a high potential to be dewatered as a result of large appropriations for irrigation (approximately 125 cfs for each) during the low flow months where flows range from 62 cfs to 217 cfs and 43 cfs to 205 cfs, respectively (Tables 7.7 and 7.8). It is important to note that there are monthly and volume restrictions placed on many of these water rights which are not addressed here. To further evaluate the potential to dewater these streams, these restrictions would need to be taken into consideration.

7.7.2 Municipal and Domestic Water Supply

Public water supply accounts for approximately 10% of consumptive water use in the lower South Santiam watersheds (Table 7.14), supplying the cities of Sweet Home, Waterloo, Lebanon, and Scio as well as the rural residential areas associated with these cities. Three of these cities (Albany, Lebanon, and Sweet Home) are in the top 50 of Oregon's largest cities, all of which are supplied water by the South Santiam River. The largest withdrawal for Municipal use occurs on the mainstem South Santiam River which feeds water to the cities of Lebanon and Albany via the

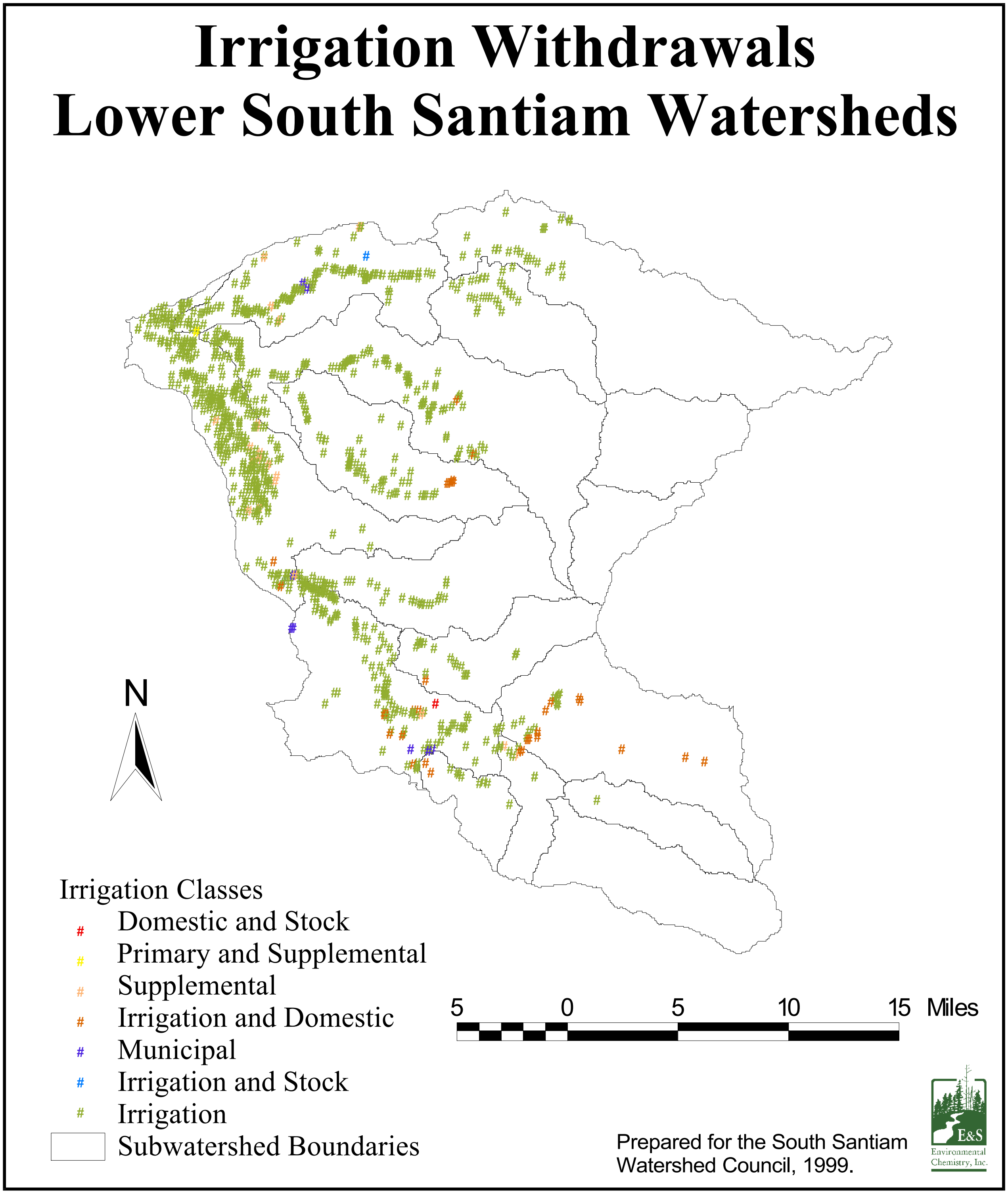


Figure 7.10. Irrigation withdrawals in the lower South Santiam watersheds.

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7.10. Irrigation withdrawals in the lower South Santiam watersheds.

Lebanon-Santiam Canal. The Lebanon Santiam Canal represents an interbasin transfer, transporting water from the Lower South Santiam subwatershed to the City of Albany and eventually into the Willamette River. Interbasin transfers have the potential to dewater downstream reaches by removing water from the watershed and any chance that the water may have of returning to that watershed. Withdrawals range from 42 to 152 cfs with the greatest amounts of withdrawal occurring during the summer low flow period (Table 7.15). However, dewatering in the mainstem South Santiam River can be mitigated by storage and controlled releases from the Foster and Green Peter Reservoirs. These mitigating effects can be seen in the low flow history at the Waterloo USGS gauge (Figure 7.5) where low flows are consistently higher since the construction of the dams.

Table 7.15. Streamflow statistics for the Lebanon Santiam Canal near Lebanon for 1991-1998.

Month	Mean Flow (cfs)	Volume (acrefeet)	Percent Runoff	Maximum Flow (cfs)	Minimum Flow (cfs)
1	70	4,325	6	86	46
2	84	4,655	7	134	50
3	95	5,845	8	156	60
4	99	5,858	8	147	48
5	97	5,959	8	127	50
6	116	6,896	10	152	66
7	125	7,670	11	148	91
8	126	7,712	11	145	100
9	113	6,732	9	146	85
10	106	6,500	9	134	83
11	85	5,020	7	99	65
12	69	4,238	6	91	52
		71,410	100		

There are two other situations in the lower South Santiam watersheds where interbasin transfers occur, namely the Lacomb Ditch and Peters Ditch. The Lacomb Ditch diverts water for irrigation and removes water from the mainstem of Crabtree Creek diverting it to the Beaver Creek watershed. This water will not return to the mainstem of Crabtree Creek before the confluence of Crabtree and Beaver Creeks. Additionally, there have been reports that up to 75% of the withdrawn water is lost to evaporation and seepage before it ever reaches its end users

(Sue Gries pers. comm.). An additional concern is the method by which the water is withdrawn from the creek. During summer low flows, a push-up dam is used to back up water to flow into the ditch which presents fish passage problems as well as dewatering problems. Peters Ditch, which feeds water to the city of Scio, shows up on the map as an interbasin transfer, although there is some question about whether this is accurate. The ditch has the potential to remove water from the Thomas Creek watershed and transfer it to the Crabtree watershed, further dewatering an already over appropriated Thomas Creek. Amounts of withdrawals, and their effects on instream conditions in Crabtree and Thomas Creeks needs to be further investigated.

7.7.3 Industrial Water Supply

Water is appropriated for Industrial use in the Ames, Crabtree, Thomas and Lower South Santiam subwatershed. These types of uses typically represent pulp and paper operations, however the specific uses in these watersheds is unknown. Although many of the industrial uses are not consumptive, they can also degrade the water quality. For example, if water is removed for cooling and returned immediately to the stream, there may be little effect on dewatering but the use may be contributing to water temperature increases that are a widespread problem in the South Santiam watershed. These uses need to be further investigated to assess their potential impacts on instream conditions.

7.7.4 Other Consumptive Uses

There are small amounts of withdrawal for other water uses in the lower South Santiam watersheds which include livestock watering, fire protection, nursery use, and incorporated lawn and garden use. These represent a rather small proportion of water use in the watersheds, and therefore are of little concern for dewatering. There is one noticeable appropriation on the South Santiam River. There is 0.45 cfs of water appropriated for temperature control which has the potential to contribute to instream temperature increases. Further investigation of the water right is warranted.

7.8 Non-Consumptive Water Use

7.8.1 Hydropower

The second largest uses in the Foster and lower South Santiam watersheds are for irrigation and power generation at Foster Dam, operated by the Army Corps of Engineers (Table 7.14). Water is also appropriated for power generation in Crabtree Creek which is probably the power generated by the Lacomb Irrigation District. Almost 56 cfs is appropriated for power generation in Thomas Creek, however it has been reported that this power generation facility is no longer in service. Further investigation of the power generation in Thomas Creek is warranted.

7.8.2 Fish and Wildlife

Water is appropriated for both fish and wildlife in all of the lower South Santiam watersheds. The specific activity that this water is used for is not known at this time, however it is most likely used for the fish hatcheries and habitat.

Due to the controlled nature of flows below Foster Dam, the greatest potential for dewatering occurs in the tributaries below Foster Dam and those that feed Foster Reservoir as well as in Thomas and Crabtree Creeks.

7.9 Water Availability

There are ten water availability watersheds nested in the lower South Santiam watersheds, namely Hamilton Creek, McDowell Creek, Ames Creek, Neal Creek, Thomas Creek, Crabtree Creek, Wiley Creek, Little Wiley Creek, South Santiam River at Waterloo, and the South Santiam River at the mouth. The data for the mouth of the South Santiam is representative of the entire South Santiam watershed. Natural stream flows are based on a 30 year record. Consumptive use and storage is the modeled amount of withdrawn water that will not return to the stream. This value is then subtracted from the natural stream flow to calculate the stream flow after the consumptive use of water. To evaluate the potential for dewatering a stream, we have calculated the percent of the modeled instream flows at an 80% exceedance level that have been appropriated for consumptive use.

It is important to note that the entire South Santiam watershed (4^{th} field watershed) is limited by a downstream watershed (Santiam River @14189000) in the months of August and September. Downstream watersheds limit those upstream in that water must be input to the downstream watershed from the upstream watershed. Consequently, if a downstream watershed is already over appropriated by senior water rights, all upstream watersheds will not have water available for appropriation.

Table 7.16 shows the percent of natural stream flows (estimated at an 80% exceedance level) appropriated for consumptive use in the lower South Santiam water availability watersheds for the summer low flow periods. The Thomas and Neal Creek watersheds had the highest potential for dewatering with an average percent withdrawal of 40% and 41% respectively. The greatest amount of water use occurred in the months of June through September ranging from 18% to 74% of natural stream flows for the Thomas Creek watershed. Although there is a large withdrawal in June (~18%), instream water rights were still met suggesting that the effects on stream quality are minimal. Water availability in the Neal Creek watershed is similar to the rest of the Thomas Creek watershed in that greatest potential for dewatering occurs during the

Table 7.16. Dewatering potential in the lower South Santiam watersheds.

	Dewatering Potential*					Overall Dewatering Potential	
Water Availability Watershed	Jun	Jul	Aug	Sep	Oct	Average Percent Withdrawal	Potential
Neal Cr. @ mouth	16	46	68	49	25	41%	High
Thomas Cr. @ mouth	18	60	74	40	9	40%	High
Ames Cr. @ mouth	12	36	63	44	23	36%	High
Crabtree Cr. @ mouth	14	52	61	28	2	31%	High
Hamilton Cr. @ mouth	8	24	35	17	2	17%	Moderate
McDowell Cr. @ mouth	5	16	24	12	1	12%	Moderate
S. Santiam R. @ Waterloo	2	5	7	7	2	8%	Low
Wiley Cr. @ mouth	1	1	2	1	0	1%	Low
Little Wiley Cr. @ mouth	0	0	0	0	0	0%	Low

* percent of instream flows that are appropriated for consumptive use.

summer low flow months (June-September) with water withdrawals ranging from 16 to 68% of the natural stream flows (Table 7.16). There was also a large percentage appropriated in October, representing approximately 25% of the stream flows.

Two other watersheds ranked as having a high potential for dewatering are Ames Creek and Crabtree Creek. The greatest amount of water withdrawal in the Ames Creek watershed occurred during June through October with withdrawal amounts ranging from 12% to 63% of the natural stream flows (Table 7.16). The 63% withdrawal occurred in August, demonstrating a high potential for dewatering. The Crabtree Creek watershed has an average water withdrawal of 31%, and ranges from 2 to 61% during the months of June through October. The greatest potential for concern occurs in July and August where 52% and 61% of instream flows are appropriated for consumptive use.

The Hamilton and McDowell Creek watersheds both have a moderate potential for dewatering, with average appropriations of 12% and 17% of natural stream flows respectively. The greatest potential for dewatering in the Hamilton Creek watershed occurred in July through September with withdrawals removing approximately 2% to 35% of natural stream flows. However, based on modeled flows, instream water rights (established for fisheries) were met in September and almost met in August, resulting in July having the highest potential for affecting instream conditions as a result of dewatering in the Hamilton Creek watershed. McDowell Creek had the highest consumption in the July through August period, with approximately 1% to 24% of natural stream flows being withdrawn.

Dewatering is not a concern for Wiley Creek, Little Wiley Creek, and the mainstem South Santiam River. Very little water is appropriated in the two Wiley Creek watersheds resulting in little affect on natural stream flows. The mainstem South Santiam River is regulated by controlled water releases from Foster Dam, mitigating the effects of water withdrawals and resulting in a low dewatering potential. However, there is a large amount of water appropriated as consumptive use for the months of February through May (19% to 35% of natural stream flows; Appendix B). Much of this water is probably removed from the winter high flow period for storage. Although the withdrawals represent large percentages of the instream flows, there is probably little effect on the instream conditions since it occurs during the winter high flow periods. Additionally, instream water rights are easily met during this period of the year, even with these water withdrawals.

Withdrawals on Ames, Neal, Thomas, and Crabtree Creeks have a high potential to negatively affect fish habitat and instream conditions because large percentages of natural stream flows have been appropriated for consumptive use in the months of June through September. There is a moderate potential for dewatering in Hamilton and McDowell Creeks. Regulation of flows by Foster Reservoir releases can mitigate these effects in the mainstem South Santiam River resulting in dewatering potential only in the tributaries. Low flow data from the gaging station shows that after the construction of the dam, low flows have been regulated to meet the instream water rights established for the mainstem South Santiam at the Waterloo gaging station below Foster Dam (Figure 7.5).

SECTION V. UPPER SOUTH SANTIAM WATERSHEDS

CHAPTER 1. BACKGROUND

1.1 Climate and Topography

Four fifth field watersheds define what this project is calling the upper South Santiam watersheds including Foster Reservoir, South Santiam Headwaters, Middle Santiam, and Quartzville. The Foster Reservoir watershed includes the mainstem South Santiam River from just above Cascadia to Foster Reservoir, as well as the Middle Santiam River from Green Peter Reservoir to Foster Reservoir. The South Santiam Headwaters includes the mainstem South Santiam River from its origin to just above Cascadia. Tributaries include Canyon Creek, Moose Creek, Soda Fork, Sevenmile Creek, and Squaw Creek. The Middle Santiam River watershed lies due north of the headwaters watershed. Primary tributaries include Tally Creek, Pyramid Creek, Bear Creek, and Jude Creek. The Quartzville Creek watershed lies northwest of the middle Santiam watershed and includes Green Peter Reservoir which is fed by both Quartzville Creek and the Middle Santiam River. The primary tributaries to Quartzville Creek include Panther Creek, Boulder Creek, Galena Creek, Canal Creek, Yellowstone Creek, and Elk Creek.

Table 1.1. Physical characteristics of the upper South Santiam watersheds.

Watershed	Area (ac)	Mean Annual Average Precipitation (in)	Minimum Elevation (ft)	Maximum Elevation (ft)
Foster	36,562	61	528	4,337
South Santiam Headwaters	101,215	82	879	5,400
Middle Santiam	66,139	91	1,076	5,272
Quartzville	110,209	83	846	4970

All of the watersheds were divided into subwatersheds based on priority areas identified by the South Santiam Watershed Council, hydrography features, land use, watersheds identified by the USFS, and watersheds identified by the Water Resources Department (Section IV, Figure 1.1). Due to the small size of the Foster Reservoir watershed, it was not divided into subwatersheds.

The entire upper South Santiam watershed is in the Western Cascades High Montane ecoregion (Section IV, Figure 1.2). The climate in these watersheds is characterized by warm dry summers and cool wet winters. Annual precipitation is usually in the form of snow in the highlands and intermittent snow and rain in the lower elevations. There is a large portion of the watershed that is in the intermittent zone where there is a potential for rain on snow events. Annual rainfall is typically 84 inches in the Western Cascade Montane Highlands (GWEB 1999).

The South Santiam Headwaters lie within the western hemlock and Pacific silver fir vegetation zones where dominant tree species include Douglas-fir, western hemlock, western red cedar, Pacific silver fir, noble fir, red alder, and big leaf maple (WNF 1995). Common understory species include vine maple, rhododendron, sword fern, salal huckleberries, beargrass, and numerous grasses and forbes. About 41% of the watershed (including Foster Reservoir) is covered with the older seral stages (understory reinitiation (27%) and late-successional/old growth (14%)) dominated by conifer tree species with a high degree of canopy closure. The other 57% is in the early seral stages as a result of clearcut patch harvesting that has been scattered throughout the watershed over the last fifty years (WNF 1995).

The Middle Santiam watershed lies within the Oregon Cascades Province of the Pacific Northwest (Franklin and Dyrness 1973). Slightly over half of the watershed is in the western hemlock zone (52% below 3200' elevation) with most of the remaining area in the higher elevation Pacific Silver Fir zone (44%) and a minor amount in the Mountain Hemlock zone (4%). Small, scattered, unmapped patches of Douglas-fir plant associations probably exist in the watershed (<1%). These plant associations are uncommon this far north on the Willamette National Forest and have been designated as rare forested plant associations in the Willamette National Forest 1992 Special Habitats Management Guide (WNF 1996). Dominant tree species include Douglas-fir, western hemlock, western red cedar, Pacific silver fir, noble fir, red alder, and bigleaf maple. Common understory species include vine maple, rhododendron, sword fern, salal, huckleberries, beargrass, and numerous grasses and forbs (WNF 1996).

Quartzville Creek watershed lays to the northwest of the Middle Santiam watershed. The vegetation types and harvest patterns are similar to the Middle Santiam. Much of Quartzville has plant associations indicating more severe site conditions for vegetation growth than in the Middle Santiam watershed. This is due to more skeletal soils in a large portion of the Quartzville drainage. However, due to high rainfall and mineralized soils, Quartzville tree growth and productivity is almost as high as the Middle Santiam. A 3,000 to 4,000 acre block of unroaded area extends from the Middle Santiam into the Quartzville drainage just north of the Middle Santiam Wilderness. The BLM is currently conducting a watershed assessment of the Quartzville Creek watershed.

1.2 Land use and Ownership

Land use in the upper South Santiam watersheds is dominated by federal forest lands and private timber lands (Table 1.2). The South Santiam Headwaters is 67% USFS land with the

Table 1.2. Percent land use for the upper South Santiam watersheds.

	Forestry				Farm and Forest
Subwatershed	Private	State	BLM	USFS	
Middle Santiam River					
South Fork	34			66	
North Fork				100	
Middle	52			48	
Totals	36			64	
Quartzville Creek					
South Fork	10			90	
North Fork	12		18	71	
Green Peter	62		27	2	
Quartzville	21		79		
Totals	36		28	33	
Upper South Santiam River					
Upper South Santiam	8			91	1
Soda	43			56	
South Fork	17			83	
Moose	33			67	
Canyon	53			47	
Totals	33			67	
Foster	88	3		<1	4

remaining portion owned by private timber industry. The Middle Santiam River is 64% USFS land with the remaining 36% owned by private timber industry. Quartzville Creek is 62% federal lands, with a large portion owned by the BLM (28%). Forest management is the dominant land use practice associated with the upper South Santiam watersheds.

CHAPTER 2. CHANNEL HABITAT TYPES

Table 2.1 Channel habitat types in the upper South Santiam watersheds.

Subwatershed	FP2	L	LC	MC	MH	MM	MV	R	SV	VH	WC
Canyon Cr.	-	-	6%	2%	13%	4%	6%	-	42%	27%	1%
Moose Cr.	2%	-	7%	5%	5%	1%	1%	-	18%	61%	-
Soda Fork	-	-	4%	5%	1%	-	5%	-	34%	48%	2%
Upper South Santiam	6%	-	10%	-	7%	-	2%	-	20%	55%	-
South Fork South Santiam	-	-	5%	3%	9%	-	3%	-	26%	54%	-
Middle Santiam	4%	-	4%	1%	7%	1%	-	-	29%	54%	-
North Fork Middle Santiam	-	1%	5%	5%	18%	-	-	-	48%	20%	3%
South Fork Middle Santiam	-	-	5%	-	12%	-	7%	-	39%	35%	1%
Green Peter	-	-	2%	3%	10%	-	2%	5%	32%	46%	-
Quartzville Cr.	-	-	8%	5%	8%	-	2%	-	23%	54%	-
North Fork Quartzville Cr.	-	-	5%	10%	14%	1%	1%	-	18%	50%	-
South Fork Quartzville Cr.	-	-	7%	2%	5%	1%	6%	-	38%	41%	1%

The three subwatersheds of the Middle Santiam (Middle Santiam, North Fork Middle Santiam, and South Fork Middle Santiam) and the four subwatersheds of Quartzville (Green Peter, Quartzville, NF Quartzville, and SF Quartzville) are predominately SV and VH, suggesting limited steelhead and resident rearing (Table 2.1). Suitable spawning and rearing habitat still exists on private and National Forest lands of the Quartzville and Middle Santiam watersheds, although about thirty percent of the prime areas were eliminated with the filling of Green Peter Reservoir (WNF 1996). The five subwatersheds of South Santiam Headwaters (Canyon Creek, Moose Creek, Soda Fork, Upper South Santiam, and SF South Santiam) are predominately SV and VH. Moose Creek, Soda Fork, and Canyon Creek have all been identified as important steelhead spawning habitat (WNF 1995).

CHAPTER 3 FISHERIES

3.1 Fish Distribution

Fish distribution in the upper South Santiam watersheds is listed in Table 3.1. The South Santiam Headwaters support a remnant of the last wild winter steelhead run in the Santiam system. Historically, this run numbered over 2,000 returning adults. Foster Dam was built in the

Table 3.1. Compilation of anadromous fish distribution in the upper South Santiam watershed: Source Report

	1961[a]	1963a[b]	1969[c]	1994[d]	1995[e]	1998a[f]	1998b[g]	1999[h]
Headwaters								
Boundary						X		
Canton							X	
MF Santiam	C,S	S	C	C,S	C			X
Canyon	C,S	C,S	C,S	S	S	X		X
Squaw							X	
Harter								X
Soda Fork	C,S	C,S	S	S	S	X		
Moose	S	S	S	S	S		X	X
Owl	S	S	S			X		X
Upper Soda				S			X`	
SF Mainstem	C,S	C,S	C,S	S	S,C			X
Middle Santiam								
Elk								
Pyramid						X		
Quartzville								
Galena		S						
Thistle								
Canal			S					
Quartzville	C,S	C,S	C,S	S	C			

[a] State Water Resources Board 1963. Middle Willamette River Basin.
[b] Oregon State Game Commission 1963
[c] Willamette Basin Comprehensive Study, Willamette Basin Task Force 1969.
[d] Healthy Native Stocks of Anadromous Salmonids in the Pacific Northwest and California, Huntington et al. 1994.
[e] South Santiam Watershed Assessment, United States Forest Service 1995. (WNF 1995)
[f] Linn County Anadromous Fish Distribution Map, United States Fish and Wildlife 1998.
[g] Willamette River and Sandy River Guide to Restoration Site Selection, Oregon Department of Fish and Wildlife 1998 (Thom and Talabere 1998).
[h] DSL 1999
C=chinook S=steelhead X=anadromous

1960's with a fish ladder and a fish hatchery. Smolt survival in the resulting reservoir has been affected by the presence of squawfish which prey on steelhead smolts during their downstream migration. It is also suspected that smolts are caught as part of the recreational trout fishery which was supported by the past planting program and served to increase fishing pressure in the system. Spawning occurs mainly in Moose Creek, Canyon Creek and Soda Fork. Moose Creek and Canyon Creek are currently closed to all fishing. In the last 10 years the run has declined to 200-400 returning adults per year (WNF 1995).

Spring chinook salmon occupied the South Santiam Headwaters in the past as well. The Oregon Department of Fish and Wildlife cut off upriver migration of adults due to concerns about disease interactions between wild and hatchery raised salmon after the dam was built. In 1994, due to a recent change in management practices and philosophy, 75,000 smolts were released in the South Santiam River above Foster Reservoir. It is expected that these smolts will seed those areas not currently occupied by winter steelhead: Squaw Creek, Sheep Creek, the upper areas and smaller tributaries of Moose Creek, Canyon Creek and Soda Fork, and the main stem of the South Santiam.

Foster Reservoir created conditions suitable for a recreational warm water fishery (bass, blue gill and crappie) and a kokanee fishery. Reintroduction of these fall-spawning salmon creates a conflict with the timing of future in-channel restoration projects and other management activities. The presence of predators (bass and squawfish) in the reservoir is limiting the survival of juvenile anadromous salmonids during downstream migration. This decreases the ability of the salmonids to reseed the available habitat because there are so few adults returning to spawn.

The Middle Santiam watershed supports a variety of aquatic dependent species. Native fish species such as rainbow and cutthroat trout, sculpin species, dace, northern mountain sucker, large scale sucker, red side shiner, blue gill and northern squawfish co-exist with introduced species such as kokanee and large mouth bass (WNF 1996).

Spring chinook and winter steelhead are the only anadromous salmonids native to the Middle Santiam watershed. Their populations were first adversely impacted during the 1920's when the Oregon Department of Game operated a fish trap on the South Santiam River near present day Foster and another on the Middle Santiam River about three miles from its confluence with the South Santiam. Steelhead and chinook were collected and used to seed streams throughout western Oregon. Bull trout were thrown on the banks and fed to cattle and hogs (Todd Buchholz, pers. comm.). Very few adults were allowed past the trap. The traps fell into disuse in the late 1930's and annual run sizes may have started to approach pre-trap numbers by the time the two dams were built.

The Middle Santiam watershed supported nearly 60% of the spring chinook and winter steelhead runs in the entire South Santiam watershed prior to the construction of Green Peter and Foster Dams. Winter steelhead and spring chinook are no longer present in this watershed due to juvenile passage problems associated with Green Peter Dam and its reservoir. Squawfish are abundant in the reservoir and contribute to anadromous fish passage problems as they prey upon juvenile salmon and steelhead. Suitable spawning and rearing habitat still exists on private and National Forest lands, although about thirty percent of the prime areas were eliminated with the filling of Green Peter Reservoir. Given the present day habitat, Oregon Department of Fish and Wildlife estimates that at least 2,000 winter steelhead and 600 spring chinook could successfully spawn and rear above Green Peter Dam. The U.S. Army Corps of Engineers has drafted a reconnaissance study that looks at the feasibility of reestablishing anadromous fish runs above Green Peter Dam.

Kokanee were stocked in the reservoir soon after the completion of Green Peter Dam and today supports a popular game fishery. Kokanee populations are now self sustaining as suitable spawning habitat occurs in Tally Creek, and to a some extent in the Middle Santiam River itself.

Bull trout have been eliminated or seriously reduced in abundance throughout most of its range (Meehan and Bjornn 1991) due to habitat altered by land management activities, fishing pressure, and interactions with introduced fish species. The last reported sighting of bull trout in the South Santiam system was in 1953 (Oregon State Game Commission 1963).

3.2 Migration Barriers

Table 3.2 lists the known migration barriers in the upper South Santiam watersheds. The construction of Green Peter Dam in the late 1960's blocked passage of winter steelhead and spring chinook, eliminating areas that once produced over 60% of the wild winter steelhead and spring chinook runs. Although the Foster Dam has a fish ladder, it still represents a significant barrier to fish attempting to reach these upper watersheds. The remaining fish passage barriers are natural. Culverts on national forest roads which were considered fish barriers have mostly

Table 3.2. Migration Barriers in the upper South Santiam watersheds.		
Location	Barrier Type	Source
Green Peter Dam	Dam	WBTF 1969
Soda Fork	Waterfall	WNF 1995
Canyon Creek	Waterfall	WNF 1995
Moose Creek	Waterfall	WNF 1995

been replaced with fish friendly culverts since the 1966 flood. Additional culverts are currently under further assessment.

3.3 Habitat Conditions

Spring chinook and winter steelhead as well as native trout and other aquatic species habitats are being adversely affected by the current condition of the streams in the watershed, primarily due to lack of LWD (Table 3.3). In 1856, a large fire in the watershed loaded the South Santiam stream channels with lots of wood which caused an aggradation of the channels. Most of this large wood component was removed by subsequent fires, flood events, and, more recently, timber salvage harvest. One result was downcutting in the channels and today many channels including the South Santiam River run mostly on bedrock. This creates high energy stream flows that affect the ability of juvenile fish to occupy the habitat. During high winter flows they suffer a greater risk of predation and can be washed out of the streams along with essential nutrients. Lack of large wood also has decreased the amount of hiding cover (holdover habitat) available for the adult fish especially during low flows. Another result of downcutting is that some Highway 20 culverts are no longer on a grade with the river. This situation plus culverts on some other roads in the watershed hamper migration for anadromous fish as well as native resident fish (WNF 1995).

The major stream channels of the South Santiam headwaters (South Santiam River, Moose Creek, Canyon Creek and Soda Fork) are downcut to bedrock along a greater percentage of their length than would occur if there were large wood in those channels. Geologically, the watershed is in a downcutting phase and these channel types would naturally have some reaches that are dominated by bedrock. The gradient of side channels coming into the main channels steepened to

Table 3.3. ODFW habitat benchmarks - upper South Santiam. Values shaded in dark gray indicate undesirable conditions while light gray indicates values associated with desirable conditions. Unshaded values are in between.

	Reach	Miles	Gradient	Pool Frequency	Percent Pools	Residual Pool Depth	Gravels in Riffles	Woody Debris Pieces/ 100m	Woody Debris Volume (m^3)/100ml	Key Pieces /100m
Canyon Cr	1	1.14	1.6	4.1	45.8	1.4	5	8	34.2	
	2	3.29	1.3	3.5	44.7	1.4	27	6	17.2	
	3	2.14	3.8	2.6	34.8	1.2	21	11	29	
	4	0.73	1	1	53.9	0.8	22	9	16.7	
Moose Cr	1	0.56	1.9	3.4	51.8	0.9	21	2	1.9	
	2	0.94	1.3	3.2	53.6	0.7	29	2	1.8	
	3	0.50	1.6	4.1	43.4	0.9	40	4	1.4	
	4	1.95	2.1	4.2	43.6	0.9	46	8	18.4	
	5	0.91	2.4	4.1	27.9	0.9	19	472	20.5	
	6	0.37	10.8	39.9	0	0	0	103	51.6	
Moose Cr(Quartzville)	1	1.91	3.4	5.6	44.2	0.6	30	23	43.6	2
	2	2.39	11.3	10.2	11.1	0.8	27	27	53.9	2
Rock Cr	1	1.17	9.3	13.7	5.1	0.7	22	7	18.9	0
	2	2.57	14.9	52.7	8.8	0.2	28	11	21.5	0
S Santiam R	1	8.53	1	3.1	43.2	1.8	32	1	22.5	0
	2	2.59	1.4	2.4	38.2	1.3	24	3	6.3	0
	3	6.18	1.2	4.8	32.6	1.1	34	2	3.6	1
	4	1.20	2.6	5.1	19.5	1.3	25	10	25.5	2
	5	0.73	1	2.8	44	1.3	58	5	33.4	2
Trout Cr	1	0.69	9.9	12.6	10.4	0.7	0	16	47.5	2
	2	1.13	20.8	246.1	144	0.3	15	26	107.6	5
	3	0.79	7.2	203.9	0.4	0.4	18	18	54	2
	4	0.36	30.4	288	0	0	0	22	62.3	2
WF Rock Cr	1	0.90	3.6	15.7	9.4	0.5	35	22	68.6	2
	2	0.78	3.4	10.1	30.4	0.5	80	24	60.4	1
	3	1.00	14.3	36.8	5.4	0.7	20	26	81.1	4

Desirable = [light gray]
Undesirable = [dark gray]

the point where many of these confluences are a barrier to the migration of some aquatic organisms. Less of the watershed is available to anadromous fish now than has been in the past.

Table 3.4 lists habitat areas that are important to different fish species in the upper South Santiam watersheds. Moose Creek, Canyon Creek, and Soda Fork have been identified as important spawning and juvenile rearing grounds for native winter steelhead (WNF 1995).

Table 3.4. Important locations for fish in the upper South Santiam watershed.

Location	Species	Source
Middle Santiam	Spring chinook	Cramer 96, ODFW 95
Quartzville	Spring chinook	Cramer 96, ODFW 95
South Santiam*	Winter steelhead	Cramer 96, ODFW 95
Canyon Cr.	Winter steelhead, RCT	ODFW 98, Buchanan et al. 1993
Moose Cr.	Winter steelhead	Buchanan et al. 1993
Soda Fork	Spring chinook, RCT	Cramer 96, ODFW 95
Sheep Cr.	RCT	WNF 95
Falls Cr.	Brook trout	WNF 95

* for 5 miles upstream of Cascadia
RCT= Resident Cutthroat Trout

CHAPTER 4. CHANNEL MODIFICATION ASSESSMENT

Several channel modifications were found for the upper South Santiam watersheds. The most common channel modification activity was stream channelization, caused mostly by adjacent roads and lack of LWD (Table 4.1).

The USFS identified several impacts of channel modification on the South Santiam River. The main facilities that have an effect on the system are Highway 20, forest roads, and campgrounds. Approximately 7% of the riparian area has been influenced by these facilities and the highway accounts for 5% of that 7%. The location of the highway has channelized the South Santiam River in the low gradient reaches such as those found by the Trout Creek, Longbow and Fernview campgrounds because riprap was placed on the riverbank and the highway cut off the meanders that would naturally have occurred in these spots. This creates a stream channel which cannot utilize its already limited amount of flood plain to moderate its energy and hence carries that energy downstream, downcutting the channel. This disassociation with its flood plain has other riparian-dependent species consequences; loss of wetland habitat due to dewatering of site

Table 4.1. Channel modification frequency in the upper South Santiam watersheds.

Subwatershed	*Sand/Gravel Removal*	*Channelized Streambank*	*Mining*	*Revetment*	*Rip-rap*	*Diversion*	*Dam*	*Channel Stabilization*	*Other*	***Total***
Upper South Santiam	0	12	0	0	0	0	0	0	1	14
Quartzville Cr.	0	0	0	0	0	0	0	0	3	6
Green Peter Reservoir	0	1	1	0	0	0	1	0	0	4
SF South Santiam	0	2	0	0	0	0	0	0	0	3
NF Quartzville Cr.	0	0	3	0	0	0	0	0	0	3
SF Middle Santiam	0	0	1	0	0	0	0	0	0	1
Soda Fk.	0	0	0	0	0	0	0	0	0	0
SF Quartzville Cr.	0	0	0	0	0	0	0	0	0	0
NF Middle Santiam	0	0	0	0	0	0	0	0	0	0
Middle Santiam	0	0	0	0	0	0	0	0	0	0
Canyon Cr.	0	0	0	0	0	0	0	0	0	0
Moose Cr.	0	0	0	0	0	0	0	0	0	0
Total	0	15	5	0	0	0	1	0	4	31

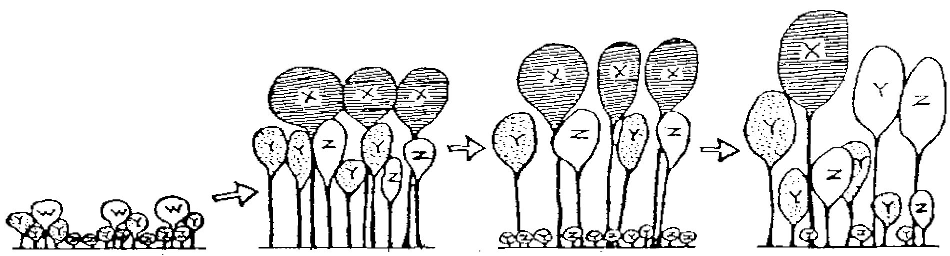
from channel downcutting; loss of tributary connectiveness due to downcutting of main channels; and loss of refugia areas. Protecting the highway west of Soda Fork will affect where and how channel restoration projects in the South Santiam River are implemented. Poor placement of structures could cause undercutting of the highway and/or flooding of the roadbed during 10 to 20 year interval storm events.

The highway interrupts the functioning of the travelway between the river and the uplands for small creatures. There is potential for a hazardous material spill that can have grave consequences if the material ends up in the river. Fluids from normal use of vehicles and equipment do not seem to be affecting water quality. The cinders used to provide traction on the highway in the winter months is becoming a component of the sediments in some Class II and Class III tributaries in the section between Soda Fork and Tombstone Pass. Roadside brushing to maintain sight distance and hazard tree removal for safety of highway travelers keeps some riparian vegetation from fully developing (WNF 1995).

CHAPTER 5. RIPARIAN

5.1. Federal Riparian Assessment

The riparian zones of the upper South Santiam watersheds were not evaluated as a part of this assessment. However, both the Middle Santiam and South Santiam Headwaters were assessed as a part of USFS watershed analyses. Following is a summary of the USFS results. A description of the USFS subwatersheds is included in the appendix (Appendix D). A description of different seral stages is presented in Figure 5.1.



Seral Stage	Stand Initiation	Stem Exclusion	Understory Reinitiation	Old-Growth
Seral Code	SI	SE	UR	OG
Typical Age Range	0-30	15-70	50-200	150+
Current Average*	10	35	75	
Typical DBH Range	0-6"	4"-10"	8"-36"	24"+
Current Average	1"	7"	20"	30"+
Elk Habitat	Forage	Hiding Cover	Thermal Cover	Optimal Thermal
Riparian Structure	Small	Small	Medium	Large
Owl Habitat	Non-habitat	Non-habitat	Dispersal/Foraging	Nesting, Rearing, Foraging
Snag Habitat	Some snags	Almost no snags	Some snags	Full complement

Adapted from Oliver and Larson (1990) *Tree ages are typically younger than the age of the disturbance that created the stand.

Figure 5.1. Seral Stage Descriptions

5.2 South Santiam Headwaters

Riparian vegetation conditions vary due to land ownership patterns and National Forest land management allocations. For example, nearly the entire riparian area adjacent to Keith Creek (Menagerie subwatershed) is composed of understory reinitiation stands indicative of the fire history of the area (Figure 5.2). On the other hand, Soda Fork Creek (Soda Fork subwatershed)

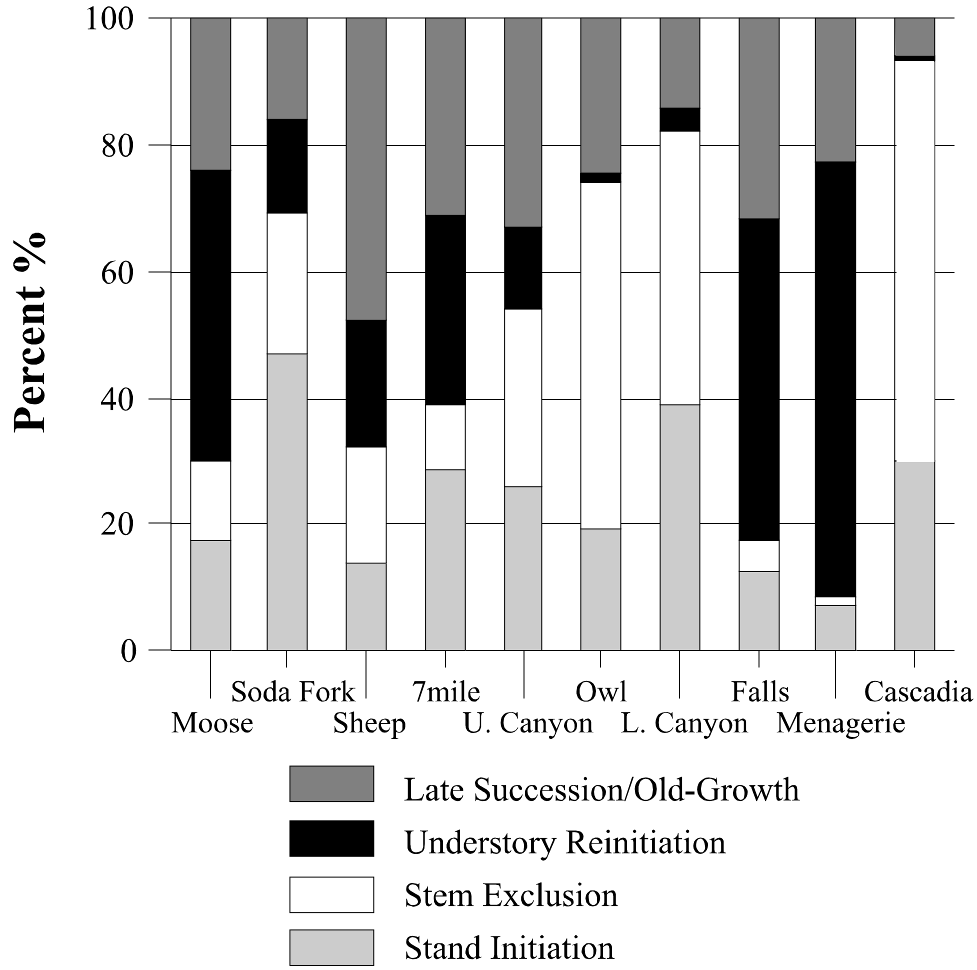


Figure 5.2. Seral stage distribution in the South Santiam Headwaters and parts of Foster watersheds. A description of the subwatersheds can be found in Appendix D.

shows a patchwork of understory reinitiation and stand initiation seral stages on National Forest lands, with stand initiation and stem exclusion seral stages being predominate on private lands.

5.3 Middle Santiam

Current riparian vegetation conditions vary mainly due to land ownership. On the National Forest the riparian areas are dominated by the understory reinitiation and old-growth seral stages with some scattered early seral stages mostly in the checkerboard area (Figure 5.3). On private lands the riparian areas are predominately occupied by the two early seral stages. Riparian areas,

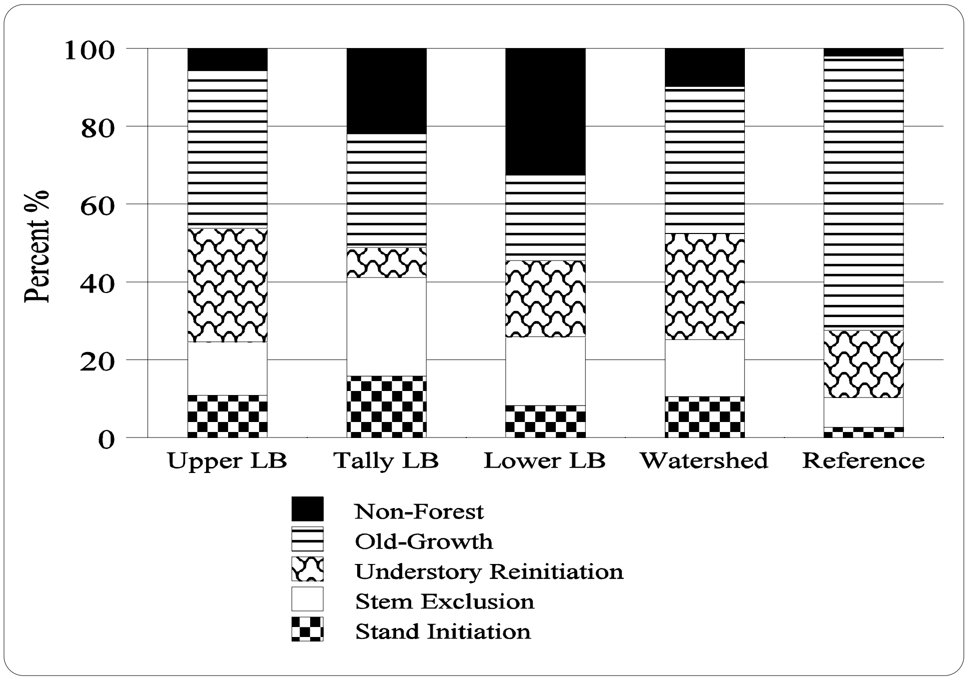


Figure 5.3. Seral stage distribution in the Middle Santiam watershed riparian reserves. Most of the Non-Forest in the Lower and Tally landform blocks is in the reservoir at full pool. A description of the subwatersheds can be found in Appendix D.

which more quickly attain characteristics of late-successional forests, may serve an important role as corridors for dispersal and geneflow. The widths used to generate the data for this graph vary by ownership. For private lands, state forest practices widths were applied on fish-bearing perennial streams. On Federal lands interim Forest Plan widths were applied to all intermittent and perennial streams.

Based on the fire regime of this watershed, it is likely that riparian areas along the perennial streams in the watershed were historically dominated by the later seral stages. Intermittent streams and smaller perennial streams (Class III) were likely to have burned whenever the surrounding area burned. The exception may be in the area covered by fire regime 1C where up to 10% of all riparian areas may have been in early seral stages at any point in time.

5.4. Stream Temperature and Shading

Stream temperatures exceeded DEQ standards on Owl Creek and two sites on the mainstem of Canyon Creek (Figure 5.4). Both Canyon Creek sites and the Owl Creek site were in forested parts of the watershed where stream shading is generally considered to be high suggesting that streams in this watershed are naturally warmer than standards. Fish are suspected to use refugia to retreat from high temperatures during these months. Stream shading and water temperatures need to be further evaluated to establish appropriate temperature standards and current stream shading conditions.

U.S. Geologic Survey records show high water temperatures associated with the Middle Santiam River (1953-1966) prior to most of the timber harvest in the watershed (WNF 1996). The broad alluvial floodplains and heating of their associated gravels contributed to these high temperatures. Tributary streams to the river are suspected to be cool water refugia areas where salmonids can retreat to during the summer months.

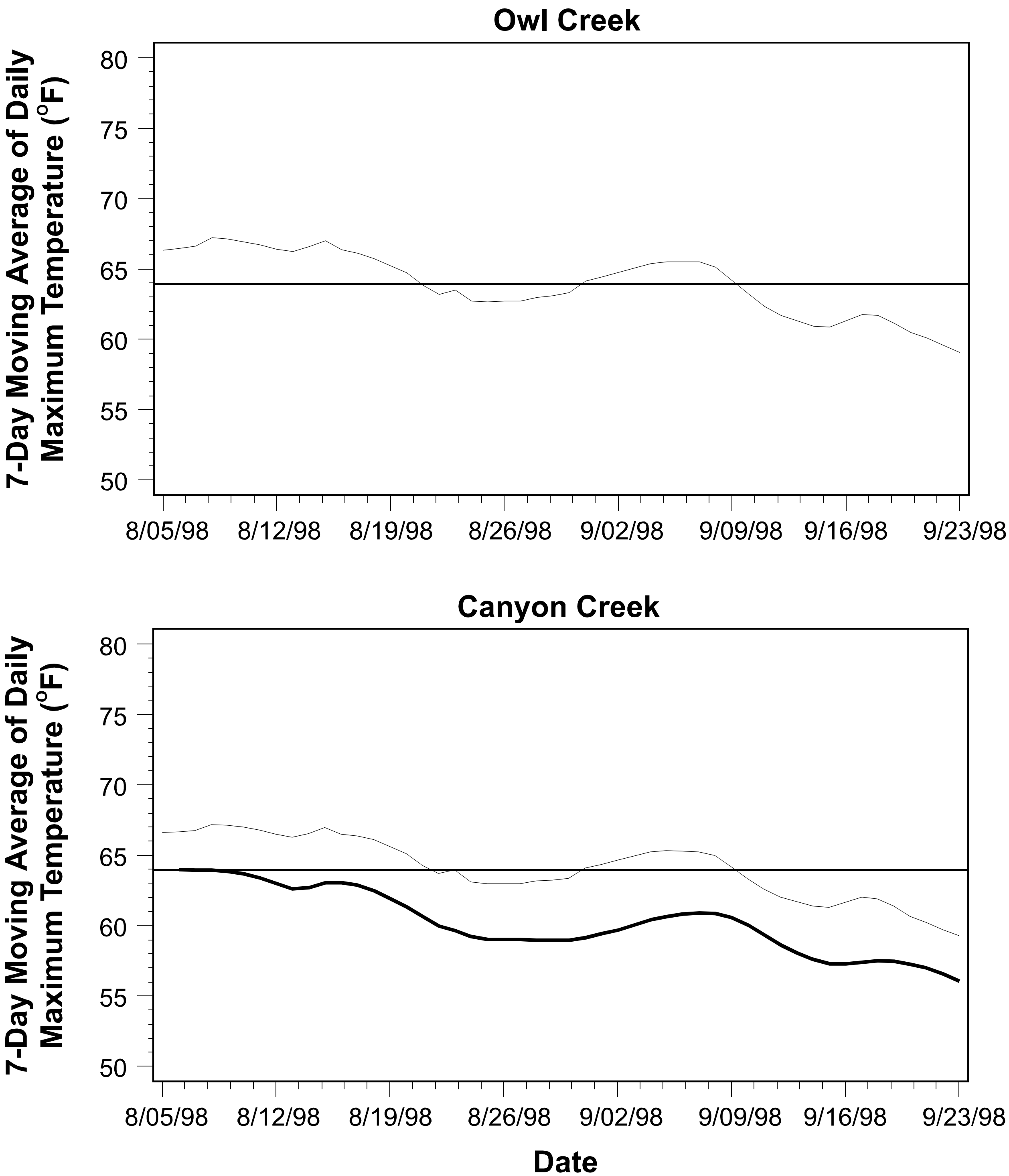


Figure 5.4. The 7-day moving average of daily maximum temperature (°F) on Owl Creek and Canyon Creek. The lighter weight line represents the most downstream site and the heavier weight line is the upstream site. The solid line represents the DEQ standard for cold water fisheries (64 °F).

CHAPTER 6. WATER QUALITY

6.1 Applicable Water Quality Standards

Oregon Administrative Rules (Chap. 350, Div. 41, DEQ) designated beneficial uses for the waters of the State. Often these uses are watershed specific, however all of the beneficial uses designated apply to the South Santiam River except for Navigation. Consequently, virtually all of the water quality criteria apply including dissolved oxygen, temperature, pH, bacteria, habitat modification, and toxics. For further discussion on the designated beneficial uses and their associated water quality criteria see the introduction section on water quality (Section II, Chapter 2).

6.2 Description of Current Water Quality

Very little water quality data exists for the upper South Santiam watersheds. Land use characterization suggests that the most probable water quality issues are temperature and sediments since the watersheds are dominated by forestry practices.

The USFS conducted a watershed assessment of the Middle Santiam River and reported that it is highly likely that the Middle Santiam River is not currently meeting state water quality standard values for temperature and sediment. These standards were probably not met historically either. However, the main tributaries to the river currently maintain temperatures that meet the state standards and most likely did in the past as well. Historically this system supported a healthy run of salmon and steelhead in spite of the "below standard" water quality of the Middle Santiam river system. Steelhead smolts probably used the tributaries as refugia from the higher temperatures in the main stem and chinook smolts migrated out of the system before the higher temperatures developed. Sediment generated in the upper part of the watershed formed lots of structure, floodplains, and braided channels in the lower part of the watershed due to the dramatic change in geologic characteristics that roughly corresponds to the ownership boundary between the Middle Santiam Wilderness on the National Forest and private land. This system created habitat conditions that allowed for a productive fisheries in spite of the water quality. Much of the best chinook salmon spawning habitat and about a third of the steelhead and native trout spawning and rearing habitat is now under the waters of Green Peter Reservoir (WNF 1996).

The DEQ 1998 Section 303(d) decision matrix lists stream segments that have been checked for water quality and have met listing criteria (Table 6.1).

Table 6.1. Stream sediments designated as ok by DEQ in the 303(d) decision matrix.

Stream Segment	Parameter	Season	Criteria	Supporting Data
Hayes Creek - Mouth to Headwaters	Temperature	Summer	Rearing 64°F (17.8°C)	BLM data
Quartzville Cr. - Green Peter Reservoir to Headwaters	pH		Willamette Basin (6.5 to 8.5)	BLM data
	Bacteria	Summer	Water Contact Recreation	BLM data

6.2.1 <u>South Santiam River above Cascadia</u>

Water quality data for the upper South Santiam River is limited. The South Santiam River above Cascadia was sampled between 1972 and 1975 (Table 6.2). Temperature exceeded the

Table 6.2. Water quality in the South Santiam River above Cascadia from 1972 to 1975. The data were obtained from EPA's STORET database.

Parameter	N	MIN	MAX	MEAN	STD
Water temperature (°C)	29.00	4.50	20.00	8.70	4.10
Turbidity (JTU)	28.00	0.00	150.00	9.07	27.79
Conductivity (:M)	29.00	19.00	56.00	32.55	9.78
Dissolved Oxygen (mg/L)	27.00	8.40	13.80	11.21	1.48
pH (s.u.)	26.00	6.80	8.70	7.67	0.53
NH_4^+ (mg/L)	1.00			0.03	
NO_3^- (mg/L)	1.00			0.04	
Total Phosphorus (mg/L P)	3.00	0.02	0.07	0.04	0.03
Calcium (mg/L)	3.00	2.60	4.20	3.60	0.87
Magnesium (mg/L)	3.00	0.60	1.00	0.80	0.20
Sodium (mg/L)	3.00	1.90	3.50	2.63	0.81
Potassium (mg/L)	3.00	0.30	0.40	0.37	0.06
Chloride (mg/L)	3.00	1.10	1.40	1.20	0.17
Sulfate (mg/L)	3.00	0.70	1.60	1.27	0.49

DEQ standards for cold water fisheries. Dissolved oxygen was high, with a range of 8.4 to 13.8 mg/L and a mean concentration of 11.2 mg/L. Nutrient (NO_3, NH_4, TP) concentrations were low for the upper South Santiam River. Turbidity values were high with a maximum of 150.

6.2.2 Middle Santiam near Cascadia

The Middle Santiam River was sampled near Cascadia from 1971 to 1978 (Table 6.3). Temperature values did not exceed DEQ standards, however without knowing the season or time of day collection occurred, it is difficult to determine if temperature exceedences occurred. Dissolved oxygen values were high, ranging from 7.8 to 14.8 mg/L with a mean value of 11.3 mg/L. Turbidity values were high ranging from 1 to 150 JTU. Nutrient values were low (NO_3, NH_4, TP).

Table 6.3. Water quality in the Middle Santiam River above Cascadia from 1972 to 1975. The data were obtained from EPA's STORET database.

Parameter	N	MIN	MAX	MEAN	STD
Water temperature (°C)	39.00	3.50	16.00	7.92	3.85
Turbidity (JTU)	27.00	1.00	150.00	11.33	28.41
Conductivity (:M)	30.00	20.00	60.00	36.27	10.62
Dissolved Oxygen (mg/L)	27.00	7.80	14.80	11.12	1.75
pH (s.u.)	28.00	6.60	8.70	7.61	0.52
NH_4^+ (mg/L)	1.00			0.04	
NO_3^- (mg/L)	1.00			0.05	
Total Phosphorus (mg/L P)	3.00	0.01	0.06	0.03	0.03
Calcium (mg/L)	4.00	3.30	6.40	4.33	1.41
Magnesium (mg/L)	4.00	0.70	1.20	0.85	0.24
Sodium (mg/L)	4.00	1.60	2.80	2.13	0.51
Potassium (mg/L)	4.00	0.30	0.40	0.35	0.06
Chloride (mg/L)	4.00	0.60	2.20	1.23	0.69
Sulfate (mg/L)	4.00	1.30	3.00	2.23	0.72

6.2.3 Quartzville Creek at USGS Gage

Quartzville Creek was sampled at the USGS gaging station from 1969 to 1973 (Table 6.4). Water temperature exceeded DEQ standards with a maximum value of 19°C. Dissolved oxygen

Table 6.4. Water quality in Quartzville Creek at the USGS gauging station from 1972 to 1975. The data were obtained from EPA's STORET database.

Parameter	N	MIN	MAX	MEAN	STD
Water temperature (ºC)	6.00	7.00	19.00	14.50	4.18
Turbidity (JTU)	5.00	0.00	6.00	1.80	2.49
Color (units)	5.00	0.00	5.00	1.00	2.24
Conductivity (:M)	4.00	38.00	49.00	43.00	5.35
Dissolved Oxygen (mg/L)	6.00	9.00	12.10	9.93	1.13
Dissolved Oxygen, saturated (%)	6.00	94.00	108.00	98.83	4.96
BOD (mg/L)	6.00	0.10	1.10	0.45	0.41
pH (s.u.)	6.00	6.90	7.40	7.17	0.18
NH_4^+ (mg/L)	5.00	0.02	0.24	0.11	0.09
Chloride (mg/L)	5.00	0.50	2.80	1.74	0.99
Sulfate (mg/L)	5.00	1.40	5.40	4.08	1.54
Fecal Coliform (cfu/100 ml)	1.00	45.00	45.00	45.00	

was moderate, with concentrations ranging from 9 to 12 mg/L and a mean value of 9.9 mg/L. Turbidity values were unrealistically low. Low turbidity values may be a direct result of sampling in the summer when turbidity is typically low. It is most likely that these values represent turbidity in Quartzville Creek and further assessment is needed to quantify turbidity response to seasonal changes. One fecal coliform sample was taken during this period and was well below the legal limit. Ammonium values were low and no Nitrate or Total Phosphorus samples were taken during this period.

Overall, current water quality information is lacking for the upper South Santiam watersheds. Samples taken during the late 1970's suggest that water quality was relatively good with the exceptions of temperature exceedences and turbidity issues. However, water quality conditions may have changed over the last two decades. Nutrients, turbidity, and temperature all need further research to evaluate water quality conditions in the upper South Santiam watersheds.

CHAPTER 7 WATER USE AND HYDROLOGY

7.1 Basin Characterization and Precipitation

Table 7.1. Subwatershed characterization for the upper South Santiam watersheds.

Subwatershed	Drainage Area (acres)	Minimum Elevation (feet)	Maximum Elevation (feet)	Mean Annual Precipitation (inches)
South Fork Middle Santiam	20,199	1,896	5,272	93.1
North Fork Middle Santiam	13,337	1,896	5,174	87.6
North Fork Quartzville Cr	15,480	1,519	4,455	94.5
South Fork Quartzville Cr	26,432	1,519	4,970	99.9
Soda Cr	10,790	1,388	4,800	86.2
South Fork South Santiam	26,211	1,388	5,400	88.8
Middle Santiam	32,603	1,076	4,951	91.3
Moose Cr	13,337	919	4,685	73.1
Canyon Cr	34,272	879	5,335	81.4
Upper South Santiam	16,605	879	5,210	78.3
Green Peter	50,540	846	4,331	69.3
Foster Reservoir	36,562	528	4,337	61
Quartzville Cr	17,757	1,249	4,419	85.9

Subwatersheds in the upper South Santiam watersheds range in elevation from 528 feet above sea level to 5,335 feet above sea level. Mean annual precipitation on these watersheds ranges from 61 to 100 inches. The South Santiam Headwaters watershed is typical of many western Cascades watersheds. This watershed has deeply incised stream channels and a high stream density. These streams originate from the glacial terraces found on the northeastern and southeastern boundaries of the watershed. Progressing downslope, these relatively flat stream channels increase in gradient dramatically and become very steep, high energy streams with very incised, steep valley walls. These high energy streams form a river system with a geologically constricted valley bottom. Within the mainstem of the larger tributaries and the South Santiam

River, small areas of deposition occur as a result of these geologic constrictions (i.e. earthflows and /or exposed bedrock outcrops; WNF 1995).

The Middle Santiam watershed is not typical of many Western Cascade watersheds. Numerous earthflows have created a conglomerate of drainage patterns and stream characteristics. The typical dendritic pattern that is common within the Western Cascades is interrupted by the earthflow activities. Longitudinal profiles show the benches that were created as a result of these earthflows. Deeply incised high density drainage systems and low to moderately incised drainage systems exist. These systems originate from the glacial terraces found on the southern and eastern portions of the watershed (WNF 1996).

7.2 Climate

One meteorological station is located in the upper South Santiam watersheds, at Cascadia. Mean annual precipitation was 63 inches in Cascadia with the largest proportion occurring in November through March (Table 7.2). The largest amount of snowfall occurs in January through March. Temperature range from a monthly minimum of 30 of in January to a monthly high of 79 of in August.

Table 7.2. Precipitation, snowfall, and temperature as measured at Cascadia from 1961 to 1990.

Month	Mean Precipitation (in)	Mean Snowfall (in)	Maximum Precipitation (in)	Mean Temperature (^{O}C)	Maximum Monthly Temperature (^{O}C)	Minimum Monthly Temperature (^{O}C)
1	8.60	3.80	15.8	38.1	45.3	30.9
2	6.91	2.12	15.8	41.8	50.7	32.8
3	6.80	1.67	12.3	44.4	54.3	34.4
4	5.38	0.09	10.6	47.8	59.0	36.9
5	4.28	0.00	9.9	53.0	64.6	41.3
6	2.96	0.00	8.4	59.1	71.5	46.7
7	0.79	0.00	4.3	63.3	78.0	48.4
8	1.21	0.00	5.4	63.8	79.6	47.9
9	2.41	0.00	6.3	58.6	73.8	43.6
10	5.37	0.00	15.6	51.3	64.0	38.5
11	9.08	0.19	19.4	43.8	51.6	35.8
12	9.64	1.81	24.2	38.5	44.7	32.2
Annual	63.44	9.67		50.4		

7.3 Hydrologic Characterization

Seven USGS gaging sites have been located in the upper South Santiam watersheds, with only the Quartzville Creek and Cascadia stations currently active (Table 7.3). The Middle Santiam River has had several sites since the 1930's, however none of these are currently active. Quartzville Creek has been gaged from 1965 to the present.

Table 7.3. USGS gaging stations located in the upper South Santiam watersheds.

Station Number	Station Name	Period of Record	Drainage Area	Datum
14185700	Middle Santiam River Near Upper Soda, OR	1989-1994	75	--
14185800	Middle Santiam R Near Cascadia, OR.	1962-1982	104	1040
14186500	Middle Santiam R At Mouth near Foster, OR	1950-1966	287	562
14186000	Middle Santiam River Near Foster, OR	1931-1947	271	733
14185880	Packers Gulch Near Cascadia OR	1983-1986	7	--
14185900	Quartzville Creek Near Cascadia, OR	1965-1998	99	1050
14185000	South Santiam River Below Cascadia, OR	1936-1998	174	760

7.3.1 South Santiam River

The mainstem South Santiam River is gaged just below Cascadia. Maximum flows occur in November through February, comprising nearly 56% of annual runoff (Table 7.4). Mean monthly flows below Cascadia range from 80 cfs to 1,524 cfs. The lowest flow period is July through September, comprising approximately 4% of the annual runoff.

Historically, the South Santiam River below Cascadia flooded frequently as can be seen in the peak flow history in relation to flood stage (24,700 cfs) at the Waterloo gauging station (Figure 7.1). Many of these floods were most likely associated with large precipitation events, although many of the events may be a result of rain-on-snow events. The South Santiam River has been channelized due to the construction of Highway 20 (WNF 1995). Streamside roads can disconnect the stream from its floodplain changing peak flows and flood intensity. No real pattern can be seen in the peak flow history that suggests a deviation from natural peak flow patterns. However the information presented is not detailed enough to discern fine scale events such as the effects of road construction.

Table 7.4. Streamflow statistics for the South Santiam River below Cascadia for 1936-1998.

Month	Mean Flow (cfs)	Volume (acre-feet)	Percent Runoff	Maximum Flow (cfs)	Minimum Flow (cfs)
1	1,440	88,372	15	3,278	107
2	1,394	77,272	13	3,326	130
3	1,172	71,965	12	2,913	324
4	1,156	68,638	12	2,053	356
5	933	57,283	10	1,639	282
6	524	31,132	5	1,261	101
7	166	10,162	2	407	54
8	80	4,919	1	222	36
9	95	5,652	1	318	41
10	294	18,073	3	1,296	32
11	1,131	67,197	11	2,442	28
12	1,524	93,559	16	4,319	82
	826	594,223	100		

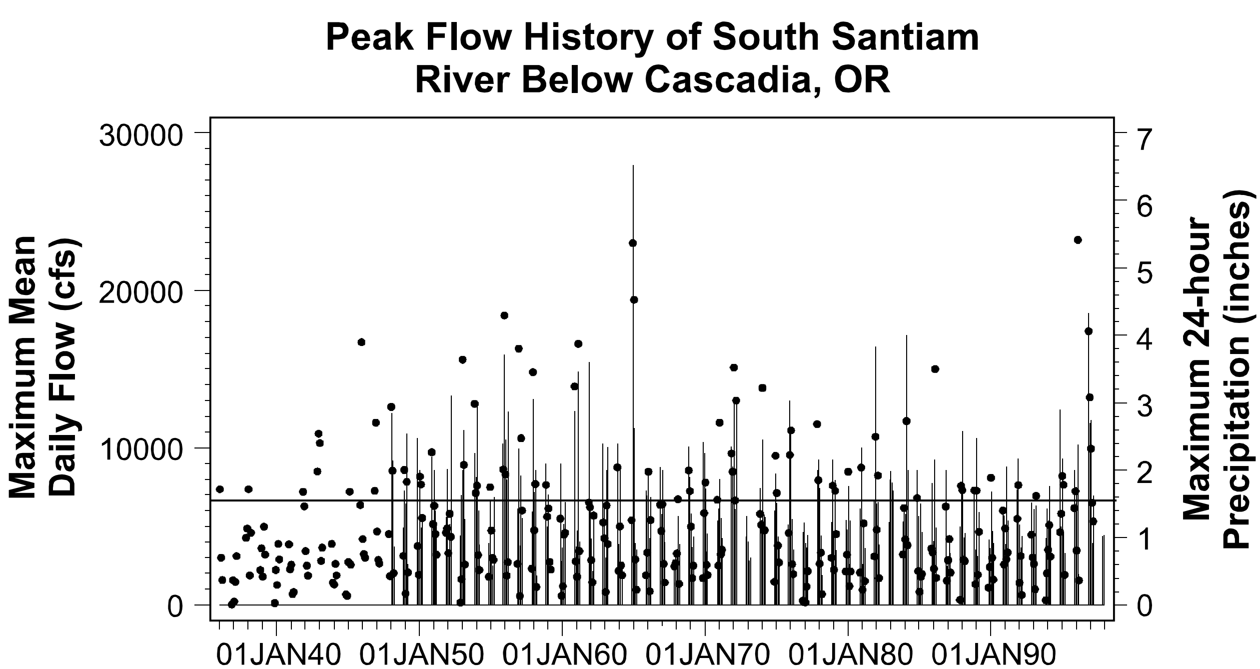


Figure 7.1. Peak mean daily flow (cfs) for the winter high flow period (November-March) for the South Santiam River below Cascadia, OR. The solid line represents discharge at Flood stage. (Bars = maximum 24-hr precipitation; C = maximum mean daily flow)

Minimum flows for the low flow period on the mainstem South Santiam River are shown in Figure 7.2. Minimum flows generally range from 20 cfs to 100 cfs for the low flow months with the lowest flows occurring in September and October. Instream water rights for the South Santiam River below Cascadia are generally 20 to 25 cfs in August suggesting that instream water needs are being met. Instream water rights for the South Santiam in late September are 100 cfs, however, which may not be met in the majority of the years. Appropriate water needs should be established for the South Santiam River and its tributaries.

7.3.2 Middle Santiam River

The Middle Santiam River was gaged at the mouth near Foster, OR from 1950 to 1966. These values represent hydrologic conditions prior to the installation of Green Peter Dam.

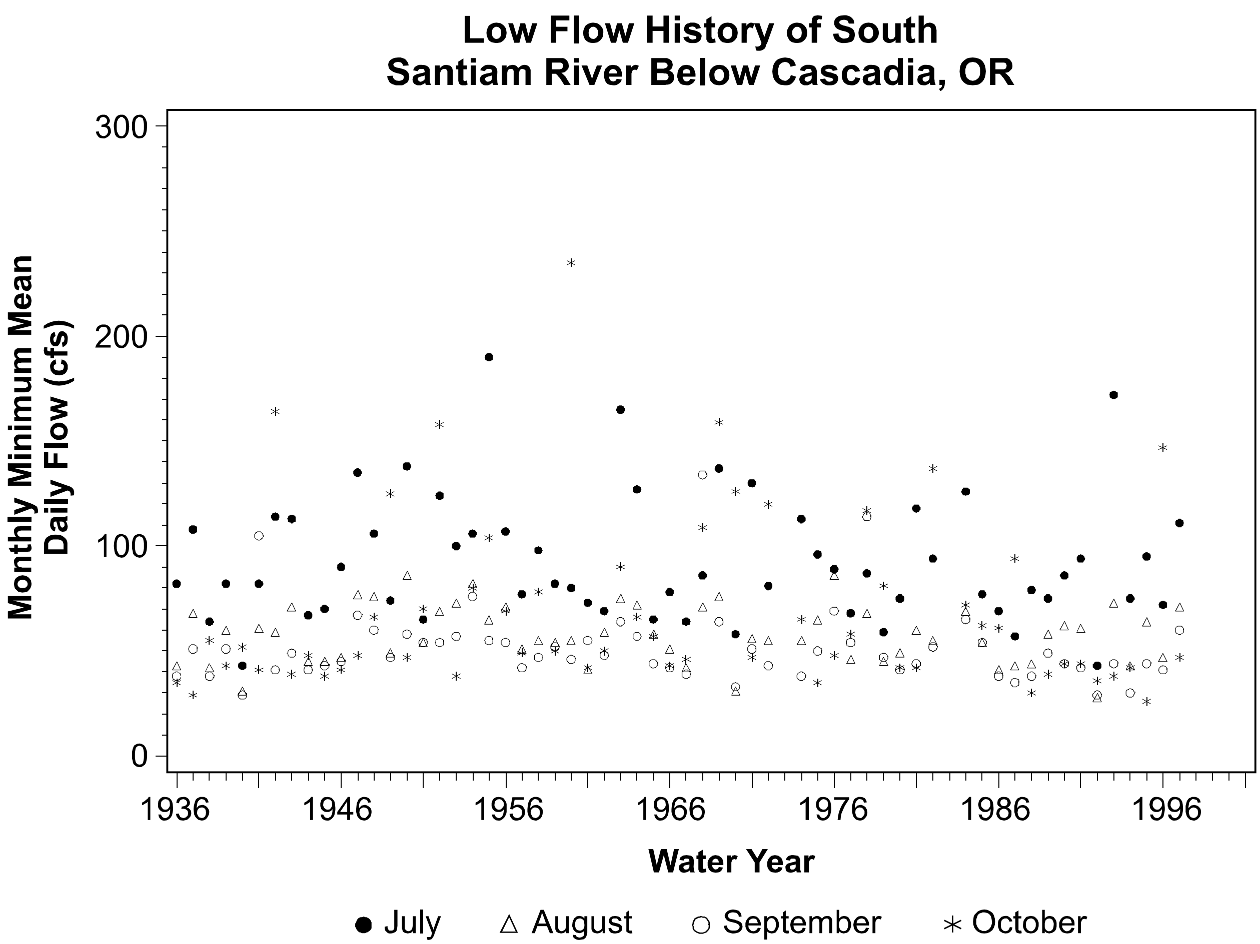


Figure 7.2. Minimum mean daily flow (cfs) for the summer low flow period (July-October) for the South Santiam River below Cascadia, OR.

Maximum flows occur in November through February, totaling approximately 57% of the annual runoff (Table 7.5). Mean monthly flows at the mouth range from 168cfs to 3,493 cfs. The lowest flow period is July through September, comprising approximately 4% of the annual runoff.

Table 7.5. Streamflow statistics for the Middle Santiam River at the mouth for 1950-1966.

Month	Mean Flow (cfs)	Volume (acre-feet)	Percent Runoff	Maximum Flow (cfs)	Minimum Flow (cfs)
1	3189	195769	15	7270	758
2	3017	167246	13	6405	1290
3	2360	144845	11	4015	1039
4	2473	146911	11	3427	1520
5	1822	111857	9	3017	850
6	907	53857	4	2162	365
7	325	19954	2	714	177
8	168	10308	1	235	106
9	203	12083	1	749	96
10	899	55202	4	2590	85
11	2524	149901	12	4660	126
12	3493	214389	17	9077	1066
	1,782	1282323	100		

Historically, the Middle Santiam River flooded frequently as can be seen in the peak flow history (Figure 7.3). Many of these floods were most likely associated with large precipitation events, although many of the events may be a result of rain on snow events due to large intermittent snow zone in the Middle Santiam watershed. The Middle Santiam River watershed has not been significantly altered historically other than by forest practices. The data presented here is not detailed enough to identify effects from forest harvest practices. However, it is likely that the flooding pattern in the Middle Santiam watershed is typical of natural variation.

Minimum flows for the low flow period on the Middle Santiam River are shown in Figure 7.4. Low flows were typically higher than 50 cfs and minimum flows occurred in September and October. Instream water rights set to protect aquatic life for this gaging station are 110 cfs.

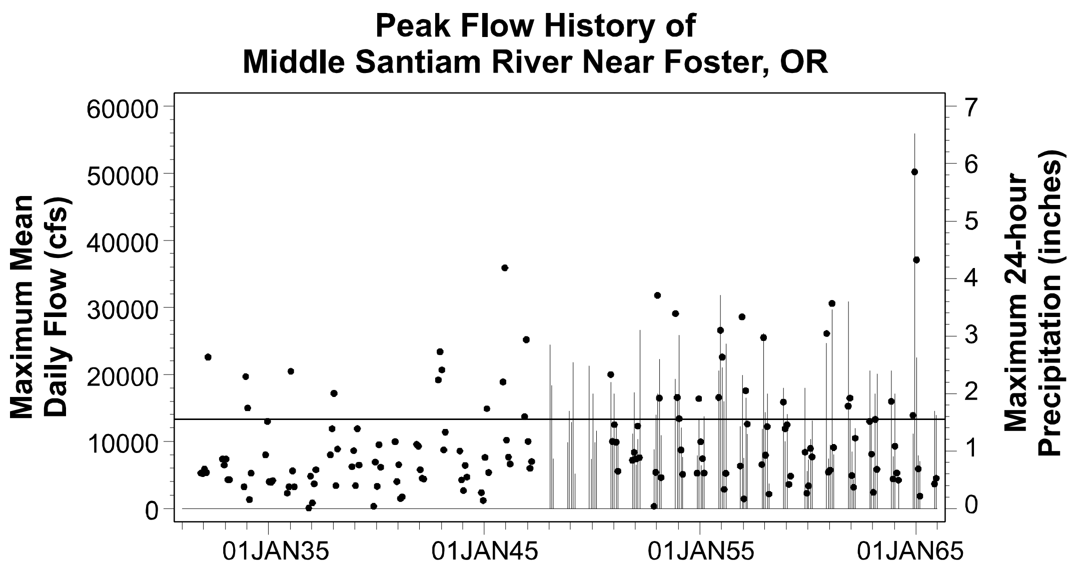


Figure 7.3. Peak mean daily flow (cfs) for the winter high flow period (November-March for the Middle Santiam River near Foster, OR. The solid line represents discharge at flood stage. (Bars = maximum 24-hr precipitation; C = maximum mean daily flow)

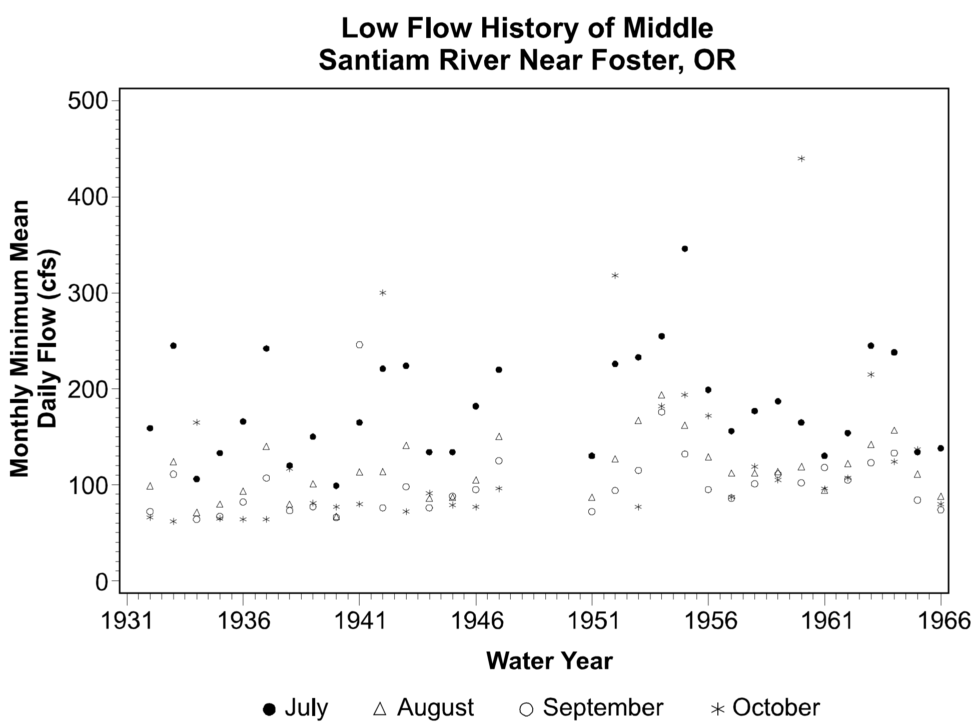


Figure 7.4. Minimum mean daily flow (cfs) for the summer low flow period (July-October) for the Middle Santiam River near Foster, OR.

Natural stream flows do not meet the established instream water needs. A more appropriate flow standard needs to be developed for the Middle Santiam River.

More recently, the Middle Santiam River was gaged near Upper Soda from 1989 to 1994. It is important to note that this gaging station has a drainage area approximately half the size of the gaging station at the mouth. Maximum flows occur in November through April, totaling approximately 79% of the annual runoff (Table 7.6). Mean monthly flows near Upper Soda range from 32 cfs to 731 cfs. The lowest flow period is July through October, comprising approximately 5% of the annual runoff.

Table 7.6. Streamflow statistics for the Middle Santiam River near Upper Soda for 1989-1994.

Month	Mean Flow (cfs)	Volume (acre-feet)	Percent Runoff	Maximum Flow (cfs)	Minimum Flow (cfs)
1	524	32,182	13	784	323
2	436	24,158	10	572	247
3	662	40,641	16	1,221	209
4	731	43,422	17	990	494
5	381	23,357	9	642	175
6	255	15,157	6	411	62
7	91	5,615	2	141	43
8	47	2,890	1	63	24
9	32	1,925	1	37	28
10	53	3,263	1	127	26
11	496	29,441	12	802	32
12	466	28,625	11	711	304
		250,677	100		

7.3.3 Quartzville Creek

Quartzville Creek is gaged at the mouth near Cascadia, OR. Maximum flows occur in November through February, totaling approximately 58% of the annual runoff (Table 7.7). Mean monthly flows at the mouth range from 59 cfs to 1,256 cfs. The lowest flow period is July through September, comprising approximately 3% of the annual runoff.

Historically, Quartzville Creek flooded frequently as can be seen in the peak flow history (Figure 7.5). Many of these floods were most likely associated with large precipitation events,

Table 7.7. Streamflow statistics for Quartzville Creek for the period 1965 to 1998.

Month	Mean Flow (cfs)	Volume (acre-feet)	Percent Runoff	Maximum Flow (cfs)	Minimum Flow (cfs)
1	1256	77117	16	2450	157
2	1124	62310	13	2441	208
3	938	57557	12	2018	204
4	856	50860	11	1600	382
5	597	36641	8	1114	182
6	312	18519	4	817	63
7	99	6103	1	336	37
8	59	3601	1	240	21
9	86	5120	1	268	24
10	255	15645	3	753	21
11	999	59337	13	2224	58
12	1255	77047	16	2897	110
		469858	100		

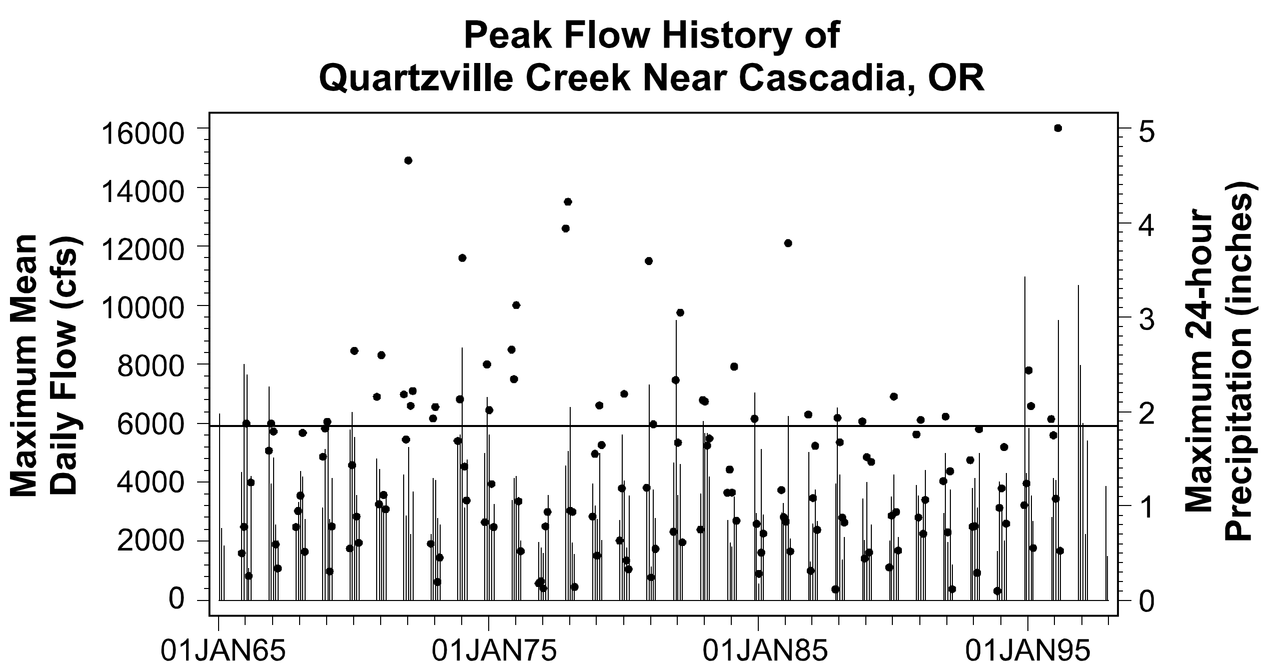


Figure 7.5. Peak mean daily flow (cfs) for the winter high flow period (November-March) for Quartzville Creek near Cascadia, OR. The solid line represents discharge at flood stage. (Bars = maximum 24-hr precipitation; • = maximum mean daily flow)

although many of the events may be a result rain-on-snow events. The Quartzville Creek watershed has a large percentage of the watershed in the rain-on-snow zone, increasing the possibility for this type of event. Many of the floods occurred without major precipitation events, further corroborating the occurrence of rain-on-snow flood events.

Minimum flows for the low flow period on the mainstem South Santiam River are shown in Figure 7.6. Minimum flow ranged from under 10 cfs to approximately 60 cfs. Minimum flows typically occurred in September and August with a few occurrences in October. No instream flow needs have been established for Quartzville Creek.

7.4 Hydrologic Issues and Associated Land Use

The primary effect on the hydrology of the upper South Santiam watershed is probably from forestry practices and roads. Some simple quantification and rankings of watershed level data can give us some insight into potential issues in the upper South Santiam watersheds.

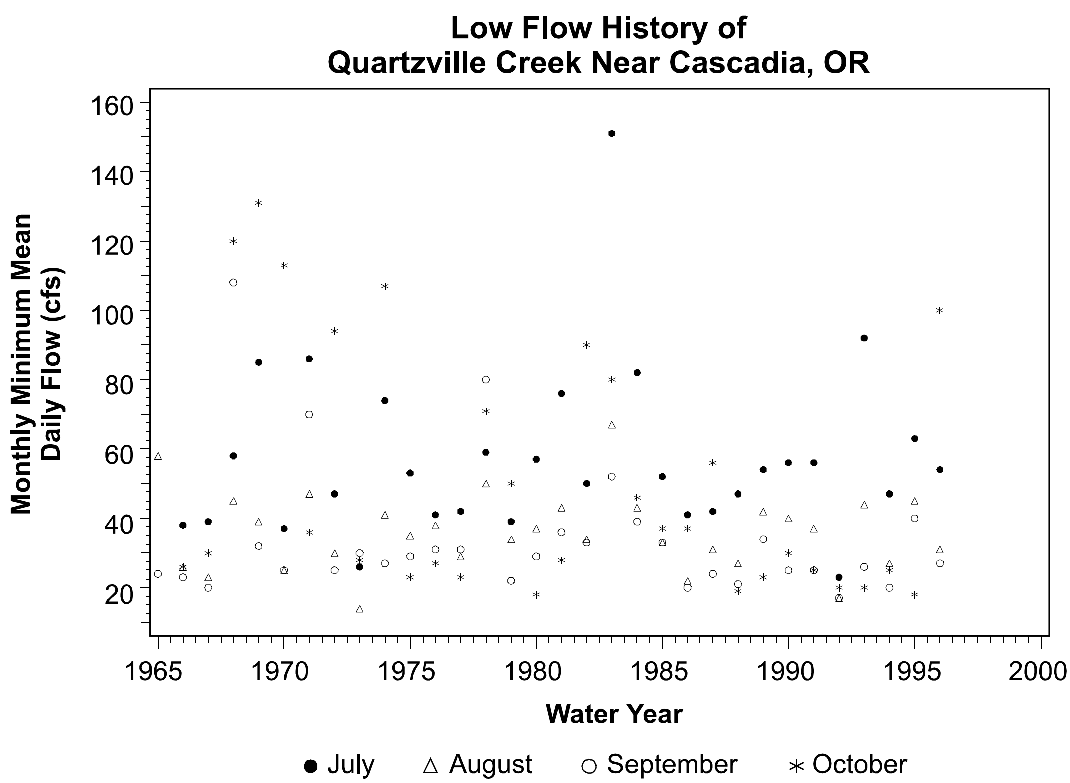


Figure 7.6. Minimum mean daily flow (cfs) for the summer low flow period (July-October) for Quartzville Creek near Cascadia, OR.

7.4.1 Forestry Issues

Most of the middle Santiam watershed is within the transitional snow zone (Table 7.8). Water storage in this watershed is provided by the soils and floodplains. They act like a large sponge that releases water slowly when there is little or no precipitation for an extended period of time. This can lead to flows as low as 15 cubic feet per second in the Middle Santiam River in the dry summer months. There have been at least ten major flood events in the watershed in the last 150 years (Figure 7.3). Flooding is a disturbance mechanism in the Middle Santiam River riparian areas. A more detailed description of the hydrology in different areas of the Middle Santiam watershed is found in the Middle Santiam Watershed Analysis (WNF 1996).

Table 7.8. Percent of subwatersheds that are forested and percent forested in the rain-on-snow zone.

Subwatershed	Percent Subwatershed Forested	Percent of Subwatershed Forested in Rain-on-Snow Zone
Moose Cr	100	64
North Fork Quartzville Cr	100	62
Quartzville Cr	100	62
Green Peter	100	60
Upper South Santiam	100	50
Middle Santiam	100	48
Canyon Cr	100	45
Foster Reservoir	100	39
Soda Cr	100	34
South Fork Quartzville Cr	100	29
South Fork South Santiam	100	28
North Fork Middle Santiam	100	23
South Fork Middle Santiam	100	20

Currently the complex history of fire, flood, and management activities in the South Santiam Headwaters watershed have created a very efficient sediment transportation system, one that is highly resistant to increases in peak flows. The upper watershed areas and tributary streams are currently developing a vegetative cover that the area has not experienced naturally since the 1850's. Due to fire suppression and other management activities (putting large wood in streams) these channels are starting to develop the capacity to store sediment again. As these channels accumulate structure and sediment, peak flows become critical in determining the residual time these characteristics can be retained. The residual time in the system will influence the amount and effectiveness of the associated habitats (WNF 1995).

Forest roads can significantly increase peak flows if a watershed has a road density of greater than 12% (Harr et al. 1975). Forest road densities were quantified for the upper South Santiam watersheds (Table 7.9). None of the watersheds had a forest road density of greater than 3% based on an average road width of 24 feet.

Table 7.9. Forest road summary in the upper South Santiam watersheds.

Subwatershed	Area (acres)	Area Forested (%)	Miles of Forestry Roads*	Road Area** (acres)	Road Density (%)	Miles of Forestry Roads per Square Mile
Canyon Cr***	34,272	100	496	1442	4.2	9.26
Green Peter	50,540	100	370	1076	2.1	4.69
South Fork South Santiam***	26,211	100	359	1044	4.0	8.77
Foster Reservoir	36,562	100	350	1018	2.8	6.13
Middle Santiam	32,603	100	222	646	2.0	4.36
Quartzville Cr	17,757	100	156	455	2.6	5.62
South Fork Quartzville Cr	26,432	100	153	445	1.7	3.70
South Fork Middle Santiam	20,199	100	137	398	2.0	4.34
North Fork Quartzville Cr	15,480	100	113	329	2.1	4.67
Upper South Santiam	16,605	100	108	315	1.9	4.16
Moose Cr	13,337	100	90	261	2.0	4.32
Soda Cr	10,790	100	87	252	2.3	5.16
North Fork Middle Santiam	13,337	100	67	194	1.5	3.22

* Forestry roads are defined as all roads in the forestry land use zones.
** Road area was calculated based on a road width of 24 ft.
*** Due to the spatial extent of roads coverages, a more general coverage was used for road data in these watersheds.

7.5 Water Rights

Only two instream water rights exist for the upper South Santiam watersheds (Table 7.10). The water rights are in the South Santiam and Middle Santiam Rivers and were created to protect aquatic life. Both instream water rights have a priority date of 1964.

Table 7.10. Instream water rights in the upper South Santiam watersheds.

Stream	Priority	Purpose	Location
Middle Santiam River	6-22-64	Supporting Aquatic Life	Above the USGS gage at Foster
South Santiam River	6-22-64	Supporting Aquatic Life	Above the USGS gage below Cascadia

7.6 Consumptive Water Use

The beneficial uses found within this watershed are: fisheries (resident and anadromous), recreation, aquatic non-fish species, domestic, recreation, hydroelectric, agricultural, and industrial. Prioritization of instream flows for western Cascades watersheds by the State of Oregon has not been done and is beyond the scope of this analysis. Potential minimum instream flow requirements will vary over the watershed due to topography, vegetation, and the beneficial uses being supported.

7.6.1 Irrigation

All three watersheds have small amounts of water appropriated for irrigation and agricultural use (Table 7.11). Agricultural uses are primarily associated with the small farms and homesteads around Cascadia. Appropriations are very small however, and likely have little affect on instream conditions.

7.6.2 Municipal and Domestic Water Supply

Domestic water use is rather small in the upper South Santiam watersheds, with the greatest amount of use in the South Santiam Headwaters watershed (Table 7.11). Domestic use in the Headwaters watershed is associated with the small landowners, located primarily along Highway 20.

Table 7.11. Water use and storage in the upper South Santiam watersheds.

Subwatershed	Irrigation		Domestic		Fish		Industrial		Other		Total	
	Use (cfs)	Storage (ac ft)	Use (cfs)	Storage (ac ft)	Use (cfs)	Storage (ac ft)	Use (cfs)	Storage (ac ft)	Use (cfs)	Storage (ac ft)	Use (cfs)	Storage (ac ft)
Middle Santiam River	0.39	5.10	0.12	–	5.31	2.00	0	2.00	0.03	–	5.85	9.10
Quartzville Cr	0.11	–	0.01	–	0.33	–	3.00	–	–	–	3.45	--
S. Santiam Headwaters	0.56	–	0.96	–	1.00	–	–	–	0.49	0.45	3.01	0.45

7.6.3 Industrial Water Supply

Triple T Studs sawmill, located near the confluence of Moose Creek, is the only industrial user in the South Santiam headwaters watershed. In the Quartzville Creek watershed, industrial water use is associated with mining, both industrial and recreational. There are several recreational mining facilities where panning for minerals is conducted. Quartzville Creek also had a high concentration of mining activities, shown in the channel modification assessment.

7.6.4 Other Consumptive Uses

Recreational uses include campgrounds, Cascadia State Park, and Highway 20 and the Old Santiam Wagon Road where they are within the South Santiam River Riparian Reserve. The current recreation uses are related to boating, dispersed camping, and the scenic qualities of the area. Recreational use was not extensive historically.

7.7 Non-Consumptive Water Use

7.7.1 Hydropower

Although hydroelectric power generation is not quantified in the water rights for the upper South Santiam watersheds, this is one of the primary uses of water in the upper South Santiam watersheds. Water from the Middle Santiam watershed contributes to the hydroelectric operations of Green Peter and Foster Dams which are below the watershed. Water from the mainstem South Santiam River also flows directly into Foster Reservoir and contributes to hydroelectric generation. Hydroelectric use in the South Santiam headwaters is also associated with the Falls Creek Hydroelectric project.

7.7.2 Fish and Wildlife

Fish and Wildlife is the most dominant use in the upper South Santiam watersheds (Table 7.11). Both the Middle Santiam and South Santiam headwaters watersheds have their largest water right allocations for fish and wildlife. The fisheries beneficial use covers anadromous and resident fisheries as well as non-game aquatic species and pertains to the portion of the watershed affected by the reservoir and those flowing waters containing fish.

7.8 Water Availability

There are only two water availability watersheds in the upper South Santiam watersheds which are the Middle Santiam River above Foster and the South Santiam River above Cascadia (Table 7.12). Dewatering potential is low in all of the upper South Santiam watersheds since very little water is appropriated for consumptive use. No information is currently available for the Quartzville Creek watershed, however there is minimal water withdrawals in the watershed suggesting that instream flows are not affected by water withdrawals.

Table 7.12. Dewatering Potential in the upper South Santiam watersheds.

	Dewatering Potential*					Overall Dewatering Potential	
Water Availability Basin	Jun	Jul	Aug	Sep	Oct	Average Percent Withdrawal	Potential
Middle Santiam near Foster, OR	0	0	0	1	1	1%	Low
South Santiam @ Cascadia	0	0	0	0	0	0%	Low

* percent of instream flows that are appropriated for consumptive use.

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APPENDIX A

USGS Gaging Station Statistics

Table 1. South Santiam River below Cascadia.

Month	Mean Flow (cfs)	Volume (acre-feet)	Percent Runoff	Maximum Flow (cfs)	Minimum Flow (acre-feet)
1	1440	88372	15	3278	107
2	1394	77272	13	3326	130
3	1172	71965	12	2913	324
4	1156	68638	12	2052	356
5	933	57283	10	1639	282
6	524	31132	5	1261	101
7	166	10162	2	407	54
8	80	4919	1	222	36
9	95	5652	1	318	41
10	294	18073	3	1296	32
11	1131	67197	11	2442	28
12	1524	93559	16	4319	82
		594223	100		

Table 2. Middle Santiam River near Upper Soda.

Month	Mean Flow (cfs)	Volume (acrefeet)	Percent Runoff	Maximum Flow (cfs)	Minimum Flow (acrefeet)
1	524	32182	13	784	323
2	436	24158	10	572	247
3	662	40641	16	1221	209
4	731	43422	17	990	494
5	381	23357	9	642	175
6	255	15157	6	411	62
7	91	5615	2	141	43
8	47	2890	1	63	24
9	32	1925	1	37	28
10	53	3263	1	127	26
11	496	29441	12	802	32
12	466	28625	11	711	304
		250677	100		

Table 3. Middle Santiam River near Cascadia.					
Month	Mean Flow (cfs)	Volume (acrefeet)	Percent Runoff	Maximum Flow (cfs)	Minimum Flow (acrefeet)
1	1260	77362	17	2244	169
2	883	48959	11	1851	178
3	796	48838	11	2218	354
4	807	47909	11	1273	409
5	781	47939	11	1296	342
6	426	25332	6	986	152
7	141	8648	2	242	79
8	84	5135	1	166	45
9	101	6022	1	218	42
10	208	12777	3	575	40
11	801	47584	10	1739	167
12	1274	78213	17	3356	121
		454718	100		

Table 4. Packers Gultch near Cascadia.					
Month	Mean Flow (cfs)	Volume (acrefeet)	Percent Runoff	Maximum Flow (cfs)	Minimum Flow (acrefeet)
1	71	4341	11	90	43
2	137	7594	19	253	48
3	78	4763	12	107	61
4	64	3787	9	91	33
5	51	3106	8	78	29
6	34	2042	5	65	8
7	15	921	2	38	5
8	5	316	1	10	3
9	10	573	1	21	4
10	25	1536	4	38	6
11	118	7007	17	158	72
12	78	4799	12	107	62
		40785	100		

Table 5. Quartzville Creek near Cascadia.

Month	Mean Flow (cfs)	Volume (acrefeet)	Percent Runoff	Maximum Flow (cfs)	Minimum Flow (acrefeet)
1	1256	77117	16	2450	157
2	1124	62310	13	2441	208
3	938	57557	12	2018	204
4	856	50860	11	1600	382
5	597	36641	8	1114	182
6	312	18519	4	817	63
7	99	6103	1	336	37
8	59	3601	1	240	21
9	86	5120	1	268	24
10	255	15645	3	753	21
11	999	59337	13	2224	58
12	1255	77047	16	2897	110
		469858	100		

Table 6. Middle Santiam River near Foster.

Month	Mean Flow (cfs)	Volume (acrefeet)	Percent Runoff	Maximum Flow (cfs)	Minimum Flow (acrefeet)
1	2471	151662	14	5351	491
2	2156	119536	11	4041	780
3	2383	146245	14	5998	648
4	2140	127130	12	4042	547
5	1509	92610	9	3059	487
6	984	58431	6	3530	220
7	294	18051	2	614	126
8	134	8222	1	199	80
9	163	9668	1	581	83
10	421	25864	2	975	74
11	1988	118075	11	5397	65
12	2792	171355	16	5741	582
		1046850	100		

Table 7. Middle Santiam River at mouth near Foster.					
Month	Mean Flow (cfs)	Volume (acrefeet)	Percent Runoff	Maximum Flow (cfs)	Minimum Flow (acrefeet)
1	3189	195769	15	7270	758
2	3017	167246	13	6405	1290
3	2360	144845	11	4015	1039
4	2473	146911	11	3427	1520
5	1822	111857	9	3017	850
6	907	53857	4	2162	365
7	325	19954	2	714	177
8	168	10308	1	235	106
9	203	12083	1	749	96
10	899	55202	4	2590	85
11	2524	149901	12	4660	126
12	3493	214389	17	9077	1066
		1282323	100		

Table 8. South Santiam River at Foster.					
Month	Mean Flow (cfs)	Volume (acrefeet)	Percent Runoff	Maximum Flow (cfs)	Minimum Flow (acrefeet)
1	5936	364330	19	7687	3915
2	3673	203649	10	6379	799
3	2968	182159	9	9407	789
4	1884	111923	6	3269	845
5	2167	132985	7	3525	747
6	1288	76511	4	2421	635
7	729	44766	2	1112	445
8	982	60256	3	1249	454
9	1698	100872	5	2660	441
10	1940	119105	6	5051	578
11	3978	236299	12	6010	2422
12	5012	307634	16	8025	3681
		1940487	100		

Table 9. Wiley Creek near Foster.					
Month	Mean Flow (cfs)	Volume (acrefeet)	Percent Runoff	Maximum Flow (cfs)	Minimum Flow (acrefeet)
1	348	21361	16	507	155
2	346	19156	14	839	161
3	309	18969	14	614	85
4	287	17076	13	488	210
5	190	11680	9	334	65
6	107	6366	5	286	20
7	28	1712	1	58	12
8	14	844	1	23	4
9	10	597	0	16	5
10	33	2033	2	73	8
11	248	14746	11	401	17
12	289	17728	13	574	131
		132268	100		

Table 10. Wiley Creek at Foster.					
Month	Mean Flow (cfs)	Volume (acrefeet)	Percent Runoff	Maximum Flow (cfs)	Minimum Flow (acrefeet)
1	399	24462	15	768	51
2	439	24324	15	779	66
3	350	21483	13	650	120
4	316	18774	11	444	124
5	204	12545	8	359	63
6	116	6863	4	341	32
7	37	2290	1	127	15
8	18	1123	1	41	8
9	23	1372	1	65	6
10	54	3339	2	122	6
11	310	18397	11	823	24
12	503	30896	19	877	39
		165870	100		

Table 11. South Santiam River near Foster.					
Month	Mean Flow (cfs)	Volume (acrefeet)	Percent Runoff	Maximum Flow (cfs)	Minimum Flow (acrefeet)
1	4927	302417	15	8951	729
2	3538	196126	10	10465	586
3	2815	172783	8	5556	781
4	2962	175940	9	6215	1180
5	2193	134578	7	3952	764
6	1594	94675	5	4096	632
7	802	49210	2	1507	559
8	763	46850	2	1169	582
9	1290	76613	4	2075	879
10	2049	125791	6	3082	859
11	4710	279802	14	9267	823
12	6324	388168	19	12773	1144
		2042953	100		

Table 12. South Santiam River at Waterloo.					
Month	Mean Flow (cfs)	Volume (acrefeet)	Percent Runoff	Maximum Flow (cfs)	Minimum Flow (acrefeet)
1	5273	323658	15	12223	713
2	4679	259416	12	12068	597
3	3930	241209	11	10528	865
4	3620	215016	10	7935	1056
5	2725	167263	8	5875	792
6	1640	97438	5	5906	437
7	641	39371	2	1527	176
8	474	29080	1	1239	126
9	746	44314	2	2769	144
10	1535	94217	4	5530	143
11	4259	252961	12	9706	111
12	5711	350531	17	15465	1068
		2114476	100		

Table 13. Lebanon Santiam Canal near Lebanon.

Month	Mean Flow (cfs)	Volume (acrefeet)	Percent Runoff	Maximum Flow (cfs)	Minimum Flow (acrefeet)
1	70	4325	6	86	46
2	84	4655	7	134	50
3	95	5845	8	156	60
4	99	5858	8	147	48
5	97	5959	8	127	50
6	116	6896	10	152	66
7	125	7670	11	148	91
8	126	7712	11	145	100
9	113	6732	9	146	85
10	106	6500	9	134	83
11	85	5020	7	99	65
12	69	4238	6	91	52
		71410	100		

Table 14. Schafer Creek near Lacomb.

Month	Mean Flow (cfs)	Volume (acrefeet)	Percent Runoff	Maximum Flow (cfs)	Minimum Flow (acrefeet)
1	16	965	15	20	11
2	18	1020	16	24	9
3	10	599	10	13	7
4	12	695	11	15	9
5	7	412	7	8	4
6	4	220	4	6	1
7	1	79	1	3	0
8	0	22	0	1	0
9	1	50	1	2	0
10	5	311	5	8	0
11	14	847	14	29	1
12	17	1049	17	22	13
		6268	100		

Table 15. Crabtree Creek near Crabtree.					
Month	Mean Flow (cfs)	Volume (acrefeet)	Percent Runoff	Maximum Flow (cfs)	Minimum Flow (acrefeet)
1	1269	77875	24	1682	752
2	671	37217	11	1078	406
3	546	33485	10	839	289
4	453	26890	8	622	306
5	353	21639	7	463	210
6	212	12570	4	431	96
7	85	5238	2	208	31
8	62	3812	1	198	18
9	78	4639	1	275	26
10	217	13326	4	591	65
11	585	34748	11	999	269
12	930	57090	17	1994	407
		328531	100		

Table 16. Thomas Creek near Scio.					
Month	Mean Flow (cfs)	Volume (acrefeet)	Percent Runoff	Maximum Flow (cfs)	Minimum Flow (acrefeet)
1	1064	65333	18	1836	144
2	866	48009	13	1666	176
3	711	43662	12	1504	245
4	560	33251	9	888	298
5	379	23248	6	744	168
6	205	12183	3	682	74
7	80	4884	1	407	30
8	43	2620	1	203	14
9	67	3986	1	251	18
10	177	10871	3	633	25
11	726	43131	12	1898	128
12	1091	66947	19	2310	104
		358124	100		

APPENDIX B

Water Availability Statistics

Table 1. Water availability.

South Santiam River at Mouth ID #: 30200601

Month	Natural Stream Flow	CU + Stor	Net Min. Flow Now	Instream Water Rights	Net Water Available	Percent Withdrawn
1	3160	73.7	3090	0	3090	2.3
2	3400	813.6	2590	0	2590	23.9
3	3230	753.6	2480	0	2480	23.3
4	3020	793.7	2230	0	2230	26.3
5	2070	384.4	1690	0	1690	18.6
6	941	128.9	812	0	812	13.7
7	458	158.3	300	0	300	34.6
8	286	144.6	141	0	141	50.6
9	263	115.1	148	0	148	43.8
10	352	68.3	284	0	284	19.4
11	1450	63.4	1390	0	1390	4.4
12	3110	73.7	3040	0	3040	2.4
Storage	2360000	313500	2050000	0	2050000	

Table 2. Water availability.

Thomas Creek at Mouth ID #: 171

Month	Natural Stream Flow	CU + Stor	Net Min. Flow Now	Instream Water Rights	Net Water Available	Percent Withdrawn
1	399	3.23	396	100	296	0.8
2	433	3.34	430	100	330	0.8
3	425	2.66	423	100	323	0.6
4	349	3.42	346	100	246	1.0
5	205	9.34	195.5	100	95.5	4.6
6	95	16.98	78	50	28	17.9
7	45.5	26.75	18.7	35	-16.3	58.8
8	30	22.24	7.7	25	-17.3	74.1
9	30.8	12.32	18.5	100	-81.5	40.0
10	36.1	3.37	32.7	100	-67.3	9.3
11	189	2.93	185.7	100	85.7	1.6
12	379	3.2	376	100	276	0.8
Storage	295000	6576	288000	60500	234000	

Table 3. Water availability.

Neal Creek at Mouth ID #: 70783

Month	Natural Stream Flow	CU + Stor	Net Min. Flow Now	Instream Water Rights	Net Water Available	Percent Withdrawn
1	37.7	1.24	36.5	60	-23.5	3.3
2	42.4	1.24	41.2	60	-18.8	2.9
3	43.6	1.23	42.4	60	-17.6	2.8
4	39.5	1.28	38.2	60	-21.8	3.2
5	25.7	1.67	24	45	-21	6.5
6	13.3	2.15	11.2	20	-8.8	16.2
7	6.1	2.81	3.29	10	-6.71	46.1
8	3.7	2.51	1.19	5	-3.81	67.8
9	3.79	1.84	1.95	5	-3.05	48.5
10	5.05	1.28	3.77	12	-8.23	25.3
11	28.6	1.24	27.4	60	-32.6	4.3
12	42.5	1.24	41.3	60	-18.7	2.9
Storage	31800	1180	30600	27400	3930	

Table 4. Water availability.

Crabtree Creek at Mouth ID #: 88

Month	Natural Stream Flow	CU + Stor	Net Min. Flow Now	Instream Water Rights	Net Water Available	Percent Withdrawn
1	492	0.53	492	100	392	0.1
2	470	0.54	470	100	370	0.1
3	458	0.33	458	100	358	0.1
4	389	1.26	388	100	288	0.3
5	217	8.07	209	100	109	3.7
6	119	16.34	103	50	53	13.7
7	53.5	27.86	25.7	35	-9.36	52.1
8	37.4	22.75	14.7	25	-10.3	60.8
9	40.1	11.02	29.1	100	-70.9	27.5
10	59.1	1.15	58	100	-42	1.9
11	207	0.39	207	100	107	0.2
12	427	0.5	427	100	327	0.1
Storage	310000	5428	305000	60500	248000	

Table 5. Water availability.

Hamilton Creek at Mouth ID #: 80

Month	Natural Stream Flow	CU + Stor	Net Min. Flow Now	Instream Water Rights	Net Water Available	Percent Withdrawn
1	73	0.26	72.8	40	32.8	0.4
2	82.2	0.27	82	40	42	0.3
3	78.6	0.19	78.4	40	38.4	0.2
4	59.8	0.2	59.6	40	19.6	0.3
5	27.2	0.56	26.7	40	-13.3	2.1
6	13.6	1.12	12.45	15	-2.55	8.2
7	7.76	1.89	5.88	8	-2.12	24.4
8	4.41	1.53	2.88	3	-0.12	34.7
9	4.38	0.74	3.64	3	0.64	16.9
10	4.93	0.08	4.9	20	-15.1	1.6
11	25.4	0.09	25.3	40	-14.7	0.4
12	63.1	0.29	62.8	40	22.8	0.5
Storage	55800	431	55400	19700	36200	

Table 6. Water availability.

South Santiam River at 14187500 ID #: 14187500

Month	Natural Stream Flow	CU + Stor	Net Min. Flow Now	Instream Water Rights	Net Water Available	Percent Withdrawn
1	1970	0.98	1970	170	1800	0.0%
2	2210	750.96	1460	170	1290	34.0%
3	2100	690.95	1410	170	1240	32.9%
4	2080	730.94	1350	170	1180	35.1%
5	1550	300.93	1250	170	1080	19.4%
6	696	12.9	683	170	513	1.9%
7	326	15.04	311	170	141	4.6%
8	191	13	178	170	8	6.8%
9	167	10.89	156.1	170	-13.9	6.5%
10	234	4.9	229.1	170	59.6	2.1%
11	981	4.93	976	170	806	0.5%
12	2070	0.99	2070	170	1900	0.0%
Storage	1590000	250563	1340000	122000	1210000	

Table 7. Water availability.

McDowell Creek at Mouth ID #: 123

Month	Natural Stream Flow	CU + Stor	Net Min. Flow Now	Instream Water Rights	Net Water Available	Percent Withdrawn
1	45.6	0.08	45.57	45	0.57	0.2
2	51.8	0.08	51.67	45	6.67	0.2
3	50.6	0.04	50.58	45	5.58	0.1
4	40.4	0.07	10.38	45	-4.62	0.2
5	19.4	0.25	19.2	45	-25.8	1.3
6	9.75	0.5	9.25	15	-5.75	5.1
7	5.28	0.84	4.44	8	-3.56	15.9
8	2.88	0.69	2.19	3	-0.81	24.0
9	2.86	0.34	2.52	3	-0.48	11.9
10	3.37	0.04	3.3	20	-16.7	1.2
11	17.6	0.03	17.6	45	-27.4	0.2
12	41.5	0.08	41.46	45	-3.54	0.2
Storage	35800	182	35600	21800	15100	

Table 8. Water availability.

Ames Creek at Mouth ID #: 73318

Month	Natural Stream Flow	CU + Stor	Net Min. Flow Now	Instream Water Rights	Net Water Available	Percent Withdrawn
1	18.1	0.18	17.89	25	-7.11	1.0
2	21	0.18	20.79	25	-4.21	0.9
3	20	0.16	19.8	25	-5.2	0.8
4	14.9	0.17	14.7	25	-10.3	1.1
5	6.69	0.25	6.44	13.3	-6.86	3.7
6	2.88	0.34	2.54	5.3	-2.76	11.8
7	1.29	0.46	0.83	2.2	-1.37	35.7
8	0.65	0.41	0.24	1.1	-0.86	63.1
9	0.63	0.28	0.35	0.94	-0.59	44.4
10	0.73	0.17	0.56	1.6	-1.04	23.3
11	4.09	0.16	3.9	14.3	-10.4	3.9
12	14.8	0.18	14.6	25	-10.4	1.2
Storage	13600	175	13400	9810	3770	

Table 9. Water availability.

Wiley Creek at Mouth ID #: 70782

Month	Natural Stream Flow	CU + Stor	Net Min. Flow Now	Instream Water Rights	Net Water Available	Percent Withdrawn
1	148	0.01	148	100	48	0.0%
2	167	0.01	167	100	67	0.0%
3	172	0.01	172	100	72	0.0%
4	157	0.01	157	100	57	0.0%
5	87	0.06	86.9	100	-13.1	0.1%
6	41.2	0.12	41.1	40	1.1	0.3%
7	19.1	0.21	18.9	18	0.9	1.1%
8	9.39	0.17	9.22	14.6	-5.38	1.8%
9	9.48	0.09	9.39	14.2	-4.81	0.9%
10	12.3	0.01	12.3	27.2	-14.9	0.1%
11	66.1	0.01	66.1	100	-33.9	0.0%
12	153	0.01	153	100	53	0.0%
Storage	120000	43	120000	48700	71300	

Table 10. Water availability.

Little Wiley Creek at Mouth ID #: 70784

Month	Natural Stream Flow	CU + Stor	Net Min. Flow Now	Instream Water Rights	Net Water Available	Percent Withdrawn
1	27.4	0	27.4	30	-2.6	0.0%
2	31.7	0	31.7	30	1.7	0.0%
3	33.4	0	33.4	30	3.4	0.0%
4	32.1	0	32.1	30	2.1	0.0%
5	18.9	0	18.9	30	-11.1	0.0%
6	9.31	0	9.31	15	-5.69	0.0%
7	4.11	0	4.11	6.31	-2.2	0.0%
8	1.91	0	1.91	3.14	-1.23	0.0%
9	1.92	0	1.92	3.09	-1.17	0.0%
10	2.64	0	2.64	6.1	-3.46	0.0%
11	14.7	0	14.7	30	-15.3	0.0%
12	30.8	0	30.8	30	0.8	0.0%
Storage	23800	0	23800	14600	9210	

Table 11. Water availability.

South Santiam River at 14185000 ID #: 14185000

Month	Natural Stream Flow	CU + Stor	Net Min. Flow Now	Instream Water Rights	Net Water Available	Percent Withdrawn
1	481	0	481	50	431	0.0%
2	555	0	555	50	505	0.0%
3	550	0	550	50	500	0.0%
4	597	0	597	50	547	0.0%
5	484	0	484	50	434	0.0%
6	209	0	209	50	159	0.0%
7	88.8	0.2	88.8	50	38.6	0.2%
8	54.8	0.2	54.8	50	4.6	0.4%
9	49.6	0.2	49.6	50	-0.6	0.4%
10	65.6	0.2	65.6	50	15.4	0.3%
11	265	0	265	50	215	0.0%
12	520	0	520	50	470	0.0%
Storage	426000	25	426000	35900	390000	

Table 12. Water availability.

Middle Santiam River at 14186500 ID #: 14186500

Month	Natural Stream Flow	CU + Stor	Net Min. Flow Now	Instream Water Rights	Net Water Available	Percent Withdrawn
1	987	0.89	986	0	876	0.1%
2	1140	391.89	448	0	338	34.4%
3	1140	672.89	467	0	357	59.0%
4	1210	728.89	481	0	371	60.2%
5	871	269.9	601	0	491	31.0%
6	352	0.89	351	0	241	0.3%
7	178	0.03	178	0	68	0.0%
8	103	0	103	0	-7	0.0%
9	94.7	1.09	93.6	0	-16.4	1.2%
10	141	0.89	140.1	0	30.1	0.6%
11	554	0.89	553	0	443	0.2%
12	1180	0.89	1180	0	1070	0.1%
Storage	856000	222536	634000	0	555000	

APPENDIX C

Water Use Statistics

Hamilton Creek			
WRIS Code	Use	Consumptive (cfs)	Storage (acre-ft)
DO	Domestic	0.01	
FI	Fish	0.15	7.35
FP	Fire Protection	0.02	0.50
IR	Irrigation	10.78	3.00
LV	Livestock	0.02	
WI	Wildlife		127.00
	Total	10.98	137.85

Thomas Creek			
WRIS Codes	Use	Consumptive (cfs)	Storage (acre-ft)
AS	Aesthetic		0.18
DI	Inc lawn and garden	0.07	
DO	Domestic	6.21	
DS	Stock	0.03	
FI	Fish	3.62	58.34
FM	Forest management		0.06
FP	Fire Protection	0.25	3.00
FW	Wildlife		0.12
IL	Irrigation and stock		5.80
IM	Manufacturing	10.00	
IR	Irrigation	121.04	190.54
IS	Supplemental	1.32	
LV	Livestock	1.21	13.35
LW	Wildlife	0.04	3.95
MU	Municipal	5.75	
PW	Power	55.50	
RC	Recreation	0.23	13.90
ST	Storage		0.08
WI	Wildlife		2.68
	Total	205.27	292.00

Crabtree Creek			
WRIS Code	Use	Consumptive (cfs)	Storage (acre-ft)
AG	Agriculture	0.10	
AS	Aesthetic		4.73
CM	Commercial	0.01	
DI	Inc lawn and garden	0.03	
DO	Domestic	0.07	
DS	Stock	0.10	
FI	Fish	25.82	11.52
FM	Forest management		1.25
FP	Fire Protection	0.18	
FW	Wildlife		6.22
IC	Primary and supplemental	0.90	
IM	Manufacturing	2.20	
IR	Irrigation	123.28	61.55
IS	Supplemental	0.88	17.20
LV	Livestock	0.91	12.08
LW	Wildlife		7.00
PW	Power	65.00	
RC	Recreation		13.00
WI	Wildlife		13.54
	Total	219.48	148.09

Ames Creek			
WRIS Code	Use	Consumptive (cfs)	Storage (acre-ft)
AS	Aesthetic		0.02
DI	Inc lawn and garden	0.03	
DO	Domestic	0.02	
FI	Fish	0.05	
FP	Fire Protection		2.03
FW	Wildlife		1.90
ID	Irrigation and domestic	0.20	
IM	Manufacturing	1.50	23.00
IR	Irrigation	1.03	3.65
LW	Wildlife		4.00
MU	Municipal	2.15	
RC	Recreation		0.30
	Total	4.98	34.90

Middle Santiam River			
WRIS Code	Use	Consumptive (cfs)	Storage (acre-ft)
DI	Inc lawn and garden	0.02	
DN	Inc non-commercial	0.01	
DO	Domestic	0.12	
FI	Fish	5.31	2.00
ID	Irrigation and domestic		1.5
IM	Manufacturing		2.00
IR	Irrigation	0.39	3.60
	Total	5.85	9.10

Quartz Creek			
WRIS Code	Use	Consumptive (cfs)	Storage (acre-ft)
DO	Domestic	0.01	
FI	Fish	0.33	
IR	Irrigation	0.11	
MI	Mining	3.00	
	Total	3.45	

Wiley Creek			
WRIS Code	Use	Consumptive (cfs)	Storage (acre-ft)
DI	Inc lawn and garden	0.01	
DO	Domestic	0.02	
FI	Fish	15.00	
FP	Fire Protection	3.11	
IR	Irrigation	0.67	
IS	Supplemental	0.22	
	Total	19.03	

Foster Reservoir			
WRIS Code	Use	Consumptive (cfs)	Storage (acre-ft)
AG	Agriculture		0.54
AS	Aesthetic	2.00	
DI	Inc lawn and garden	0.21	
DN	Inc non-commercial	0.02	
DO	Domestic	1.52	
DS	Stock	0.01	
FI	Fish	7.55	22.75
FP	Fire Protection	10.34	278.89
FW	Wildlife		4.02
I*	Irrigation, domestic and stock		1.80
IC	Primary and supplemental	2.06	42.00
ID	Irrigation and domestic	0.62	
IL	Irrigation and stock		3.20
IM	Manufacturing	23.77	1089.80
IR	Irrigation	300.01	410.81
IS	Supplemental	8.61	244.01
LV	Wildlife	0.16	26.80
LW	Wildlife		3.47
MS	Mint still	1.12	
MU	Municipal	112.10	
NU	Nursery use	0.11	
PW	Power	325.00	
RC	Recreation	7.11	32.62
ST	Storage	0.80	0.18
TC	Temperature control	0.45	
WI	Wildlife	0.60	27.12
	Total	804.17	2188.01

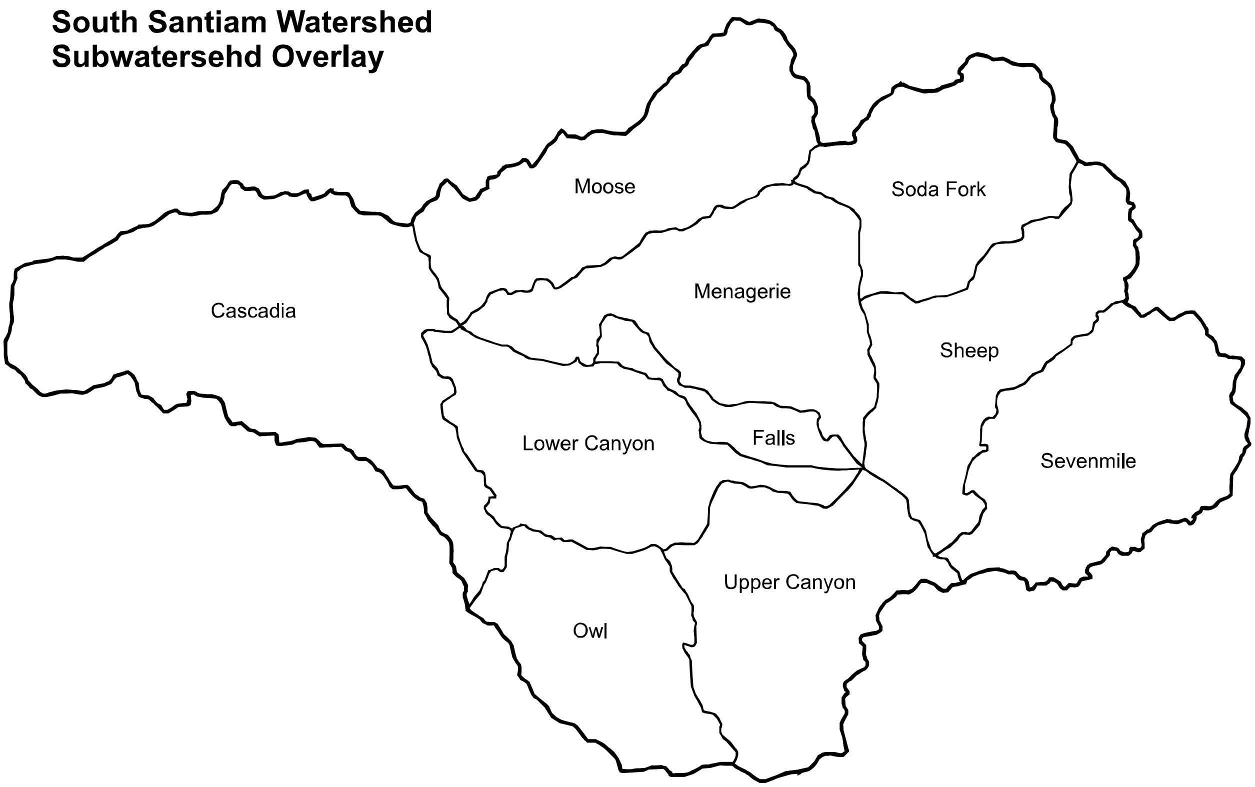
Canyon Creek			
WRIS Code	Use	Consumptive (cfs)	Storage (acre-ft)
RW	Road construction	0.01	
	Total	0.01	

South Santiam River, Headwaters			
WRIS Code	Use	Consumptive (cfs)	Storage (acre-ft)
CM	Commercial	0.01	
DI	Inc lawn and garden	0.16	
DN	Inc non-commercial	0.01	
DO	Domestic	0.96	
DS	Stock	0.01	
FI	Fish	1.00	
FP	Fire Protection	0.30	0.45
ID	Irrigation and domestic	0.50	
IR	Irrigation	0.06	
	Total	3.01	0.45

McDowell Creek			
WRIS Code	Use	Consumptive (cfs)	Storage (acre-ft)
AG	Agriculture	0.37	
DI	Inc lawn and garden	0.02	
DO	Domestic	0.01	
FI	Fish	0.02	0.02
FP	Fire Protection	0.02	
FW	Wildlife		0.02
ID	Irrigation and domestic	0.02	
IR	Irrigation	3.76	9.20
LV	Wildlife	0.01	0.25
RC	Recreation	0.90	31.00
WI	Wildlife		9.00
	Total	5.13	49.49

APPENDIX D

USFS Subwatersheds


South Santiam Watershed
Subwatersehd Overlay
Moose
Soda Fork
Cascadia
Menagerie
Sheep
Lower Canyon
Falls
Sevenmile
Upper Canyon
Owl

Middle Santiam Watershed Subwatersehd Overlay