Pringle, Glenn-Gibson, Claggett, and Mill Creeks Watershed Assessment

Funding provided by the Rural Investment Fund,
Resource Assistance for Rural Environments,
SumcoUSA,
Oregon Watershed Enhancement Board,
and the U.S. National Oceanic and Atmospheric Administration

Pringle, Glenn-Gibson, Claggett and Mill Creeks Watershed Assessment

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for the
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Chapter 1 – Introduction and Purpose of the Assessment

Contents

Introduction and Purpose of this Assessment

This document is the product of a watershed assessment for Pringle, Glenn-Gibson, Claggett and Mill Creek watersheds. It provides current and historic information on the physical, biological and cultural landscape in the four watersheds. The main focus of the assessment was a synthesis of existing data sets and studies pertaining to the four watersheds in order to provide a clear picture of the condition and health of the watersheds at this point in time. This assessment did not collect any new data other than what could be gleaned through geographical information systems (GIS) analyses.

There are two main purposes of this assessment. First is to help council members understand how their watersheds function at an ecological level. This means bringing together all the pieces of the "watershed puzzle" by explaining all the different functions of a watershed and how these functions interrelate. Aspects of the watershed that were studied include historical conditions, water quality and quantity, soils, aquatic and terrestrial habitats, and fish and wildlife. These aspects or functions are dealt with in separate chapters, although their interrelationships become evident when reviewing this document. Every chapter in this document provides background information or a "textbook" explanation of the importance of each watershed aspect. We believe the inclusion of this information was necessary in order for council members and people with non-science backgrounds to understand watershed-specific data provided in this document.

The second purpose of the assessment is to provide information to both council members and members of the community. At a watershed council level, the assessment results can be used to: 1) identify aspects of the watershed that warrant further study and 2) identify ecological functions and habitat types that would benefit from restoration or enhancement. Please note that the assessment does not identify specific locations or pieces of property in need of restoration or enhancement. The purpose of the "Action Plan", the next step in the planning process for the watershed councils, will be to identify specific sites for future restoration and enhancement work based on the information provided in this document.

This document provides a scientific framework for future decision-making in both the public and private sector. Considerable efforts have been made by the authors not to pass judgment or to incorporate the judgments or opinions of others on any particular activity, land use or agency in this document. Recommendations provided at the end of each chapter are based on science and/or the limited information compiled on each subject.

This assessment is a **living document**. It is the intent of the watershed councils to add information to this document as it is collected and analyzed by the watershed councils, other volunteer organizations, government agencies, schools and universities and other organizations. The assessment will be formally updated on a biannual basis. Assessment revisions will be distributed to current assessment recipients.

Methods

The guidance to develop and write this assessment came from two watershed assessment manuals and the questions resulting from an initial meeting of the Intercouncil Watershed Assessment Committee (IWAC). The first manual, the *Oregon Watershed Assessment Manual* (OWAM) (Watershed Professionals Network 1999), was developed specifically for watersheds in Oregon. This manual was used as the basic framework for this assessment. Because the manual was specifically written about large rural watersheds, we used the *Rapid Watershed Planning Handbook: A Comprehensive Guide for Managing Urbanizing Watersheds* (Center for Watershed Protection 1998) as a supplemental guide. Due to time constraints, funding shortfalls and applicability to urban watersheds, not all methods presented in both documents were employed in this assessment (e.g. field verification of wetlands and sediment sources). For the same reasons, not all of the questions generated by IWAC were answered. However, we were able to use information generated from GIS to integrate several data sources and come to some meaningful conclusions.

Channel Habitat Typing (CHT) information for Claggett, Glenn-Gibson, Mill and Pringle creeks is not included in this assessment edition. CHT research will continue and findings will be incorporated into revised assessment editions. Action plans for each watershed will be developed after the CHT work is complete.

Geographic Information Systems (GIS)

All of the maps and most of the quantitative information (e.g. percentage of land use/watershed, percentage impervious surface, etc.) presented in this document were created using GIS. GIS is the compilation of information by specific location, creating the ability to compare different information in relation to spatial locations. The advantage of using GIS, as opposed to paper maps, is that different layers can be combined on a computer to produce quantitative estimates of landscape features. For example, a layer showing the location of current wetlands in the four watersheds was overlaid on a layer showing the location and extent of hydric soils in the watersheds (i.e. soils that are highly impermeable to water). This combination produced a map showing the probable extent of historic wetlands and the location and acreage of existing wetlands. From this information we can estimate the wetland loss in each watershed since European settlement.

Enclosed watershed maps have been reviewed and corrected within the limited financial resources available. Recently generated information on topics such as delinated wetlands or fish species present may not be reflected in these maps. Future assessment revisions will incorporate new research findings.

Public Participation

To guide the preparation of this document a committee consisting of 33 technical advisors, government agency representatives and watershed council members was convened in late November of 2000. The purpose of the first meeting was to identify issues of importance in the four watersheds that may affect water quality and fish habitat. Meeting participants were asked to develop five questions/issues for each of the following topics as outlined by the OWAM: hydrology and water use, riparian/wetland habitat, sediment sources, channel modifications, water quality and fish and fish habitat. The authors of the assessment then attempted to address these questions/issues while compiling data and writing the chapters. The issues are listed in a sidebar at the beginning of each chapter.

Draft chapters of the watershed assessment were mailed to committee members as they were completed. Many committee members provided their comments in writing to the authors within a month of receiving a draft chapter. Other committee members attended scheduled meetings in which they provided verbal comments to the authors directly. Five meetings were conducted for the review of six chapters.

Members of the Intercouncil Watershed Assessment Committee (IWAC)

We thank the many members of this committee for their time and expertise for reviewing this document. Many of the committee members also provided information and data that helped shape the watershed assessment. Members are listed in alphabetical order and include their affiliation.

Les Bachelor.......Natural Resource Conservation Service
Jeff Bickford.......Marion County Solid Waste Management
John Borden.......Oregon Department of Environmental Quality (retired)
Jim Castle.......Glenn-Gibson Watershed Council
Barbara Ellis-Sugi.......United States Forest Service
Dana Fields.......Oregon Division of State Lands
Monte Grahmn.......Marion Soil and Water Conservation District
Gary Galovich.......Oregon Department of Fish and Wildlife
Sue Geniesse.......Friends of Mill Creek
Derek Godwin.......Oregon State University Extension Service
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Tina Schweickert………City of Salem Community Development Dept., Natural Resources
Peter Scott ....Pringle Creek Watershed Council
Dennis Sigreist ....Oregon State Police, Office of Emergency Management
Dorald Stoltz ....Glenn-Gibson Watershed Council
Bill Warncke……………………………………………Pringle Creek Watershed Council
Bob Williams .... Claggett Creek Watershed Council
Jon Yoder ....Friends of Mill Creek and North Salem High School

Additional Reviewers of the Assessment

In addition to the Intercouncil Watershed Assessment Committee, other experts provided input and constructive criticism when needed. We appreciate their efforts and value their input.

Steve Downs..City of Salem Public Works Dept.
Bill Ferber..Oregon Water Resources Department
Jeane Fromm ....City of Salem Community Development Dept., Natural Resources
Peter Gutowsky ....City of Salem Community Development Dept., Natural Resources
Monte Graham..Marion Soil and Water Conservation District
Ernst Lau...Marion Historical Society
Jeanne Miller ....City of Salem Enviro`nmental Services
Heather O'Donnell ....City of Salem Community Development Dept., Natural Resources
Ken Roley..City of Salem Public Works Dept.
Larry Trosi ....Santiam Water Control District

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Rob McDougald... GIS Technical Services Coordinator
Lori Moore...Secretary
Sandra Quatier ....Secretary
Richard Schmid............ Program Director for Transportation and Environmental Planning

A big thanks to Glenn Dolphin, volunteer extraordinaire, who worked tirelessly on photo-rectifying aerial photographs and coding riparian habitat using GIS. In addition to the people listed above, we extend our thanks to many others who provided information for the assessment.

Chapter 2 – Overview of the Watersheds

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MAPS

Overview of Watersheds

Location

The watersheds of Mill Creek, Claggett Creek, Pringle Creek and Glenn-Gibson Creeks all lie in the mid-Willamette Valley (**Map 2-1**). The Glenn-Gibson watershed is located on the west side of the Willamette River in Polk County. The other three watersheds are in Marion County.

The total land area within the four watersheds is approximately 153 square miles. The largest watershed is Mill Creek at approximately 110 square miles. It stretches west from the foothills of the Cascades to the Willamette River. It empties into the Willamette River north of the intersection of D Street and Front Street in Salem. Mill Creek has several tributaries, including Beaver Creek, McKinney Creek and Battle Creek. Water is diverted from Mill Creek into Pringle Creek via the Shelton Ditch and the Mill Race in Salem. The watershed encompasses Salem and several smaller communities, including Turner, Aumsville, Sublimity and Stayton (**Map 2-2**).

Claggett Creek drains approximately 20 square miles. This watershed drains most of East Salem, the city of Keizer, the west portion of Lake Labish and agricultural lands that lie in the north portion of the watershed. The creek flows in a northwesterly direction draining into a slough of the Willamette River northwest of Clear Lake (**Map 2-3**).

The Pringle Creek watershed covers a little over 13 square miles and drains a good portion of south Salem. Specifically, it drains the area north of Kuebler Blvd., west of the Salem airport, and east of the hills identified by the Belcrest Memorial Park and Cemetery. It flows into the Willamette River under the Boise Cascade building in downtown Salem on Commercial Street. It has several tributaries including Clark Creek, West Fork of Pringle Creek, Middle West Fork and East Fork (**Map 2-4**).

The smallest of the watersheds is Glenn-Gibson. It drains approximately 10. 4 square miles of West Salem in Polk County. Glenn Creek flows east and north through the city of Salem and into the West Willamette Slough, northwest of Winslow Way. Gibson Creek is a tributary of Glenn Creek. The confluence of the two creeks is just west of Wallace Road, below the Salemtowne pond. Over 20 small tributaries flow into Glenn and Gibson Creeks (**Map 2-5**).

Population/Land Ownership/Land Use

While the exact population of people in the four watersheds is unknown, the following numbers are estimates using 2000 Census data: Pringle, 34,299; Glenn-Gibson, 19,667; Claggett, 64,888; and Mill, 47,289. The majority of the land is in private ownership with less than 6% of the land held as public property. The predominant land uses in the four watersheds are urban and agricultural (see Hydrology Chapter for land use maps of each watershed).

The Pringle Creek watershed lies almost entirely within the Salem-Keizer urban growth boundary (UGB). Approximately 60% of the watershed is urbanized. Another 27% of the watershed is in agricultural use, primarily in the very southeast portion of the watershed. The watershed contains two large tracts of public land: the Salem airport and the Fairview Training Center site.

About half of the Glenn-Gibson watershed lies within the Salem UGB. Land use is predominantly residential in the east half of the watershed. The upper reaches of the watershed are used for agricultural purposes. Approximately 33% of the watershed is urbanized and 44% is in agricultural use. The Glenn-Gibson watershed is experiencing rapid urban growth in the upper-western reaches inside the UGB.

About two-thirds of the Claggett Creek watershed lies within the Salem-Keizer UGB. Agricultural use is mainly limited to the north portion of the watershed outside of the Salem-Keizer UGB. Approximately 46% of the watershed is urbanized and 45% is in agricultural production. Large areas of public land include the Oregon State Fairgrounds, Chemawa Indian School, and Chemeketa Community College.

The Mill Creek watershed includes part of the city of Salem as well as four smaller communities: Turner, Aumsville, Sublimity and Stayton. Outside of these small communities and the Salem UGB, most of the land is agricultural or rural residential. Only 8% of the watershed is urbanized. About 68% of the watershed is in agricultural production. Oregon Department of Corrections owns several large parcels of land in the watershed.

Climate

The study area has a modified marine climate (U.S. Soil Conservation Service 1972). Winters are cool and wet. Summers are moderately warm and moderately dry. In the Mid-Willamette Valley near Salem, annual average precipitation is about 41 inches, 90 percent of which falls between October and the end of May (Schott and Lorenz 1999). Most of the precipitation received on the valley floor is in the form of rain. The amount of precipitation increases gradually, and the average annual temperature decreases, from the valley eastward to the low foothills of the Cascade

Mountains. About 45 inches of precipitation is received annually along the lower slopes of the foothills (U.S. Soil Conservation Service 1972).

Topography

Elevations in the study area are between 100 feet near the Willamette River to 2400 feet in the foothills of the Cascade Mountains. Hilly areas are located in the Glenn-Gibson watershed of West Salem, in the Pringle Creek watershed and the Battle Creek Basin of the Mill Creek watershed in south Salem, and in the headwaters of the Mill Creek watershed located in the foothills of the Cascade Mountains. There is also an elevated bench marking the edge of the modern floodplain (100 to 500 year recurrence intervals) of the Willamette River in the north end of Keizer. The valley floor is flat with slopes typically 3 percent or less.

Geology and Soils

The Willamette Valley is an inland valley that was at one time part of a broad continental shelf. Uplifting and tilting of both the Coast Range and Western Cascades left a valley in what had previously been a shelf extending from the Cascades to the west (Orr et al. 1992). Tilt of the valley floor is south to north rather than inward toward the center. Hills within the valley such as the Eola Hills in West Salem, the Ankeny Hills in south Salem and the Waldo Hills north of Turner are blocks of volcanic rocks (Columbia River Basalts) uplifted along faults (Schott and Lorenz 1999).

From about 15,500 to 13,000 years ago there was a series of glacial floods that came down the Columbia River and backed up into the Willamette Valley. These floods covered parts of the valley with up to 350 feet of water. Ice jams at the mouth of the Willamette River slowed retreat of floodwaters. Soil formations in the valley are the results of silts and clays settling out of the massive flood events (Schott and Lorenz 1999).

Geologists suspect the Willamette River has meandered across the valley in several locations. At one time the river may have followed an easterly course, flowing northward through a gap between the South Salem and Waldo Hills in the present day location of Mill Creek. Lake Labish in the northern portion of the study area likely represents an old channel of the Willamette River following a course that is now the Pudding River. Alluvial deposits from the Cascades coming down Abiqua and Butte Creeks deposited material on the eastern side of the valley, pushing the river to the west. Deposits may have dammed the river, creating Lake Labish. The thick layers of peat in the ancient lake suggest the area was once a swamp or bog (Schott and Lorenz 1999).

Deposits of gravel interspersed with layers of silt, clay and sand are located below the flat terrain that stretches from Stayton east to Turner and south to the North Santiam River. These deposits can be up to 100 meters thick (Crenna and Yeats 1994) and were episodically flushed into the area by the ancestral Willamette and North Santiam Rivers. The North Santiam River transported glacial outwash from the Cascade Mountains, laying down fan-like deposits in the Turner and Salem areas. These layers of silt and clay are discontinuous lenses, which impede surface infiltration and create perched water bodies and high seasonal water tables. The gravel resources in this alluvium have been, and are currently, extensively mined in the Turner and south Salem areas along Mill Creek (MWVCOG 2000).

Wetlands in the Salem-Keizer area are a reflection of the relatively level topography. Most are found in mineral soils, on fine clay deposits which settled in swales and depressions. They are slow-draining, holding water for a significant portion of the growing season (Schott and Lorenz 1999).

Vegetation

Before European settlement, the mid-Willamette Valley was composed of a variety of native plant communities (**Maps 2-6** and **2-7**). An excerpt from Marion County's *Natural Heritage Park Selection and Acquisition Plan* (Marion County Public Works Department 2000) summarizes the nature of the land prior to European settlement:

> Drawing from information found in early land surveying records and settler accounts, we can recreate a picture of the landscapes that greeted this area's first pioneers. The pre-settlement landscape that they saw was not untouched by humans. Native Americans had managed the valley by using deliberately set fires as a way to maintain game habitats, desirable plants, and open areas. Some of the early landscapes such as the scenic oak savannas and native grass prairies that covered much of the Willamette Valley were a direct result of this fire ecology (Boyd 1999). Along the rivers spread forests of cottonwood, alder, ash, and the other hardwoods, sometimes for miles back from the banks. Extensive wetlands formed along the winding rivers and also made up shrub swamps, wet prairies, and marshes (Oregon Biodiversity Project 1998; Hulse 1998).

Urban development, changes in hydrology (e.g., channelizing streams and swales for stormwater management), logging, agriculture, and fire control have altered historic plant communities in the Salem-Keizer area (Schott and Lorenz 1999) (**Table 2-1** and **Map 2-8** and **Map 2-9**). With increasing settlement of the area came deliberate fire suppression, intensive agricultural and forestry practices, and an influx of new plants. In comparison with pre-settlement conditions, areas that once held ecosystems such as the oak savannas, wide riverside forests, expansive wetlands, and open prairies, now features growing urban centers, highly productive agricultural and forested areas, and rural homes (Hulse 1998).

Table 2-1. The six primary ecosystems in Marion County and the percentage lost since the 1851-1865 Federal General Land Office Survey

Pre-settlement Ecosystem Type	% Original	% Lost
Closed Forest: riparian-wetland	10.5 - 14%	71.8 - 57.6%
Shrubland	0 – 2%	100%
Prairie	26.1%	99.4%
Savanna	50.6%	87.9%
Woodland & Closed Forest: upland	10.8%	86.7%

Source: Kagan et al. (2000)

Table 2-2 shows the historic vegetation communities of the four watersheds. Prairies and savannas dominated the landscape in Pringle, Glenn-Gibson and Mill Creek watersheds (**Maps 2-6** and **2-7**). The Claggett Creek watershed had the most diverse landscape of plant communities. In addition to prairies and savannas, the Claggett Creek watershed also contained upland and riparian forest communities. Shrublands once dominated Lake Labish.

Table 2-2. Acres of Historic Vegetation Types per Watershed Prior to European Settlement[1]

	Pringle	Glenn-Gibson	Claggett	Mill
Closed forest; Riparian & Wetland	59	96	1140	413
Closed forest; Upland	0	0.00	4230	3298
Emergent Wetland	0	0	23	0
Prairie	185	1262	6185	31449
Savanna	8281	6739	3574	31729
Shrubland	0	0	726	882
Water	0.3	31	169	0
Woodland	0	0	409	1732

[1]Data Source: Kagan et al. (2000)

An analysis of aerial photographs from 1993 by ODFW has provided some information on the current vegetation communities in the Willamette Valley (ODFW 2001). Urban and agricultural vegetation communities currently dominate the four watersheds (**Table 2-2** and **Maps 2-8** and **2-9**). Non-native species such as English Ivy and Himalayan blackberry are frequent in the "managed" vegetation community found in urban areas. Urban areas are also dominated by cultivars and non-native vegetation planted for landscaping purposes. Native understory vegetation has been replaced by mowed lawns in many areas. Agricultural areas are managed for the production of food and goods. Native vegetation is typically limited to strips along waterways and in areas where poor soils limit agricultural production. The heavy use of pesticides in both urban and agricultural settings is indicative of how humans manage these vegetative communities (see Water Quality Chapter).

Table 2-3. Acres of Current Vegetation Types by Watershed[1]

	Pringle	Glenn-Gibson	Claggett	Mill
Urban	5097	2657	7631	5644
Agricultural	1545	2954	6666	38954
Unmanaged Pasture[2]	780	599	776	8489
Riparian/Wetlands	444	481	1017	5245
Oak/Fir/Madrone	479	1245	115	5702
Upland Forest	180	194	252	3817
Unclassified Forest	0	0	0	1670

[1]Data Source: ODFW (2001)
[2]Unmanaged pasture is considered an agricultural use. It is shown as a separate category to highlight the fact that these areas have a high potential for inclusion into habitat protection programs according to ODFW. The display on Maps 8 and 9 shows that many of the areas coded in this category are simply fallow or unmanaged lands, not necessarily abandoned pasture.

Agriculture

The type of crops grown in areas dominated by agriculture depends on the topography and soils. Perennial grass production for grass seed and hay is the major agricultural use in the Pringle Creek watershed. Orchards are common in the hilly landscape of the Glenn-Gibson watershed. Agricultural uses vary in the Claggett Creek watershed. Perennial grasses and row crops (e.g. onions in Lake Labish) are common in the watershed. Vineyards and hops are commonly grown in the agricultural fields north of Keizer on the fertile land of the Willamette River floodplain. Agricultural uses in the Mill Creek watershed are varied and many. Approximately 61% of land in agricultural production is used to grow perennial grasses in the Mill Creek watershed. The second most common agricultural use is unmanaged pasture at 18%. Over 8,000 acres of land is categorized as unmanaged pasture. ODFW believes that land in this category has a high potential for inclusion into habitat protection programs. Other agricultural uses in the Mill Creek watershed include row crops, annual grass production and Christmas tree farms.

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Chapter 3 – Historical Conditions

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Historical Conditions

Introduction And Methodology

This chapter provides an overview of historical conditions for the Pringle, Glenn-Gibson, Claggett, and Mill Creek watersheds. The purpose of this chapter is to provide insights into how each watershed appeared from the time of the early inhabitants up to the present. With a better understanding of the watershed's natural history and cumulative land-use changes, this information can be used to help guide future restoration actions. Historical information was collected and written by members of the Pringle, Glenn-Gibson, and Mill Creek Watershed Councils and Friends of Mill Creek, using the guidelines outlined in the *Oregon Watershed Assessment Manual.*

Pringle Creek Watershed

History of Pringle Creek Watershed

By Wendy Kroger

Introduction

Long before the population of the City of Salem had grown to nearly 140,000 people, and before 40,000 vehicles crowded downtown's Front Street every day, and before a public debate raged about whether to build a fountain in Riverfront Park, citizens of our fair town could watch ice skaters as they swooped across the Willamette Slough and see ferries loading tons of high quality flour -- locally produced flour from wheat grown in the immediate vicinity -- from docks owned by Salem Flouring Mills at Front and Trade Streets (Becktel 2001).

A short walk south, at Bush's Pasture Park near the Bush Barn where thousands of art lovers now gather each year during the Salem Art Fair, is a grove of oak trees that probably are the progeny of another stand of oak trees -- in the exact same spot -- that were flourishing when Columbus discovered America (Chapman 1995).

And before there was a community hospital straddling Pringle Creek, or a major electronics industry pumped out gallons of ground water daily from beneath its building alongside Pringle Creek, thick riparian forests flanked the banks of the streams that emptied into the Willamette River. Back then, settlers coming up the Willamette would have seen mighty Oregon white oaks, big-leaf maples and scatterings of Douglas fir dotting the savannas (Marion County Public Works 2000). In a June long gone, when the ship *Lausanne* -- the Mayflower of the Pacific -- came to Chemeketa Plains, sailors en route to our area would have seen upland prairies awash with waving perennial grasses and envisioned wheat fields (Rutledge 1957). They would have spotted plump salmonberry growing in the seeps and swales and along the wet slopes of ravines that cut swaths through the numerous forests. They might also have noted red huckleberry in shrub swamps and brush prairies along the way and, in the upland forest areas, thickets of thimbleberry. They certainly would have seen meadows of camas exactly as described by explorer Meriweather Lewis: "resembling a lake of fine clear water" (Lewis 2001).

Before there was a sea of parking lots, streets and roofs in downtown Salem, the spot now occupied by the intersection of State and Commercial Streets at one point of geologic history was under 243 feet of water and the land where Hilfiker Lane is now in the southeast part of town, all the way around to the grounds of West Salem's new high school, was lakefront property. The waters from the massive "Lake Missoula Floods" are thought to have crested about 400 feet above sea level here, and the last of those gigantic cataclysms -- of which there were perhaps 40 that broke loose from glacial dams in Northern Idaho -- generated walls of water 200 feet high which contained 800 times the energy of the 1980 eruption of Mt. St. Helens. Kalapuya native legends include a description of a "water beast" which once roamed the Willamette Valley floor (Jacobs 1945).

Natural History

F*loods*. Forty million years ago, all of Marion County was under water. In the next ten million years, volcanic activity set the Cascade Mountains into upward motion and Oregon climbed out of the water. The uplift of the South Salem Hills happened about the same time. Weather exposed and decomposed the topmost peaks of those hills, leaving them capped with bauxite, the most common aluminum ore. World War II shortages caused the nation's eyes to glance at those hills and interested parties to secure reserves. In the last million years the Ice Age came to North America, but glaciers did not cover the Willamette Valley. Instead, over time, gigantic glaciers covering much of the rest of the Northwest began to melt, their droplets becoming walls of water -- the Lake Missoula Floods -- which poured southward into the Valley, creating a huge, freshwater lake, called by some a "Willamette Sound." Icebergs in Central Washington broke loose and ended up floating on the new lake. Chunks of rock came with the icebergs and were left stranded when the ice melted. One ended up in front of Collins Hall at Willamette University. For many years after the disappearance of the Valley lake, seasonal floods surged from the Willamette River to the eastern and western borders of the Valley. As the water overflowed the banks of the river, its velocity was greatly reduced so that much of its load of sand and silt settled to the bottom near the river, with only the finest mud remaining to drift farther out before settling. Thus the valley floor was built highest near the river in the form of broad natural levees. These natural levees along the river and its streams are only slightly higher than the surrounding flood plain. In a result that questions logic and sometimes causes confusion, upland plants are more likely to grow close to the streams on the drier levees, while wetland plants often grow farther away on the flood plain (Clark 1957; Guard 1995).

Early Life. Active current anthropological research in Woodburn indicates humans lived in the Valley approximately 12,000 years B.P., based on human hairs recovered from undisturbed marshland clay deposits. DNA testing has not been completed, but early indications point toward a conclusion that the hairs belong to "a much older and unrelated population in North America than any that are currently known." Carbon - 14 tests on stone artifacts discovered at the same location add weight to the conclusion that humans were in the area as long as 12,700 years ago. They are the earliest dated artifacts yet to be found in the Willamette Valley (Hibbs pers. comm.).

The Curator of the Condon Museum of Fossils at the University of Oregon has identified numerous Pleistocene and post-Pleistocene fauna fragments from strata at the Woodburn site including ground sloth, mastodon, dire wolf, bear, possibly sabre-toothed cats, big-horn sheep, horses and the largest known Pleistocene bird, the *teratorn* with a 14-16 foot wingspan, and the first to be found north of the La Brea tar pits archeological site in Los Angeles. Twelve thousand years ago, horses, camels, mammoths, bison, deer, bear, panthers, tigers and lions roamed the Willamette Valley. Thousands of birds, including giant condors, hawks, eagles, geese and ducks nested in the area (Hibbs pers. comm.; Allen and Burns 1986).

Location and Climate. Salem sits in the north-central part of the Willamette River Valley basin and straddles the east and west banks of the Willamette River. At an elevation of approximately 150 feet above sea level, Salem rests in a natural basin formed by the westward Eola Hills rising between 900 and 1,000 feet, the Waldo Hills to the east between 500-600 feet, and to the south the volcanic South Salem Hills rising 600-700 feet. The Willamette River does something unique in Salem: it is the only place along its entire length where it does not flow across wide expanses of flat floodplain but instead pinches between two sets of bedrock hills: South Salem and Eola. Midway between the North Pole and the Equator, the Willamette Valley has a climate described as Northwestern Mediterranean: dry summers and wet winters, warm summer days with cool nights. Average rainfall in Salem is 39.16 inches a year, and according to local weather and climate records, the average date fall rains begin is October 18th. The only day on which no measurable precipitation has ever occurred is July 12 (City of Salem 2001a; Bell pers. comm.).

Soils. The last and largest floods formed the major geologic features of the Willamette Valley including the rich deposits of alluvial soils upon which Salem sits today. The Salem area has soils ranging from "first rate clay loam to first rate sand or alluvial, stony and gravelly," according to an 1851 report of the Surveyor General. Much of downtown Salem north of Pringle Creek sits on well-drained Woodburn soil along creek corridors and on broad valley terraces. Lower Pringle Creek to its mouth is Clackamas gravelly loam (C-K). Salem's Civic Center is grounded on Columbia River Basalt, but the builders of Fire Station #1 at the corner of Liberty and Trade searched downward 30 feet before they found bedrock, and a pond was noted at Liberty and Trade in 1890. A potential "soil creep zone" parallels the bank line of the Willamette River and Slough approximately a half-block west of Commercial (City of Salem 2001a and 2001b; Marion Soil and Water Conservation District 1971; City of Salem Urban Renewal Agency 1972; Moore pers. comm.).

Three geological zones meet in the general area of City Hall, Pringle Plaza and the downtown fire station. One is basalt rock, but the other two are alluvial gravels and sediments. This mixed area can pose problems for the structural stability of large buildings. East of Church Street and above Pringle Creek's immediate riparian zone, geophysical characteristics are primarily that of Linn Gravel Formation (QLg): surface soils which are a mix of silty clay ranging in depth from one to ten feet underlain by 40 to 120 feet of medium to fine alluvial gravels which in turn overlie basalt rock or sedimentary deposits. Moving upstream and out toward the ancient volcanic South Hills is a great diversity of soils, mostly Courtney (Cu), Nekia (NeB slope 2-7%), Nekia (NeC slope 7-12%), Nekia (NeD slope 12-20%), McAlpin (MaA slope 0-3%) and Silverton (SuC slope 2-12%) (City of Salem Urban Renewal Agency 1972; Marion Soil and Water Conservation District 1971).

Streams. It is believed that in ancient times the North Santiam River emptied into the Willamette River by flowing from Stayton through what is now downtown Salem rather than flowing south of the city as it does today (City of Salem 2001c). Early pioneers may not have realized that when they cut through the gravel bar at Stayton and brought Santiam River water via the "Salem Ditch" to Mill Creek in 1855, their success was due to a former watercourse (Salzmann 1984). While Salem boosters celebrated the wall of muddy water that arrived in Salem in 1855, folks living in Jefferson and along the Santiam mourned this turn of events.

Maps depicting Salem through the last 150 years show a bewildering array of streams threading, tumbling, wending and meandering their way through South Salem, sometimes changing course from season to season. Kalapuyas and settlers alike sought out and made use of springs, seeps, rivulets, and changing stream courses. The settlers' redirecting of streams only added to the natural confusion.

For example, in about 1864, the first Waller Dam (named after Reverend Waller on whose land the dam was built) was constructed at 20th and State Streets to split Mill Creek. The southern split became the millrace, which ran along Ferry Street to about 14th, through Willamette University, after which it rode in a flume along Trade Street to Liberty where it was used to produce power for Salem Flouring Mills. Later, it was buried under several industrial buildings, surfacing downstream at a City generating station at Liberty and Trade. In the fullness of time, actually in 1971, urban renewal arrived, resurrecting, refurbishing and redirecting South Mill Creek (or the millrace/flume) so that today it brings the enjoyment of a burbling waterway in Pringle Plaza to a public in need of diversion from urban speeds and sounds. A couple of blocks downstream it joins Pringle Creek at Mirror Pond near the City Center complex (Salzmann 1984). On the 1878 Illustrated Atlas Map, Pringle Creek is joined at Church Street by Shelton Ditch and a stream of mystery which split south from the Mill Race, beginning between 12th and 13th, Mill and Trade Streets, flowing north of and roughly parallel to Mill Street until it turned almost 90 degrees south along Church Street, crossing Bellevue. Two earlier writers note this stream. According to landscape architect Elizabeth Lord writing a description of Pringle Park, "...There was Pringle Creek meandering through Bush Pasture, the Shelton Ditch in natural state, very attractive trees on the bank and the third, Mill Creek, all three joining hands under the Church Street bridge..." (Lord 1983). Dan J. Fry, an early settler who grew up in Salem, notes in his story that "...a small stream ran along Church Street into Mill Creek (now called Pringle Creek) which was very clear and a good fishing stream..." (Fry 1998a).

There appears to be agreement about the general locations of Mill and Pringle Creeks. Discrepancies arise over their forks and tributaries. It got more complicated after settlers began damming the creeks for waterpower, creating millraces and flumes, digging ditches, splitting creeks, "straightening" channels, and finally filling in and paving over entire streams.

Some streams never had names; some were spoken of pejoratively because they were "muddy," or just plain in the way. The banks of many were used as trash dumps --- out of sight, out of mind -- a practice that continues today. What will future anthropologists think of us as they go through our middens? A Volkswagen has become part of the bank riprap, nose-down into Pringle Creek near Berry Street SE. In the year 2000, 10,740 pounds of trash were taken from Pringle Creek, and that's good news: In 1999, more than 12,000 pounds were pulled out of the creek.

Other streams just faded away. Where is Arbor Creek? Where is Railroad Creek? Did Shelton Ditch begin as a 1930s Great Depression work project to tame Mill Creek flood waters? Maps show another Shelton Ditch (or Creek) in the mid-1800s coming off Mill Creek east of Airport Road, curving "in natural state, very attractive trees on the bank," crossing a corner of the Post Office property on 25th, and traveling along Shelton and Mission Streets for several blocks (Chapman 1995). The Depot Addition Historic Landmark Nomination indicated that the ditch was built on an earlier alignment of Turner Road, which was abandoned in 1931.

According to a City of Salem Public Works memo regarding the Shelton Ditch/Winter Street Bridge Flood Mitigation Project, "Shelton Ditch was 'constructed' generally along the existing Shelton Creek alignment..." (Lambert 1998). Is South Mill Creek really Pringle Creek, or is it the old Shelton Ditch, or is it the old flume? To complicate matters further, Mill Creek overflows during flood conditions to both the East and Middle forks of Pringle Creek.

Most people today cannot follow the course of Pringle Creek, its forks and tributaries, in and out of pipes and culverts and people's backyards from their various points of origin in the South Hills. Confusion about where these streams originate is not new. For example, while it now skirts Gilmore Field, Clark Creek used to meander diagonally across Judson's cow pasture and Lewis E. Judson remembers catching "big rainbow trout" in the stream more than 70 years ago. Where the bench rises near 12th Street, seeps still run (Smith pers. com.).

During the 1960s and early '70s, South Salem High students conducted many natural and environmental science studies on the hillside next to Clark Creek at Gilmore field. Other youth recall building forts on the hill next to seeps (Crawley pers. comm.). They were probably unaware that the Chemeketa Indians had been there before them. In other early reports, Clark Creek joins Pringle Creek near Hines Street at about the same place that a stream, now gone, traveled north through the Depot Addition area to join Shelton Ditch (Salzmann 1984). Before the mid-1970s, South Salem High School biology students observed frogs, small stream animals and dragonflies in the riparian area of the braided, meandering channel behind the school (Smith pers. comm.).

Today Clark Creek is ditched at right angles, travels in and out of pipes, and shares space with trash and blackberries in a straight, narrow, unshaded concrete sluice box between the ball fields of South High and neighbors' backyards. Its latest improvement is one provided in the summer of 2001: a 48" pipe carrying stormwater and street and parking lot runoff flows underground from several blocks west, runs under the school to Howard Street, coming to light a few feet above, and perpendicular to, where the concrete-lined channel of Clark Creek goes underground for good. An eternal optimist could find something good about Clark Creek spending the rest of its life underground in a pipe: because Clark Creek is out of the sun, its water temperatures are several degrees cooler (thus affording one of the few places cutthroat trout have been observed recently) when it meets Pringle Creek near where it flows between Deepwood and Bush's Pasture Park (Andrus 2001).

Earlier drainage patterns appear to have provided their share of runoff to Pringle Creek. Portions of Ferry and Trade were chronically under water most of the year. Dan Fry speaks of much of Ferry Street being built on stilts to avoid standing water in the street (Fry 1998a). Even today, chronic surface flooding and storm drainage surcharging occur at Mission and Liberty Streets. A proposed but as yet unfunded storm sewer project is planned in 2002 to address the situation there.

Gravity, seeps, springs, and seasonal rain and runoff feed the many forks, tributaries and diversions of Pringle Creek as it travels through much of southeast Salem on its way to the Willamette River, falling its last 30 feet over a weir dam under Commercial Street, then past Boise Cascade to the Willamette Slough at the south end of Riverfront Park. The complex system drains 13.3 square miles, almost all of which is within the Urban Growth Boundary.

The Paths of Pringle Creek. The West Fork begins with springs near Liberty and Boone Roads, flows through Cannery Park, dives in and out of culverts and under streets and a few homes, daylighting in people's backyards above and below the open areas of Judson Middle School, Carson Springs Natural Area, Woodmansee Park, and the Pringle Creek Nature Preserve. Short tributaries such as Alder Brook and Stagecoach Brook are now piped to join the West Fork on the west side of Commercial Street. But in 1910, Alder Brook, a small branch of Pringle Creek and fed by Maple Spring, was photographed meandering through Woodmansee Park (Duniway 1987a).

Meanwhile, Clark Creek begins near Idylwood just east of Liberty Road and flows diagonally across the Faye Wright Neighborhood under Browning, through Hidden Lakes, under Madrona and Commercial, buried under the Fred Meyer store, coming to light in Clark Creek Park, traversing back yards to where it skirts Gilmore Field, then on to South Salem High where it is reduced to a concrete sluice box at the eastern edge of the ball fields, then buried once again under backyards and the lower Lefelle parking lot until it surfaces for the last time to join Pringle Creek in Bush's Pasture Park.

Back upstream, the West Fork of Pringle Creek crosses under Commercial near the 12th Street intersection in a large reinforced concrete box culvert measuring five feet wide by five feet high by 230 feet long which Oregon Department of Transportation reports show was in the ground in 1968 and now assumed to prevent fish passage upstream (Downs pers. comm.). The West Fork daylights again and flows through another patchwork of open stream and closed pipes to Leslie Middle School and Fairview Training Center. After Fairview Training Center, it splits its flow with the West Fork diversion at the Middle Fork near Madrona Avenue; both ultimately incorporate the Middle Fork and carry it forward to where the East Fork meets the West Fork at 14th and Oxford.

The West Middle Fork continues on, capturing flows from the area around Pringle School and north along Reed Road, gathering in flows from Hillcrest and along Strong Road, continuing in mitigated meanders on both sides of Fairview Industrial Drive, eventually joins the Middle Fork near the southwest side of the Union Pacific Railroad tracks which follow the northern boundaries of Mitsubishi Silicon America (now SumcoUSA) and Yamasa. Having built in a wetland, SumcoUSA daily pumps gallons of cold, clear water from springs under its building into the West Middle Fork. The old Hillcrest Ditch, which drained agricultural fields prior to industrialization, was mitigated with a created meander between SumcoUSA and Yamasa. Planting projects continue in this area in an attempt to shade this part of the West Middle Fork.

The Middle and East Forks drain farm fields south and east of I-5, skirting or flowing out of wetlands around Fairview Industrial Park. Some 40+ acres of complicated wetland mitigation projects continue with varying success in this area. The Middle and East Forks share waters via a double culvert on the west side of I-5 under the Union Pacific Railroad trestle and roughly parallel one another for a time -- one on each side of the UP Railroad tracks -- flowing northwest through flat, flood-prone areas interspersed with rail road tracks and manufacturing plants. At the meander, they go their separate ways: the Middle Fork moving on to meet the West Fork and the East Fork flowing north by the airport, past Spinnaker a.k.a. Webb Lake, crossing McGilchrist and more heavily industrialized properties, the City shops, through Walling Pond to its meeting with the West Fork at 14th and Oxford by the Union Pacific Rail yards. Contrary to popular belief, Pringle Creek does not normally flow into or out of Spinnaker a.k.a. Webb Lake. It skirts it -- unless there is a flood.

Pringle Creek, all its forks now together, picks up Clark Creek at Bush's Pasture Park immediately south of Deepwood. From there, the main stem of Pringle Creek flows between Bush's Pasture Park and Deepwood, crossing under Mission, flowing between Salem Cardiology and Oregon School for the Blind on the south side of the stream and Salem Hospital and Pringle Park on the north. Pringle Creek flows under, and during flood conditions, into Salem Hospital. Shelton Ditch flows on the north side of Salem Hospital and Pringle Park while Pringle Creek edges the park on the south. They come together just west of the Church Street bridge, flowing ever northwest along and through Pringle Plaza, under Liberty Street to Mirror Pond where they are joined by the Millrace. From there, they flow under Commercial Street and Boise Cascade to the Willamette Slough.

Chemekatas and Chemawas

It is likely that in the winter of 1839, the winter before Jason Lee bargained with local Native Americans for a site on which to build his saw mill and grist mill, Chemeketa and Chemawa Indians came together as they always did at the place of meeting and formed their winter camp on Chemeketa prairie where Salem now stands. The Chemeketa and Chemawa were clans of the Kalapuya tribe. (Some researchers indicate that the Chemeketa and Chemawa were part of the Santiam Tribe which, in turn, was part of the Kalapuyan Indian Family). While the Chemeketas lived in the Salem area, the Chemawas lived about ten miles down river from Chemeketa prairie, near the Methodist Mission, and circulated from the Willamette River to the Cascade Mountains, going no further north than the Molalla River. The trail the Native Americans followed between Chemeketa and the mountains to the east became a road when traveled by white settlers. With very little change in location it is now known as State Street (Strozut undated; Gilsen 1998; Oregon Department of Transportation 1984; *Capital Journal* 1972; Clark 1957).

Native Americans made their seasonal encampments near springs. In the Salem area there were large springs near the present site of Boise Cascade downtown, in the area of the Yew Park subdivision between Hines/Mission and 12th/13th and along the creek banks between Bush School and the railroad station. Because of these springs, Indians made their winter encampments at these locations, generally called "Chemeketa," which, according to one pioneer, meant "our home." Ancient sweathouses, used to cure sickness by the Kalapuya, were often near springs also (Marion County Historical Society (b); Salzmann 1984; Clark 1957; Strozut 1951; *Capital Journa*l 1972).

*E*xisting today on the bench land south and southeast of the South Salem High School, are but the slightest traces of pits used by the Native Americans during at least part of their many centuries of dominance of this region. These pits, eleven in number, were evidently in use when Jason Lee and his party arrived in the Willamette Valley. The northern most of these pools (or pits) was located near what is now the southwest corner of Bennett Field where football is now played. The southernmost pit was increased in size to become the basement of a house on Summer St. SE in Salem. The westernmost was located near the center of the block surrounded by Rural, Electric, Church and Cottage Streets; the easternmost was somewhat east of the center of the block surrounded by Summer, Raynor, Electric and Hoyt Streets. All that remains of any trace of these pits at the present time is but the slightest trace of two of them. One trace is a slight settling of the west curb in Cottage Street a short distance south from Rural. The other trace is a place in the north curb of Electric Street a short distance east of Winter Street. "..The pits were kept full of water channeled in from springs higher on the hills. These springs almost completely disappeared when the forests were removed from them. Those remaining have long since been drained" (Judson 1971).

According to Lewis E. Judson, grandson of Lewis H. Judson who surveyed Salem in 1850, he used to play in an "Indian sweathole" located directly back of (old) Leslie School, on the south side of the school grounds. When Leslie School, now Howard Charter School, and the playground (Bennett Field) were constructed, all traces of the sweat hole were obliterated, even though Judson said he begged the construction superintendent to save it for posterity (Strozut 1951). Bennett Field was named for Captain Charles Bennett (1811-1855), Salem area entrepreneur, builder of posh Bennett House in 1850 and the steamship *Canemah* in 1851, reputedly a co-discoverer of the California gold fields and killed in the Yakima Indian wars (Marion County Historical Society (b)).

Judson also noted that at the time of the initial development of the South Salem High School grounds, "considerable trouble was experienced" in controlling the flow of water from a spring near what was then the corner of Winter and Oxford Streets (*Capital Journal* 1972). Now Clark Creek has been "improved" so that it flows around South Salem High in a concrete ditch. "Strange that the schools teach ancient Greek mythology and history of other nations, while at the same time destroying our own," Judson said (Strozut 1951).

Pringle Creek was the scene of "almost yearly" flooding, and before "relief measures were affected," many Indian relics were found in the 12th and Mission Streets area. Farther south along the creek, there was evidence of "much hunting, arrowheads of good quality, scrapers for treatment of animal skins, and both good and broken mortars and pestles... There were at least fifty plants with edible roots in this area, but the most important were the camas and the wapato" (Tompkins 1964).

Members of a Chemeketa band usually included five to ten families and in the summer they stayed in a summerhouse. The remnants of one such house was found at 2600 Pringle Road SE, according to retired Willamette University sociology professor John A. Rademaker. This home was 80 feet long and accommodated four families. Family members slept on tule mats laid over gathered moss on a shelf built for sleeping around the top of a fire pit. The thatched roof had a long hole in it from 12 to 14 feet above the fire to let the smoke out. Winter homes were built using wedges and hammers made from obsidian to split boards from logs. After ridging and grooving the edges to interlock, the Indians used the planks for siding and sometimes for the roof (*Capital Journal* 1972).

Chief Quinaby, who was reported to have died both in 1878 and 1883 and is reportedly buried under the trees at the corner of Mission and University inside Bush School grounds, told historian Henry Brown that he distinctly remembered the first white man who settled in the Willamette Valley. It was Joseph Gervais, a member of the 1805 Lewis and Clark party who returned in 1809 and settled on French Prairie. Quinaby's mother was a Chemawa and his father was a Chemeketa. When the missionaries moved the Indian Mission Manual Labor School to Chemeketa prairie in 1840, they found Quinaby among the Indian residents. Quinaby's Salem area home is said to have been in the brush near Bush School, a spring, a stream and the Salem passenger depot (Brown 1878; Marion County Historical Society 1974).

Estimates of the number of Kalapuya in the Willamette Valley vary widely. One report states that, at their peak, as many as 80,000 Kalapuya are thought to have lived in the Willamette Valley. Lewis and Clark estimated a Native American population in the Willamette Valley of 9,000 in 1803. Outbreaks of smallpox prior to 1803, probably spread by trappers and other explorers, wiped out a third of the population, so the pre-1803 estimate would be approximately 13,500 (Marion County Historical Society (c); Boyd 1986).

According to State Archeologist Dr. Leland Gilsen, the Willamette Valley drainage basin consists of 12 sub-basins. Of these the Santiam basin is the largest and most complex, and it includes the Calapooia Creek system and the larger watersheds on the east side of the valley draining the Cascades. The correlation between language groupings and drainage basins strongly suggests that river sub-basins were the basic social, economic and political units of Kalapuya groups. Archeological evidence suggests that each drainage basin or watershed was an economic unit containing all of the resources needed for support of the groups living within it (Gilsen 1998).

The economic seasonal round based on gathering and hunting followed the movement of ripening plants up the valleys. Lower elevations are warmer than higher ones, so plants reach maturity at slightly different times of the year as spring and summer warm their way up the valleys. Gatherers are dependent on wild plants as their primary source of food. As valued plants mature and produce edible crops, the groups would move camps to exploit their seasonal availability.

For the Willamette Valley groups, the key plants were bulbs (camas), seeds (tarweed), berries, and nuts (acorns). These four plant foods supplied a seasonably abundant and predictable plant food base for the native economies. Three of the four plant groups benefited from a fire regime. Studies of fossilized pollen have determined that the oak-savanna wetland environment has dominated the Willamette for over 6,000 years (Hansen 1942).

About 3,500-3,000 years ago, the Kalapuya began to practice "pyroculture" -- systematically burning portions of the Willamette Valley. This reduced the climax forest into an open grassland/forest mosaic where fire-resistant oaks dominated and camas and tarweed moved into the grasslands. Burning removed competing plants and encouraged the re-growth of tarweed, camas and filberts. Fires "are generally lighted in Sept. for the purpose of drying the seeds of the [blank] (sunflower). Which is then gathered and forms a large portion of their food" (Wilkes 1845). Another reference indicates that "it was the custom of these Indians, late in the autumn, after the Tarweed (also known as wild wheat or *lamoro sappolil*) was fairly ripe, to burn off the whole country. The grass would burn away and leave the sappolil standing, with the pods well dried and bursting. Then the squaws both young and old, would go with their baskets and bats and gather in the grain" (Applegate 1914).

The wet forests along the streams and river resisted the burns, forming linear gallery forests. The edge habitat of either mosaic or grassland, oak forest and riverine forest, was a rich place for berries to grow and perfect habitat for deer and elk. Evidence indicates "ownership" of valued areas of production. Tarweed patches were so valued that they were "owned" by specific groups. Camas patches also appear to have been "owned" by groups, and multiple campsite locations clustered around valued camas patches. The same place was probably not be used year after year, but one of a group of places was used each year. Rotation of camps allowed nature to cleanse and compost previous camps (Gilsen 1998).

Camps were located to take advantage of camas patches and placed near gallery forests or oak forests for a ready supply of wood for camas roasting ovens. Camas roasting ovens used stones and leaves of maple and ash. The most readily available supply of stones in the lowlands were the rivers, and maple and ash are riparian species. Archeological studies along Mill Creek done as part of I-5 and Kuebler Road construction opened up "camas oven after camas oven." Archeological work along the NW Pipeline project down the east side of the valley indicates that sites were clustered on the tributary streams of both the Willamette and its major tributaries along the boundaries of the gallery forests. Testing the sites revealed a camas processing industry concentrated on these streams. Data suggests that exploitation of wood from the forests was leading to stripping out of the gallery forest trees for camas processing, leading to the increasing abandonment of streams because wood was no longer available (North Santiam Watershed Council 2001; Gilsen 1998).

Early observers noted that the Native American men were seldom over five and a half feet tall, and women scarcely above five feet. Both sexes were strong though "loosely built," wintering in puncheon cabins or skin-covered teepees. The Native

Americans were hunters who hunted big game such as deer, elk, bear, ducks, geese and swans, and they were gatherers, harvesting "an abundance of freshwater fish, acorns, seeds, roots and fruits including crabapples, wild cherries, elderberries, huckleberries, salal, several species of wild raspberries, 'luscious' blackberries and strawberries" (Strozut 1951).

*W*hat vision unfolded before the Methodist missionaries and settlers who came to the Willamette Valley? One vast oak forest, interspersed with groves of fir undisturbed by fire, which the Indians had found necessary to induce the deer to remain in the valley, dotted undulating hills. The fir groves show that for not less than 1500 years the civilization of the Native Americans had remained practically stationary. In that time, great trees had grown up and other great trees had fallen down. Debris up to three feet deep was found lying in the forests. Through the seasons, Native Americans had harvested acorns from the oaks, hazelnuts, seeds from tarweed, camas bulbs and berries. They had established methods of sustainable harvest and lived well in the Valley (Strozut 1951).

The U.S. exploring expeditions of the 1840s noted, "The Indians had communication with various tribes by runners or canoes, and they always knew when to go somewhere to trade with a number of other tribes" (Strozut 1951). Historian Henry Brown wrote in 1878 that it was the custom of these inland tribes,

> ... (so I was informed in an early day) to purchase all of the dried salmon that they consumed of the Indians who resided at the Willamette Falls, now Oregon City, paying for the same in camas, dried meats and pelts. It is well known to all settlers of the Willamette valley that but very few salmon succeed in surmounting the falls at Oregon City, therefore the Indians living at that place had a monopoly of that highly necessary species of food for the Indians, and at certain seasons a brisk trade was carried on among them (Brown 1878).

Indian mothers taught their babies to swim by taking them and walking out into the water, which was perhaps waist deep, and tossing them in the water. When the baby had kicked around a little and had started choking, the mother picked it up and repeated the swimming lesson. It was found that after about four times the baby could swim; by the time they could walk, the children could also swim (Strozut 1951).

The Native Americans often went naked: "Jason Lee required that whenever an Indian came to the Mission or to a white's home, he must be at least partially dressed because he usually wore only his 'birthday suit' in his own camp" (Strozut 1951).

The Native Americans' situation deteriorated rapidly. "Twenty two years after the arrival of Jason Lee in the Willamette Valley (1856) what was left of the Indians, after the white man's diseases had taken their toll, was removed by treaty from their ancient homes to some of the poorest land in the Valley. They had caught malaria, small pox and measles from early French fur trappers and American/Europeans who began to visit the Valley. When they moved to the Grande Ronde Reservation in the 1850s, fewer than 1,000 made the journey" (Gilsen 1998). Worse yet, government officials were often purposely lax, and wrongly sold off the Indians' own property (Strozut 1951).

Settlers

*O*ur geographic landmarks are called Lee, Leslie, Judson, Pringle, Quinaby, Bush, Hilfiker, Minto, and Hrubetz. They carry utilitarian names such as Mill, Trade, Ferry, Commercial, and visionary names such as Liberty, Fairview, Mission and Bellevue. They are also named Oak, Yew, Water, Berry, and honor the place called Chemeketa and the river called Walamet. What is behind those names? What ideals and strengths did the settlers bring to their new home?

According to family historian Roy V. Ohmart, Fabritus R. Smith stood in his doorway near Marion Square on Christmas Day, 1846 and watched the arrival of the Pringle family party who had left Missouri the previous April and been among the first immigrants to try the very difficult Southern Road of the Oregon Trail. As their story unfolded, Smith discovered that they had suffered incredible hardships and delays, losing nearly all their belongings and barely surviving (Steaves 1927; Ohmart 1960).

Octavius Pringle was 14 when he came across the Oregon Trail. The number of wagons that joined the family along the way totaled 68. Orus Brown, maternal uncle of Octavius Pringle, was appointed pilot because he had crossed the plains twice before. Pringle wrote, "It was on the 15th day of April, 1846, that a family of nine persons, consisting of father, mother, three sisters and four brothers, left Warren County, Missouri, equipped with two ox teams and provisioned for a six months' journey of over two thousand miles, across the almost unknown, savage wilderness of wild, savage beasts and men, of vast plains of sand and desert wastes and wild and rugged mountains to the then Territory of Oregon, upon the sunset shores of the Pacific Ocean" (Pringle 1847).

Orus Brown started out from Ft. Hall, leading his train down the old emigrant trail. His company arrived in Oregon City in September. But several families were persuaded to take the southern route, including Tabitha Moffett Brown, founder of Pacific University and mother of Orus Brown, and her daughter Pherne Brown Pringle and family. Sixty-six-year old, 96-pound Tabitha Brown wrote, "Our journey was pleasing and prosperous until we passed Fort Hall. Then we were within eight hundred miles of Oregon City, if we had kept on the old road down the Columbia River. But three or four trains of emigrants were decoyed off by a rascally fellow..." (Spooner 1929).

After many months of weary travel, their numbers, supplies and strength exhausted, the settlers who took the Southern Road arrived at the southern edge of the Oregon Territory, still 300 miles from any help and facing streams beginning to swell from cold winter rains. The storm that brought the rainy season to Oregon on October 21 is the same that trapped the Donner Party in the Sierra Nevada. Tabitha Moffatt Brown wrote, "I rode through (the Umpqua Mountains) in three days at the risk of my life, on horseback, having lost my wagon and all that I had but the horse I was on. Our families were the first that started into the canyon, so we got through the mud and rocks much better than those that came afterward. Out of the hundreds of wagons, only one came through without breaking. The canyon was strewn with dead cattle, broken wagons, beds, clothing and everything but provisions, of which latter we were nearly all destitute.... Some people died without any warning from fatigue and starvation. Others ate the flesh of cattle that were lying dead by the wayside" (Spooner 1929).

Going through Cow Creek Canyon had required fording the icy snow-water-filled creek thirty-nine times. Many waded chest-deep in the water and Mrs. Pringle carried her most precious household goods on her head as she waded the creek. During the Cow Creek Canyon episode, according to Octavius, "The extremity had now come, with famine and starvation staring us in the face." The family sent Octavius on its only horse to find and return with provisions stashed over the next mountain range 125 miles away at a depot established by the Mission at Salem for the relief of immigrants. It took three days to reach the depot. Lashing upon the emaciated mare as much dried peas and wheat graham flour as he thought she could carry, he started back to his family, on a foggy, rainy day (Spooner 1929). After a sleepless night spent in a tree, he came upon an Indian wickiup. Knowing he'd been seen and fearing the worst, he went into the camp and discovered the people came from Jason Lee's mission at Salem. Seeing his condition, they "took care of my things and myself as though I had been a brother" (Pringle 1847). They sent him on his way the next morning with venison for his people. He had been gone for six days.

In another week, the family reached a large Indian camp (about where Eugene is) where most of their oxen died under cold rains and heavy snowfall. While waiting for the roads to harden enough to travel on, Octavius and his father, both accomplished shoemakers, made shoes for Indians in the area in trade for venison. The notation in the diary of Virgil Pringle, 1846 for November 11-13 reads: "Lay by to repair shoes and lay in a stock of meat; get 3 deer and a salmon from the Indians..." (Pringle 1846). Shortly thereafter, provisions again gave out and Virgil Pringle set off on horseback to find help. Many days later, he returned with Orus Brown who had come south to find them, bringing four pack horses and provisions for their relief.

Traveling along the west side of the Willamette, they crossed the Long Tom, Mary's, Luckiamute and Rickreall rivers without benefit of bridges or ferries, and, wrote Octavius Pringle:

> every small, insignificant branch, creek and swell was a swimming river, but, nevertheless, upon Christmas Day we landed at Salem, barefoot, weary and worn out.... When we reached the summit of the Polk county hills just west of Salem, we looked down upon Salem, prairies bordered with grand forests and settlers' cabins and a few buildings clustered around that old mission, called the Oregon Institute, now the Willamette University, and it looked as if a scrap of civilization had made a tremendous leap of three thousand miles and dropped down in this

> beautiful valley. To this hungry, footsore and weary boy it looked like paradise and the end of a long and weary pilgrimage (Pringle 1847).

Then it snowed for three weeks.

The next September, Fabritus R. Smith married Virgilia, the oldest of the Pringle girls. Shortly thereafter, they claimed, settled and began farming 626 acres in South Salem proved up as Donation Land Claim No. 47. Almost a square mile, the Fabritus R. Smith Donation Land Claim's north edge was at what is now McGilchrist and it stretched east from Commercial Street to 12th Street, a short distance west of the stage route to the South via Parrish Gap and Jefferson. Their first home was a log house at the foot of the hill near Gerleon Street. Three children born to them in this house all died of diphtheria.

When gold was discovered in California, many men from Salem, Fabritus R. Smith among them, joined the gold rush. Returning a few months later and a thousand dollars richer, Fabritus Smith went on to become one of the largest landowners and most prosperous farmers in Salem (Ohmart 1960).

In recalling his youth in the 1880s, Lewis E. Judson, grandson of one of Salem's founding fathers Lewis H. Judson, said that Salem was considered a farming town. Most of the farms averaged around 300-325 acres, the largest owned by Mr. Smith, who farmed around 400 acres of wheat, oats, with some sheep and cattle. Usually found on Salem's early farms were houses, barns, chicken coops, potato hills and a smoke house. Smith was a progressive farmer and stock breeder, interested in the latest machinery and methods. He partnered with John Minto to import purebred Merino sheep, Jersey cattle, and fine horses. He served his community as Vice President of the Board of Trustees for Willamette University and as an Oregon legislator in 1876 and 1878 (Strozut 1951; Ohmart 1960).

When the stage road was changed to South Commercial Street, also known as "The Road to Albany" and 99E, the Smiths built a new frame house in 1854 just east of the new road where Waldo Avenue now is. Here three more children were born, surviving to old age. The oldest, Valleda, married Roy V. Ohmart (Ohmart 1960).

In the 1850s, the pioneer era was in full swing. Population and agriculture increased, and a system of roads and ferries was developing. Outside of downtown Salem, there was still much open land and significant modifications had not yet been made on channels and riparian areas. Making their mark were herds of free-range cattle, some being remnants of the Methodist Mission herds, and swine which escaped and lived well in the wild. These roaming herds and wild pigs had to have impacted the meadows and waterways of the Pringle Creek watershed through grazing, trampling, and spreading introduced seed (North Santiam Watershed Council 2001).

Virgil K. Pringle married his wife Phernie Tabitha Brown Pringle a year after emigrating from Connecticut to Missouri. Twenty years later, they brought their family, skills and energy to Oregon. Virgil Pringle had farmed in Missouri, but mostly he operated a prosperous boot and shoe shop. In his diary, Virgil Pringle wrote on November 25, 1846, after having led the way through the mountains into the Willamette Valley from the south: "Camped on the Willamette, handsomest valley I have ever beheld. All are charmed and think we will be repaid for all our suffering" (Ohmart 1956; Steaves 1927).

Lewis H. Judson concluded that "The choices of some persons arriving early seem strange to later inhabitants. Red rocky hills were often chosen when the best of silt loam was available, but each had his reason for choosing where he did" (Strozut 1951). Fear of malaria was often a guiding influence. Arriving after months on the trail over barren plains, the settlers saw the Willamette Valley as a paradise. Grass and wild lavender-blue flowered pea vines were interwoven to waist or even shoulder height. As one who arrived in the late spring of 1844 described it, "The scene was so beautiful that it seemed almost a sacrilege to ride my horse through it" (Judson 1971).

The Pringle family first took up land near Stayton, but then settled just south of Salem, on the creek that bears the family's name (Steaves 1929). Pringle Creek was described as four miles wide when nearly dry and flowing northeast (Andrus 2001). According to various records, Virgil K. Pringle claimed 633 acres on behalf of himself and his wife under provisions of the Sept. 27, 1850 Donation Land law which created the Office of Surveyor General of the Public Lands, provided for a comprehensive General Land Office (GLO) survey of, and made donations to settlers of, those public lands. Married settlers arriving in Oregon before 1850 were entitled to 640 acres, providing they settled and improved their property with a home, barns and farming (Duniway 1987b). Single men could claim 320 acres.

According to the Donation Land Claim Map (Marion County Assessor's Office undated) Virgil K. and Phernie Pringle's almost square mile of land took up portions of Sections 14 and 23, Township 8, Range 3 of the West Willamette Meridian. Immediately northeast was their son Clark's claim for 640 acres (Marion County Clerk's office undated). Clark Pringle joined the volunteers to put down the Indian uprising resulting in the 1847 massacre (Chapman 1995) at the Whitman mission, and afterward married one of the girls rescued from the Indians, Catherine Sager (Steaves 1927).

Pringle Elementary School was built in 1934 at 4985 Battle Creek Road SE, with the likelihood that two rooms of the structure were built as early as 1914 and subsequently relocated to the current site. The school was named for Clark Pringle, who established a Donation Land Claim in this area in 1873 (Oregon Department of Transportation 1984). Land at the southeastern corner of Virgil's land was claimed by Sam L. Clarke, Oregon Statesman editor from 1869-72. In his description of how Battle Creek got its name, Sam L. Clarke wrote, "South of Salem, a few miles, a creek pours through the beautiful hills, to enter Mill Creek, and there I located my donation in 1853" (Clarke 1905). Octavius Pringle filed a donation land claim for almost 303 acres on Minto Island and later traded it to Sam A. Clarke for his land in South Salem (Marion County Historical Society (f)). The claims of the immediate Pringle family totaled more than 2,250 acres, or approximately three and one-half square miles.

The Pringle lands were gently rolling hills, mostly white oak savanna and upland prairie covered with perennial grasses. Hills rose to the south and east. On higher ground stood open groves of Willamette Valley Ponderosa Pine, remnants of which are quickly disappearing with current development along South Commercial Street. There was an aspen grove near the John Minto Donation Land Claim northwest of the confluence of Waln and Battle Creeks, according to the General Land Office survey maps of 1850-51 (Marion County Public Works Department 2000). One fir tree was noted as being 40 inches in diameter and one white oak was 36 inches in diameter.

Pringle land stretched from a point near Fabry Road midway between Sunnyside Road and Commercial Street SE south to Neakanie, east across I-5 and Battle Creek Road, and north as far as Marietta Street and Reed Road. Much of the southwest corner of Sam Clark's/Octavius Pringle's land was covered by extensive wetlands just upstream from the confluence of Battle and Waln Creeks (Marion County Public Works Department 2000). According to *Oregon Geographic Names,* "Pringle Creek, Marion County... This stream arises in the hills of South Salem, and it flows through the southern part of town. Virgil K. Pringle, who arrived in Salem on December 25, 1846, took up a Donation Land Claim near the stream, which was accordingly named for him" (McArthur 1982).

While the Pringles came overland to Salem, other early settlers had come even earlier to the "Eden of this New World, the beautiful, and fertile Valley of the Willamett," (Judson 1957), traveling by sea and upriver from Oregon City along the Willamette River. Settlers came to the Willamette Valley in the mid-nineteenth century for many reasons: to minister to the Indians; to start new, productive lives; to settle the West with "Americans" to prevent the British from making good on any claims to the territory; to seek opportunity and wealth. Indeed, in an 1843 report on The Oregon Mission and concerned that Jesuit Priests might move into Oregon, David Leslie wrote: "...There is however one portion of this field which more *appropriately* belongs to *us* (the Methodist Mission*),* I speak of the Eden of this New World ...This valley at present embraces what is and is to be the site and center of a civilized population. There are at present about one hundred and sixty white men the most of whom have families. About two thirds of them are Canadians, --The remainder are mostly Americans, Some few English and Irish..." (Judson 1957).

What did the settlers see when they came up the Willamette River? Naturally curious, "...Pioneer children were no different from children everywhere. They first learned the peculiarities of their surroundings. They found raccoon, skunk, grouse, ruffed grouse, and native quail. As spring came on there were the wildflowers, spring beauties, buttercups, johnny-jump-ups, lamb tongues, cat ears, and white lady-slippers... When wild strawberries or blackberries appeared for the table, mother was pleased" (Judson 1971).

Grown-ups saw natural resources waiting to be cut, plowed or caught -- this was a place to build saw mills to take advantage of the area's water power and timber and grist mills to grind high quality flour from wheat which they would grow on the prairies. The town would become a center of commerce: places where wheat was ground into flour, oaks and Douglas fir were turned into lumber, window sashes and doors. Apples became cider, merino sheep provided top grade wool via the Mission Mills, an iron foundry, slaughterhouses, warehouses and mercantile and drug stores served an increasingly prosperous town (Judson 1971).

Central to the mission in Salem was the Indian Mission Manual Labor School. The school, which replaced an earlier one built at Mission Bend, was built on the current site of Willamette University in 1842. It was built apart from the remainder of the mission to try to separate the Indian children from the white community and the diseases they carried (Chapman 1995). "They (the missionaries) wanted to teach the Indians to settle down and eat what they produced instead of what they found" (Strozut 1951).

Ironically, "The settlers were essentially a restless lot, speculators and those looking always for better land. Lewis B. Judson took out his claim on the banks of the Willamette River and by 1878 it belonged to Albert Davidson. Judson had acquired another river front claim to the south... Similarly, John Minto did not stay long on his hilltop farm between Commercial and Pringle Road, but acquired the O.M. Pringle claim which included the north part of Minto Island" (Duniway 1987c).

The Oregon Institute was organized in 1842 to educate the children of the missionaries. Land on Wallace Prairie near the current Oregon State School for the Deaf was purchased for the school. In 1844, the Indian school property was sold to the Oregon Institute. Founders of the Oregon Institute feared claim jumpers would seek to take over the land near the Institute because the school was not incorporated and thus could not hold land in its own name. Four surrounding landowners, W.H. Willson on the north, H.B. Brewer on the east, David Leslie on the south and L.H. Judson on the west all enlarged their land claims to encompass the school grounds and surrounding property. In 1846, Willson became the agent of the Institute and the Institute land was transferred to him and his wife. The area surrounding the Institute was then divided into small lots and sold with the intent of endowing the school with the proceeds. Mrs. Willson refused to relinquish her right to the lands north of State Street; thus, sales from those properties benefitted her, not the Institute (Judson 1957).

Arriving as part of the 1837 "First Reinforcement" dispatched by the Methodist Board of Missions after urgent pleas by Jason Lee were Methodist ministers David Leslie, a student of French who decided at age 39 to become a missionary in Oregon upon becoming friends with Jason Lee, and Lewis H. Judson, a school teacher, wheelwright and cabinet maker who was self-taught in medicine (Strozut 1951). Among the tools Judson brought with him was a magnetic compass -- priceless to the man who would be Salem's first surveyor (Marion County Historical Society 1991). Judson's sister Adelia, who later married David Leslie, came to Salem at the same time.

Judson was the Willamette Mission's cabinetmaker and in 1840 became superintendent of construction for the new grist and saw mills at the place called Mission Mills for the first two years of its existence (Strozut 1951).

Three years later, the "Great Reinforcement" of 52 people came on the *Lausanne* , arriving in June, 1840. The machinery, flour mills, lumber mills, and a stock of goods for sale brought on the Lausanne were destined to play a very important role in the economic progress of the Willamette Valley. (Rutledge 1957). After leading missions of exploration in 1840 and returning to the old mission station that fall, Lee and Leslie agreed that the home station should be "removed to a spot near the Indian village of Chemeketa... There, on somewhat higher ground and slightly back from the river, water power could be developed" (Judson 1957).

In his section on street names in Salem, Judson wrote: "The Street named Chemeketa perpetuated the Indians' name for their village, which was located on the edge of a forested area, extending from the present Liberty Street on the east and Mill Creek and the Willamette River on the north and west and narrowing to a point at Pringle Creek on the south" (Judson 1971).

Judson family stories relate traditions about the name of the town:

> In the many informal gatherings of the women aboard the *Lausanne* in 1839-40, there was much time for talk of the homes which they had left and the speculation as to the place where their new homes would be established. According to what they were told by Jason Lee, the new site was on the bank of a creek at the edge of a pleasant prairie and near a wooded area. They were missionaries, and like the Israelites of old, travelling to an unknown land. Among the unsolved mysteries which lay ahead was a name for the place to which they would ask their people to direct letters. They wished a Biblical name and favored the name Salem as being the last part of the word Jerusalem (Judson 1971).

An unfortunate but immediate need was met with the establishment of Pioneer Cemetery in 1841 on land donated primarily by David Leslie. Life was hard. In 1841, Leslie's wife died leaving him with five daughters. By 1843, he had lost four daughters and a son-in-law. Remarrying in 1844, he built the fourth house in Salem on his land claim lying between what is now Mission and McGilchrist streets and between the east edge of Bush Pasture Park and the Willamette Slough. He cleared the ground and planted a large orchard extending from south of what is now Miller Street to Mission Street and from Commercial Street to his yard fence. He died in 1869 (Judson 1957).

The third house in Salem was built by Lewis Judson in the middle of the block surrounded by Commercial, Court, Liberty, and Chemeketa. Later it was moved up to face Court Street. Among its later inhabitants were the Pacific Christian Advocate and the famous (or infamous) North Star Saloon of "Sandy" Burns (Strozut 1951).

Members of the Mission in the presence of Lewis Judson told of a Fourth of July celebration "held on the south bank of Pringle Creek west of South Commercial Street, near a freely flowing spring which was located north of Bellevue Street and about one hundred feet west of Commercial Street. This probably took place between 1841-1843. One of the women in the group was very susceptible to poison oak and spoke of existence of some nearby. A man who had no fear of the shrub cut it down and burned it. The smoke carried to a number of people in the party and they were severely poisoned" (Judson 1971).

Lt. Neil M. Howison, U.S.N., visited Oregon in 1846 and wrote back to his folks about a sixth spot by the name of Salem, of which, he relates, "too little exists to be worthy of any attempt at description" (Strozut undated).

In the winter of 1847, a year after the Pringles came to town, 400 Chemeketa and Chemawa Indians formed their usual winter camp in Salem. They suffered a great deal that winter. Measles broke out among them which was, according to Henry Brown's report in December 1878, "very fatal from their mode of doctoring the malady. It was simple sweat houses and a plunge in the ice cold water of the creek. There was at least one half of the encampment that died" (Brown 1878).

Where the Chemeketa had previously gathered for generations in winter camps between Mill and Pringle Creeks along the Willamette River, a town sprang up. Where the Chemeketa had for generations laid their dead to rest, commerce took over.

While Mr. Brown reports that the burying ground was "in the flat above the Capitol Lumbering Company Mill," (Brown 1878), other sources indicate "when an Indian died, the body was usually taken to an island in the Willamette River and placed in a part of a canoe, or most usually, it was left on top of the ground. The island always flooded during the winter, and all the bodies floated away. Small children were sometimes placed in boxes which were hung up only in oak trees, never in any other kind of tree" (Strozut 1951). The July 1890 Sanborn Map #1 shows an island at the mouth of Pringle Creek (Marion County Historical Society (g)).

In a 1951 interview Lewis E. Judson said the Indian cemetery was on a small island only a short distance from the east shore of the Willamette River. The island was filled in and used by Capitol Lumbering Company Mill, built in 1866 (Strozut 1951) and located on Front Street between Ferry and Trade Streets. (Westenhouse 1998). By 1878, Capitol Lumbering Company employed 20 men, was powered by two steam engines, and produced 25,000′ of lumber a day (Marion County Historical Society (d)). The Capitol Lumber sawmill grew to cut 1,500,000 board feet annually (Maxwell 1957).

Salem Flouring Mills, located at Front to Commercial and Trade Streets, was reported in 1878 to be the largest flouring mill in the state, run by two water wheels with five sets of burrs grinding 500 barrels of flour daily, and employing 25 men (Maxwell 1957). "Steamboats run up to the mill and are unloaded by an elevator. The company annually loads several ships for foreign ports" (Marion County Historical Society (d)). According to Daniel J. Fry, as a boy "... it was fun to watch the wheat going in there (Salem Flouring Mills) and the flour coming out of the bin, and the boat was landing right there to load the flour aboard to go somewhere.... And the flood conditions were always of interest. One time there was enough floodwater in town for one of the boats to tie up right at the corner of Ferry and High Streets. At that time the street was kind of a swamp arrangement and was covered with water whenever the water was high" (Fry 1998b).

By 1909, the C.K. Spaulding Logging Company was located on the old Capital Lumbering Company site, where it used the "Spaulding Slough" just upstream from the mouth of Pringle Creek for its operations. It continued in operation until 1941. In 1942 the Oregon Pulp and Paper Lumber Division took over the site. The lumber and paper mill enterprises expanded south and encompassed the old Salem Flouring Mills property, as Boise Cascade does today (Strozut 1951). In the mid-twenties, the paper company's warehouse was built over Pringle Creek (Smotherman pers. comm.). In 1890, where Riverfront Park is today, sat piles of lumber, long lines of sawdust piles extending along the river bank, planing and lath mill buildings, warehouses, Salem Wharf and a roadway serving the Oregon Railway and Navigation dock at the foot of Trade Street.

Soon after the first of three stations to occupy the Salem depot site opened in 1870, economics dictated service to Salem's growing industrial area near the Willamette River. O&C Railroad built a spur through the Willamette University campus to Trade Street which served twelve active industries before ending at its Front Street freight house. In 1912, the spur was extended north along Front Street and it became part of Salem's electrified streetcar system (Austin and Dill 1987). "Electric Avenue was a real estate promoter's dream in which was envisioned an electric car line on that east-west street, connecting a line on Commercial Street with one on Twelfth Street and thus forming a loop road" (Judson 1971).

After World War II the number of industries along Trade and Front Streets declined and in 1980 urban renewal resulted in the relocation of one set of tracks along Front Street, with a second set, and those on Trade Street, being lifted altogether (Austin and Dill 1987). The "Acid Ball"-- now called Eco-Earth and soon to be available for viewing by visitors to River Front Park-- was used in the pulp and paper industry. A footbridge and a covered bridge crossed both the Salem Flouring Mills' flume and Pringle Creek (Ladd and Bush Quarterly 1913).

In late 1848, "every able-bodied man went to the California gold fields. After March 1851, there was a good deal of building in Salem, for gold dust in large quantities had been coming from the California mines" (Strozut undated). Rivalry arose between what had been the main business center prior to 1848 at the confluence of Broadway and North Liberty Streets near the Mission Mills, and what became an area of booming expansion near Commercial, Front and Ferry Streets at the mouth of Pringle Creek and along the Willamette (Marion County Historical Society (e)).

Men returning with their gold dust started steamboating on the Willamette River and the main landings were at the foot of Ferry Street. The steamship "Hoosier" arrived from Oregon City carrying mail and passengers. Many of the goods found their way to Salem's first retail stores, but some was ferried west across the Willamette River. When the Hoosier left Salem, it was carrying passengers and outbound freight including agricultural goods, much of which was bound for the California gold fields. An increasing number of homes settled in among the oaks and firs in the central downtown district (Strozut undated). The Fourth of July was celebrated in 1851 with an oration by E.M. Barnum and a great barbecue in the vacant lot east of Commercial between Bellevue and Oak Streets (Brown 1957).

General Joseph Lane, upon assuming the duties of the first Territorial Governor in 1849, proclaimed Oregon's capital to be Oregon City. The legislature disagreed, and, in 1850, passed an act locating the seat of government in Salem. In 1851, the *Oregon Statesman* moved from Oregon City to Salem. Its editor was Asahel Bush. The *Statesman*'s office was in a two-story house belonging to J.W. Nesmith on the corner of Front and Trade Streets, located near where the Salem Flouring Mill was afterward constructed (Brown 1957).

South Salem was first settled in the 1850s, although it was not platted until 1878. The area between Mission Street and Fairmount Hill, Luther Street, the Willamette Slough and Commercial had several interesting nicknames including Sleepy Hollow, Coon Hollow and Starvation Gulch. Logs from Fairmount Hill and others rafted up the Slough went to a sawmill at the foot of Owens Street. As was often the case, a flour mill was also built nearby. By 1865, the mill had been sold and moved to the foot of Ferry Street. The area languished for the next 25 years, until the streetcar line brought suburban living to South Salem out Commercial to Pioneer Cemetery (Duniway 1987c).

In 1855, the area between Commercial Street and the Willamette River was still a "thicket," and creek bottoms afforded a favorite camping place for visiting Indians. In a 1979 study of Salem's riverfront, writers noted that "several existing pedestrian paths have been pioneered through this vegetation to the shore. Despite natural attractions, such as the water and vegetation, use of the river and its bank will be difficult because the riverbank is very steep. The bank continues to recede sharply once it reaches the water" (City of Salem Urban Renewal Agency 1984b). When the legislature assembled in 1855, there were "few accommodations" for its members. It met in the residence of J.W. Nesmith. On December 30, 1855, a suspicious fire destroyed the brand new capitol building. (Strozut undated).

In 1859, Lewis H. Judson's son, Robert, purchased five acres from David Leslie for $75. From this acreage, located near the Willamette River according to Lewis E. Judson , he logged over 2,500 cords of wood. "By 1861 when he was 19 years old, he had five horses, a pig and a cabin full of oats in addition to his acreage" (Strozut 1951). About December 1, 1861, "...the most disastrous flood that every occurred in Oregon was experienced, " (Brown 1957) and in its aftermath Robert lost four of his horses due to starvation and cold. "The pig was saved, and one horse lived also, but was soon stolen and probably went to work in the mines in southern Oregon. The oats were lost with the cabin which was washed away in the flood" (Strozut 1951). Later he rebuilt. His son, Lewis E. Judson, was born in the house located at 1000 Judson St. SE. He hand-dug his well and got water at 51 feet (Strozut 1951).

In the 1861 flood, the Willamette River swept away every mill, warehouse and dwelling house, from the mouth of the creek on Mill Street (Pringle Creek), north and west of Front. The river covered all of Salem from where the Commercial Street bridge now stands to the corner of Willamette University, and the water was sufficiently deep near the courthouse to swim a horse. There was a broad stream of water extending from west of where Reed's Opera House Mall is today to the corner of G. W. Gray's brick building, which was at the northwest corner of State and High Streets. The flood destroyed a great quantity of property in Salem.

B.M. Durelle's steam sawmill, which had just been rebuilt after burning down in the summer of 1859, washed away; Brown and Rector lost a cider manufactory, and a warehouse containing a vast amount of wheat, apples and other produce was swept away. "Hundreds of horses, cattle and other stock were drowned throughout the Valley, and many persons lost their lives, and entire farms were swept clear of every vestige of improvement" (Brown 1957). Mr. J.G. Wright sketched the first South Commercial Street Bridge in 1853. It was ruined by the flood of 1861 and replaced by a covered bridge, which was removed in 1892 because it collected filth and to build a structure the full width of the street (Ladd and Bush Quarterly 1913).

Prior to the 1861 flood, the Willamette River flowed between Isaac "Whiskey" Brown Island and John Minto's Island, so that Minto Island was on the east bank and Brown Island was on the west bank of the river. After the flood subsided, it was discovered that the river had changed its course to the present location (Waitz 1976).

Lewis E. Judson wrote in 1971, "there were places in Salem where people who respected their reputation did not go" (Strozut 1951). The principal one of these was the block of Ferry Street between Liberty and High Streets which was left to public women. This was known as 'Peppermint Flat' where the houses and walks were built on stilts over a lagoon-like former channel of the Willamette River. A trace of that old channel still exists in the depression centering at the intersection of Ferry and High Streets and the alley through the block southwest of that intersection. That ancient channel ran from a broad front on Pringle Creek between Commercial and High Streets, north on Liberty to Ferry, then east to the center of the block on State Street south of the courthouse. From there on north to Mill Creek was low ground. During the high water of 1861, a steamboat followed this channel and tied up in State Street opposite the courthouse (Judson 1971).

The home into which Daniel J. Fry moved in 1905, called Bright View, had been built in 1859 at 606 High Street -- high enough to have escaped the 1861 flood. He wrote that the floodwaters of Pringle Creek came clear up to the railing on the Church Street bridge. "One winter when we had a siege of extremely cold weather, father was able to walk across the Willamette River just about where the current bridge stands. Skating was done most of the time, however, on the slough... Ferry Street was a no-no street. It was really all built up on stilts. Water stood in that part of town nearly all summer long. The people who lived on Ferry Street were the gay ladies of that day... There was a very narrow, high walk along Ferry Street over this sunken part of the City.... 'China Town,' when we moved here, was on Liberty, High and Ferry Streets and I don't know how many dozens or hundreds of Chinese who lived in this town" (Fry 1998).

Lewis Judson recalled:

> To the east of the water department office and shops there was a large pond where the water was at the level of the race leading to the paper mill. It was about thirty inches deep and was well gravelled in the bottom. It was arranged so teams and wagons could be driven into it and easily turned around without backing up. There horses were taken for water and wagons to soak their wheels during dry weather and to wash the mud off during the winter. After the water company installed their first pump near the creek just east of Commercial Street, they used power generated by a water wheel at a falls about a block farther east. The power was transmitted by means of an endless rope which was supported by wheels on posts about fifteen or more feet above the water. One pair of posts was in the edge of the pond and some of the horses would become so frightened at the whirling of the wheels that they would not drink and often those in the wagons were in danger of being dumped into the water (Judson 1971).

In 1865, the murder of pioneer Daniel Delaney at his farm south of the Pringles' farms toward Turner shook the entire area. He was commonly rumored to have a fortune stashed at his farm, and two opportunists decided to relieve him of it. During the course of the robbery, they killed him and ransacked the house -- but a witness reported what he saw. Subsequently, the murderers were convicted and hanged at a "place of public execution"-- reported to be a scaffold set up among a clump of oak trees near the bridge over the creek on South Church Street -- at Pringle Park. "A crowd of nearly 1,000 watched this enforcement of the law as they gathered in the area now called Pringle Park" (Judd 1958). A number of school children brought their lunches to the event. Several were reported to have lost their lunches as the event moved to its conclusion. A later description of Pringle Park indicated plans for other, more pleasant gatherings: "Pringle Park will remain a passive center of activity. A more relaxed environment is intended for the Park, with opportunities for strolling, reading, sprawling, and picnicking" (City of Salem Urban Renewal Agency undated).

Ben Maxwell, a reporter, noted, "...By 1870 Salem had a water plant, a gas works, and during the evening of Sept. 28, 1870, the first train bearing mail and passengers chuffed from Portland to the State Fair." But, he asked, what was Salem like in 1869, the "final year of frontier village life?" He concluded that Salem was "...small, somewhat lacking in gentility, unsanitary by modern standards, self-satisfied and dull. There were those here distinguished for their holier-than-thou piety. Another element whooped it up in the town's numerous saloons, were occasionally seen around Maggie Gardner's place and engaged in fisticuffs, rowdy conduct and undignified displays on the streets on Saturday afternoon. So much for generalities and extremes. An intermediate group was decent, dignified, wore whiskers, plug hats and chewed tobacco..." (Maxwell 1957).

According to Maxwell, in 1869, Salem's downtown streets were unpaved, dimly lighted, and some were so low that water standing in them became ponds for skating in exceptionally cold weather. In 1872, the Salem *Weekly Mercury* pointed out that the $1200 spent annually to illuminate Salem's streets was a waste of money since even in broad daylight no one could discover a single crosswalk in the business section that was not submerged in mud. Further, the *Mercury* went on to say there was scarcely a street or block in the business section that did not have its foul cesspool or pile of filthy rubbish emitting a disgusting stench and disseminating disease in the locality. The city charter of Jan. 1857, did provide for removal of standing water and unwholesome and offensive substances, but the provision "had not been enforced with determination" (Maxwell 1957).

A swale ran from the vicinity of State and Liberty streets southwesterly behind structures of the 1870's still standing in the 300 block of State Street. Charles Bagley, recalling times in the 1860s, remembered that a depression extended diagonally across Liberty Street at Court and that there was a bridge across the swale where A.N. Moores (who built Capitol Lumbering Company) had "a high old time" ice skating during the Civil War (Maxwell 1957). Anecdotal information indicates that over about 70 years, Salem began filling the old Willamette River channel area from State Street south to Pringle Creek (Moore pers. comm.).

The streets had been graveled for their full width with the exception of the sidewalks in the downtown area, but farther out they were dirt or, at best, graveled in the center:

> There were hitching rails on posts or rings in the sidewalks where horses could be tied. Horses tied any length of time would become restless and paw out holes where their front feet stood. These holes would become filled with water and the streets seas of mud in the wintertime. In the summer the dust was kept down by sprinkling. In winter mud would cover the streets to a depth of two or three inches. To remove this mud the city would maintain a crew of men, often city prisoners, who would shovel it into dump carts drawn by a single horse and dump it into some low spot, of which there were many in early day Salem. Keeping crosswalks reasonably free of excessive mud was a constant chore... (Maxwell 1957).

Thomas Cross, "an Englishman, a livestock-raiser, meat dealer and packer, whose imported purebred Berkshire swine were probably the first purebred swine brought to the Oregon country and whose business was conducted east of Bush's Pasture Park gave his name to Cross Street. Howard is named for another livestock man and meat dealer" (Judson 1971).

On May 19, 1869, an ordinance was considered by the city council that would prohibit any person from keeping on private or public property any animal bones, putrid and unwholesome meat, feet or hides. The ordinance was aimed at a "fly-blown abattoir conducted by a prominent Salem meat packer southeast of Salem "(Maxwell 1957) in the same area where, more than 100 years earlier, Native Americans gathered at lively seasonal encampments on this oak savanna near Pringle Creek.

When surveyors later platted Yew Park in the area of Hines and Mission between 12th and 13th, they remarked about the ground in that area being strewn with bleached bones of slaughtered animals. A newspaper ad from May 24, 1889 enthused: "Yew Park Addition (Hines/Mission, 12th/13th) is the only addition to the city having smooth and solid streets with no mud in winter and no dust in summer. Yew Park is the finest residence location with its grassy slopes, beautifully shaded with oak, ash, maple, fir and yew, skirted by the crystal waters of Arbor Creek with springs of cold pure water" (Salzmann 1984).

Even though Yew Park had been rehabilitated, a newspaper investigator reported in 1890 having seen backyards of butcher shops elsewhere in the city with trickling streams of water carrying blood and poultry offal. This organic matter was deposited in the soil, and ultimately washed to Salem's streams. In the 1870s, a slaughterhouse ran full bore south of Mission near 22nd. From the 1890s to 1910, Edwards Tanning and Taxidermist was open for business on 12th Street south of Cross Street (Maxwell 1961; Marion County Historical Society (g)).

On June 1, 1869, the City Council instructed the street commissioner to place four coal-fired street lamps, including one at the covered bridge spanning South Mill Creek (Pringle Creek) on Commercial Street. When publisher S.A. Clarke left the office of the *Unionist* late at night on August 11, 1869, he noticed that some of the street lamps were smoking horribly and that others were extinguished by flies that had entered the chimneys and put out the lantern. Editor Clarke stumbled his darkened way homeward over loosened wooden sidewalks with projecting nail heads (Maxwell 1957).

In 1869, no known Salem home had running water or inside plumbing. By 1870, an adequate supply of city water was becoming an issue. The townspeople generally used shallow wells or river water. One resident, Mr. Lee Tong, delivered river water to homes and businesses in old oil cans. "A candle lighted adventure from the house late on a stormy winter night to an outdoor privy must have been an experience to remember... And all too often this outdoor convenience and the shallow household well beneath the back porch were not far apart" (Maxwell 1957). It would be 1878 before

Asahel Bush moved into his new home, which would include his personal indoor bathroom complete with hot running water piped through the wall from the kitchen wood stove to the copper-lined bathtub which had been constructed in his bathroom. The water came from the cistern built on the roof. The only water used in the house came from rainwater stored in the cistern (Narcum-Perez 2001).

On Jan. 14, 1869, the City Council assembled to consider the spread of smallpox within the city, and in March of 1869 a newspaper report stated that Salem had 1,000 cases of measles though as yet there had been no fatalities. William Graves became Salem's first known undertaker in 1868, but Salem would have no hospital until 1896. In 1896, with life expectancy at 46 years, the first hospital opened its doors in a donated building at 12th and Ferry. Its primary reason for existence: growing recognition among physicians that surgery requires a clean environment. According to a history of Salem Hospital, "That was impossible to provide when surgeons operated on kitchen tables in people's homes with family members watching" (McMillan 1996).

Ben Maxwell reported that:

> Salem in 1870 had 13 saloons, three drug stores that sold liquor and two breweries, one of which advertised to deliver anywhere in town for forty cents a gallon. At John 'Patch-eye' Byrne's Crystal red-eye cost a dime and a black eye came for free. Sandy Burn's North Star featured the only set of hurdy-gurdy girls every brought to Salem. Capitol Saloon advertised 'pig's feet by the thousand and every other luxury in excellent style.' Only E.M. 'Plum' Plamondon's Belvedere appears to have any reputation for gentility. 'Madam' Maggie Gardner conducted a well-ordered bagnio with four or five inmates on the east side of Liberty Street between Court and State. Nor did an Indian camp at the mouth of South Mill Creek (Pringle Creek) add a scintilla of moral tone to Salem's reputation (Maxwell 1957).

The *Oregon Statesman* for Oct. 29, 1869 called the camp "a nuisance where low grade whites consorted with the aborigines and where whiskey seemed to be free. Almost every night the camp was the scene of a drunken riot and such disgraceful orgies as truly made the night hideous. Here, presumably, Joe Hutchins, chief of all Santiams, fell asleep by his campfire on a January night in 1870 and awoke to find his shoes burned off and his feet nearly burned up..." (Maxwell 1957).

Maxwell continues, "During 1869, while one element in Salem staggered, another swaggered. Times were prosperous and a boom was in the making. Speculations in downtown real estate brought quick and easy wealth for more than one investor. Salem's property values had increased from $699,261 in 1863 to $1,250,000 in 1869" (Maxwell 1957). Coincidentally, perhaps, during this same period, several spectacular and totally destructive fires occurred, beginning when John "Patch-Eye" Byrne's saloon burned to the ground along with most of the rest of the city block, at about 3 a.m. on May 10, 1863, "undoubtedly the work of an incendiary" (Brown 1957).

The last big fire of many big fires in Salem during the "flimsy 1860s" blazed a conclusion to 1869 with the destruction of the Capitol Hotel. During the 1860s, many frame buildings housing livery stables, saloons, hotels, stores, homes and several downtown city blocks went up in flames. A number of the losses were saloons and most of those were victims of arson, the perpetrators rarely found since Wiley Chapman appears to have been the town's only police officer except for extra watchmen hired during the State Fair. The intense rivalries between Salem's three volunteer fire companies, Capitol Engine No. 1, Tiger Engine No. 2 and The Alert Hook and Ladder Company, don't appear to have helped the situation. Before 1869, 32 brick stores had been built. In 1869, 13 more brick stores were under construction, among them the Patton block in the 300 block of State, the Ladd and Bush bank building and Reed's Opera House (Maxwell 1957).

As Salem grew, it used drainage courses and creeks and their riparian edges as sewers and trash dumps. For a time the natural system was up to it. The Chemeketas had used areas seasonally, returning to sites only every two years or so to give the natural processes time to heal the land and the creeks. When the first settlers came and scattered to their new farms, the natural system could still accommodate what it was given. And, seasonally, the creeks and the Willamette River could be counted on to flood, thus washing away detritus no longer desired by settlers. But more people kept adding more waste, until the natural system was unable to cleanse and wash away the garbage placed in it. Nowhere and at no time did the limits of ridding the community of its overwhelming waste become more apparent than when Pringle and Mill Creeks and their natural drainage systems were overcome by man-made waste in the late 1800s.

Salem in the 1880s and 1890s was abundant in hovels abandoned by white tenants, many in an area called "Chinatown" which included settlements of "evil repute," bawdy houses, opium dens and bars on the east side of Liberty between Court and State, along Court Street, along Ferry Street and near Commercial and Trade Streets. Intermingling at Chinatown's edges were purveyors of various goods and services aimed at denizens of the dark and frequenters of demimonde establishments (Maxwell 1961).

Ben Maxwell reported that Salem's Chinese laundries in the 1880s were housed in at least two buildings with distinguished pioneer heritage. William Rector's building, erected on Commercial Street in 1851 as a town hall, housed the territorial legislature in 1856. In 1885, it housed Hop Sing and Hop Sing's wash house. A spectacular fire gutted the building, then owned by Oregon's state treasurer, who later became Salem's postmaster. The building had no insurance.

In January 1887, fire flamed from the old Bennett House, built in 1850 and well-known in its day as a leading hostelry. Falling upon hard times after the Civil War, it deteriorated to its final dismal state as a Chinese laundry and "rookery." At the time of the fire, the building belonged to a wealthy Salem businessman -- who had no insurance on the building. Complaints about these rookeries, and what went on in them, was frequent and constant. Less was said about their prominent and well-to-do owners (Maxwell 1961).

In 1890, the *Capital Journal* published an account of Chinatown headlined, "Death from Dirt, Horrible Filth in Chinese Quarters." The block southwest of the post office, then located near the southwest corner of Commercial and Ferry streets, was the first place visited by the reporter.

> Taking his life in one hand and holding his nose with the other the reporter punched a stick into the plastic scum that formed a kind of a quaking mass under the Chinese wash house in this vicinity. There was a mass of greenish, decomposing slime, the extracted filth from thousands of pieces of dirty underclothes, that gave forth a powerful kind of chemical stench. When stirred it sent up millions of little bubbles of mephitic gases, near which no animal life was possible. A constant stream of grayish-blue water ran out of the rear of the building and leaped into a large cesspool covered with rotted plank and full to the brim of the nauseous mass. ... Wash houses off the alley, on State Street between Liberty and High, were found to be unspeakably foul. The ground on which these structures stood was positively reeking with filth. The trickling streams of wash house slime, the decomposing refuse from Chinese kitchens and the stinking remains of fish and poultry combined to render these places nuisances of a deadly character (Maxwell 1961).

On Ferry Street the investigator found a lake of soap suds and a lethal accumulation of disease-breeding filth over 100 feet in diameter. A sewer drain emptied into this cesspool of filth. All drained toward Pringle Creek or the Willamette River (Maxwell 1961).

The *Capitol Journal* followed its investigation by an interview with a number of Salem physicians. Generally they favored a clean-up and sanitation for the city. A few doctors expressed no interest at all and some were entirely indifferent since they were reported to be booking substantial sums monthly off the existing conditions of disease-spreading filth.

In 1893, in yet another report of conditions in Salem's Chinatown entitled "Chinese Fragrance," the *Capitol Journal* reporter ventured into the alley at the rear of the Chinese "dens" on the east side of Liberty, between State and Court. In this alley, near the fire bell tower and also near a house of prostitution called The Bell Tower, the reporter saw a number and variety of putrid carcasses. At one of the dens along Liberty, slop pails were emptied out a side window into a standing pool of filth.

These exposes, and the concurrent public disgust, eventually seem to have worked: In 1903, a *Statesman* story bid farewell to the old Chinatown which had finally been condemned to destruction by City Council approval of a report by a committee on health and police. The report indicated that the property at Commercial and Ferry especially was "simply filthy with space between walls filled with decomposed matter of all sorts. Water closets emptied into cesspools and water from sinks flowed into the cesspools or over open ground" (Maxwell 1961). This "run-off" made its way to Salem's creeks and eventually to the Willamette River.

While Salem was expanding and prospering, outlying farm towns were thriving as well. The Liberty Store was the center of the Liberty community for many years. It stood across from the United Growers cannery on Liberty Road when the Liberty post office opened in January 1895. Today, Liberty School, first built in 1908, remains a healthy neighborhood elementary school. It has its own parking lot bioswale, the first in Salem, which is overseen by its Liberty School Environment Club (City of Salem 2001d; Duniway 1987d).

After falling under the early settlers' plow for wheat, much of the upland prairie and oak savanna toward the South Salem Hills became fruit farms near the beginning of the 20th century, having names such as Smith and Ewald. William McGilchrist, a native of Scotland, became a prune grower in the Rosedale section of the Red Hills in 1892. Berry St. was named by Jacob Morlock because of the planting of Lawton blackberries, a luscious berry of good flavor, on the Judson property at the south end of the street. Cunningham Lane was named for a family who owned a large farm at the west end of that street and were early prune and berry growers. Hrubetz Road bears the name of Frank Hrubetz who farmed for many years north and east of the Liberty area.

Early pioneers in the prune industry planted orchards in 1890 in the hills south of Salem in Liberty, Sunnyside and Rosedale as well as west of Skyline Road and south of Fairview. As many as seventy prune driers could be found within a radius of 2 1/2 miles between Liberty and Rees Hill Roads from 1905-1930. The driers were large barn-like structures with furnaces, frequently built at the Rosebraugh Foundry in Salem, to dry the fruit by heat. Many of the driers were by springs; otherwise, a 30-50′ deep well had to be dug for water, and a windmill, gas engine or hand power used to pump it (City of Salem 2001d).

According to one historian:

> Out Sunnyside Road near Twelfth Street Junction was the Hilfiker Orchards and drier... Ross Miles used the old drier after the Hilfikers were gone for a secondhand store for years. That is now gone and stores occupy that area. The next drier was south on Liberty Road and known as the Nines Drier, off east in his orchard. Then came the Hrubetz orchards and drier just north and east of Liberty. Next was the Zosel drier just north of Liberty School... Down Boone were the Dasch and Johnston driers. Out on Skyline Road were several driers. Walnuts were interplanted when the prune market went bad, and eventually all their prune trees were pulled out, to have a solid walnut orchard... said to be

> the largest walnut orchard in the world. In time, these trees began to die because of the lack of depth of the soil. So out went the walnut trees to grow grass seed and grain (Cammack 1983).

Today there is a bioswale and parking lot north of Liberty School. Springs and seeps in the area have caused many structural problems at the school.

According to a 1921 *Oregon Statesman* article, "...The Salem District which included southern Oregon and Clark County, Washington, should have had 80,000,000 pounds of dried prunes last year: they were on the trees, but unprecedented rains during picking time cut the marketable crop in two. Salem's local market district equaled 22,833 acres set to prunes, over one-half the prune acreage in Oregon. This acreage should yield five tons of dried fruit per acre. Marion County Fruit Inspector S.H. Van Trump said, 'There is no better prune district on Earth"' (Cammack 1983).

But not even prunes lasted forever. The *Capitol Journal* reported on Jan. 25, 1921 that

> The big market for dried prunes was in Europe, especially France, England and Germany from 1890-1920. Then prune growing in the Balkans began and was closer to the dried prune market. They could sell them cheaper, so the prune industry here began to fade from 1921-1939 when almost all the driers in this area were shut down. Canning Italian prunes as "purple plums" began in 1930 and grew to use a lot of Salem's crop. In the Depression, canned prunes were the cheapest fruit one could buy. Gradually times got better and people liked pears and peaches instead, so as of 1982 not many prunes were canned. With the collapse of the dried and canning prune market, the hundreds of acres of prunes in the Willamette Valley were bulldozed out to grow other crops. The Seeger Brothers and Cammack dozers cleared most of the orchards in the Liberty, Sunnyside and Rosedale areas (Cammack 1983).

Before subdivisions began sprouting houses in South Salem in the late 1960s and 1970s, many of the hills surrounding Salem were covered with extensive cherry orchards. Salem-grown cherries were noted for their quality, size, and flavor; indeed, Salem became known as the "Cherry City" in 1907. In 1928, the Salem trading district had more than 2500 acres bearing cherries. Salem was known for two black cherry varieties, Bing, and Black Republican, as well as Lamberts and Royal Annes, which were the most profitable cherries grown in the Northwest. During the first part of the 20th century, Salem's canning industry grew from one plant to more than ten, and canned cherries were an important part of the Salem pack. Improved rail refrigeration resulted in increased shipments of fresh cherries out of the Valley in the 1920s. Brined cherries, using a new method to make maraschino cherries developed at Oregon State University, came on line in 1927. Canned cherry production increased in World War II, and remained high into the 1960s, when consumers no longer wanted canned cherries (City of Salem 2001e).

But the farms were, of course, a later use of the land, as settlers were sometimes reminded:

> In the spring of 1924, John Berg, while ploughing on the Bruce Cunningham farm near the Skyline orchards six miles south of Salem discovered a hundred elongated stones standing in an irregular circle 35′ in diameter on the brow of a gentle rise facing the east. These were the only stones of the kind in the locality, according to Donegan Wiggins, an amateur archeologist residing in Salem. Just the upper ends of the rocks were visible and their peculiar shape was not suspected until they were dragged from their beds with tractor and chain. . Because the rocks were an encumbrance in the tilling of the soil they were exhumed and heaped into a pile nearby (Horner 1986).

According to Horner's unpublished notes, "These stone monoliths are composed of sedimentary material (similar to sandstone) which formed naturally into cylinders. Prehistoric inhabitants, during an unknown time period, chiseled the cylinders and placed them into a crude ring. The purpose of this circle of vertical stones is still a mystery. Speculations have included seasonal rituals perhaps corresponding to solar or lunar positions, and fertility rites based on a phallic resemblance of some stones. Since the site was destroyed before accurate documentation -- systematic excavation with field notes and photographs -- the meaning of these artifacts will probably remain questionable" (Horner 1986).

According to Connie Schultz, a cultural protection specialist with the Confederated Tribes of the Grand Ronde, these monoliths are neither mysterious nor unknown. Rather, the place they were displayed was a very sacred prayer area to the Native peoples of the Valley (Schultz pers. comm.).

Based on available information, it is possible to determine the approximate location of the field where the monoliths were found. However, historical preservationists request that specific sites not be divulged.

Seven of the artifacts are known to remain in existence at this time. They are currently housed at the Horner Collection at Oregon State University. Negotiations are underway to determine whether the monoliths will be displayed at all, or whether they will be turned over to the Confederated Tribes of the Grand Ronde. One possibility is that the Horner Collection will be transferred to the Benton County Museum upon completion of a building to house the collection, according to the Benton County Collections Specialist (Sutliff 2001).

According to notes at the Museum, Inventory #98584-1 was acquired by the Museum in 1985, donor unknown. The monolith was noted as having been found on the Carl Denzel farm on Cunningham Lane near Skyline Road. While there were notes in the Museum regarding the circumstances surrounding its possession of Museum Inventory #98584-1, there is no information about how the Museum obtained the other six stones. The Museum noted the piece as Kalapuyan (Horner 1986).

Roads to market, often dirt, meant mud or heavy dust in season. Then came rock crushers. The *Oregon Statesman* reported in 1902 that the new road from Liberty to Salem was the "first road in the county constructed on scientific principles" using crushed rock from the Ewald property on the southeast corner of Madrona. The tracks for the streetcar line were laid to bring crushed rock to Salem to pave its streets. At Madrona, the quarry created in the process became Hidden Lakes off Liberty Road (Duniway 1987f and 1987g).

In 1907, Salem Heights School District was created from the Liberty School District and Salem Heights school was built in 1908. Salem Heights Community Hall followed across Madrona in 1911. Fred Thompson, a prime mover in the creation of the Salem Heights School District, owned 20 acres east of Liberty Road and five acres to the west, next to his father's home. His father's home remains standing today as Thompson's Brew Pub (Duniway 1987g).

Also in 1907, the state purchased 672 acres of land for an institution for "feeble-minded, idiotic and epileptic persons." Fairview Training Center opened its doors in 1908. In 1962, resident population exceeded 2,700. In the early 1960s, Fairview had 80 acres of orchards, 30 acres of truck gardens, and poultry, pork, beef and dairy operations. Most of these operations ran parallel to or immediately upslope from Pringle Creek. At one time, a small lake near the main entrance offered residents and staff the opportunity to swim and row boats (Oregon Department of Human Resources 2000).

The Modern Era

The mid-1930s brought sweeping changes to the landscape of the Willamette Valley. The Flood Control Act of 1936 authorized dollars and projects in the Willamette Basin for "bank protection works and clearing flood channels to prevent the loss of land by erosion and reduce flood heights." Most of the funds were spent on hydraulic control of regional rivers.

During the same decade, the Works Progress Administration (WPA) and the Army Corps of Engineers began the State of Oregon Willamette Valley Project. Major goals included (1) flood control through bank revetment and construction of seven reservoirs in the tributaries of the Willamette, (2) navigation by maintaining channel depths through dredging, (3) irrigation, soil conservation and erosion abatement for agriculture and (4) social and recreational programs to establish parks and encourage "healthy outdoor life."

Most people supported the dams and flood control projects, but early warning flags were raised by the Izaak Walton League and the Fish Commission of Oregon. The League was concerned over the low priority that recreation and fishing were being given compared to flood control and they also issued an early call for control of pollution caused by municipalities. The Fish Commission wrote an early report entitled "Fish and Wildlife Problems Arising from the Willamette Valley Project." The report's opinion on the effect of the dams and flood control projects on fisheries was: "All competent fisheries authorities on the Pacific Coast are thoroughly agreed and have never wavered from the considered opinion that any and all multiple-purpose dams blocking major salmon runs have an ultimate and definite deleterious effect on them" (Oregon State Planning Office 1936).

Taking care of business, getting through two World Wars and surviving a major Depression and the downturn after World War II consumed most of Salem's efforts in the first sixty years of the twentieth century. Staying alive, keeping afloat, and remaining competitive took the front burner. Any worry about clean industry or finite natural resources or pollution of waterways was fleeting. Internally oriented, Salem proudly informed outsiders at both the old bus depot and along 99E that Salem was 99.9 percent white, native-born (*Statesman-Journal* 2001).

In the 1950s, Salem took stock and decided some things needed to be changed.

Salem improved and extended facilities such as the sewage treatment system, natural gas connections and water system upgrades. Completion of the Detroit Dam and other dams on the Willamette River and its tributaries reduced chances of flooding and encouraged development in low-lying areas (City of Salem 2001f). In 1961, Salem won a coveted "All-American City" award.

Salem voters annexed 2,827.06 acres in South Salem on June 29, 1964. The City's previous southern edge had jogged from Hoyt Street and Fairview Avenue on the east of Commercial Street across to King Street and Salem Heights Avenue on the west of Commercial Street. The new city limits extended south of Boone Road. The City Council had decided to promote a "metropolitan day of reckoning" by placing on the ballot an election of annexation within the entire South Salem sewer district plus amending the City Charter to allow the City Council to levy additional taxes to pay for the district and the annexation (City of Salem Public Works Department 1964a and 1964b). With the advent of a centralized and common sewer system, Salem began growing houses in the midst of orchards and fields. A resident remembers when she was a child galloping her horse along a dirt road, later Madrona Street. Neighbors crossed a stream (Clark Creek) and went to the dairy farm which became 93,000 square foot Fred Meyer South in 1968 (Baynes pers. comm.).

*I*n 1967, Salem recognized it had substantial problems with urban decay in its downtown core. The City obtained a federal grant to fund Salem's Urban Renewal Agency and produce a General Neighborhood Plan for an area covering approximately 680 acres. By 1972 a 110-member Citizens' Advisory Committee produced the Central Salem Development Program (CSDP). Within the CSDP, the Pringle Creek area was defined as being Central Salem's most blighted area: "...Over 58 per cent of the buildings in a 76.8 acre delimited Pringle Creek renewal area warrant clearance due to structural substandardness and blighting influences, while incidents of incompatible land uses, obsolete building types, inadequate public services, and degradation of natural waterways continue to intensify" (City of Salem Urban Renewal Agency 1972). That was after excluding the Boise Cascade's paper division, chip storage pile and container division from consideration as well as setting aside for later consideration all areas south of Pringle and Shelton Creeks, east of Church Street and north of Trade Street.

The Pringle Creek Urban Renewal Project became the first designated renewal area under the CSDP. It was a 21.1-acre five-block area in which the plan noted that over 75% of the buildings were substandard, and the current mixture of industrial, residential, commercial, and wholesale uses "extremely inharmonious"(City of Salem Urban Renewal Agency 1972). Objectives of the plan included protecting vistas, natural areas, natural vegetation and elements of historical significance. The Historical Structure Subcommittee reviewed all the buildings noted as having historical interest within the Pringle Creek project area and agreed that every single one was expendable (City of Salem Urban Renewal Agency 1972).

The major change proposed in existing land use in the Pringle Creek renewal area was the elimination of most manufacturing and wholesale uses. However, there was a caveat: "Industrial and warehousing development should not be located on major waterways UNLESS water in volume is absolutely essential to the industrial activity and there is every assurance that pollution of resources will not occur." (City of Salem Urban Renewal Agency undated). Plan objectives included using the Willamette riverfront and creekways to their greatest potential as parks and open areas, and developing greenbelts of open space along Pringle Creek, Shelton Ditch, and the Millrace in order to utilize the natural amenities these waterways afford, and facilitate pleasurable and safe pedestrian and bicycle movement." (City of Salem Urban Renewal Agency undated). Obviously these amenities were in short supply in 1972.

As part of the area's redevelopment, several sewer lines were abandoned, rerouted or replaced and the study noted that several were severely deteriorated. A storm drainage study proposed building a flood wall and/or earthfill dikes on the north banks of Shelton and Pringle Creeks to protect new development from flooding.

Also in the late 1960s, voters approved a bond measure to acquire a four-block area and construct a centrally located library, civic center and fire station. Within that four-block area were several single family homes and a Masonic Temple which had been converted from an old cold storage warehouse. The new Salem Civic Center was completed and open for business in 1972 (Waitz 1976; Moore pers. comm.). The new fire station was built on pilings and fill in an area which, historically, had often had standing water. When new fire station personnel were assigned to work at the building, "old timers" assigned them to go find the basement. They would spend hours looking for access with no success. The building has no basement (Henlin pers. comm.).

Four additional studies in 1979 and the 1980s presented options for Salem's Riverfront and Greenway, noting that most of the riverfront and its surrounding uses in their current condition were "unattractive." A 1981 study remarked on the continued presence of the Boise Cascade container plant at the riverfront, stating that the plant represented a considerable investment on the part of Boise Cascade and that equipment currently used had an anticipated life in excess of 25 years (City of Salem Urban Renewal Agency 1981). Comments about Boise Cascade's location abound: in 1983, a neighborhood association proposed connecting Front Street to South River Road through Boise Cascade with a convention center over the top. At a 2001 Willamette University forum, the presence of Boise Cascade on Salem's waterfront was likened to having a gorilla in the living room (Rice pers. comm.).

While Salem was looking to clean up its downtown, residents in close-in South Salem lived pretty much as they had for several decades. They raised their families, still had summer gardens and put up with seasonal flooding during the other months. One current resident, born in 1958, has early boyhood memories of playing in Clark Creek from the stretch along Gilmore field, as it ran through all of the yards along the east side of Davidson, and on toward Pringle Creek in Bush's Pasture Park. His grandparents had a wooden driveway/bridge to cross from the street, over the creek, and up to their house. It was a compelling adventure to take an underground trek leading from where the then open-air Clark Creek fed into a tunnel leading underneath the south end of Bush's Pasture Park, reemerging at its confluence with Pringle Creek. He and his younger brother used rag and stick torches soaked in lighter fluid - every mother's nightmare - to light their way. He remembers that it was "extremely creepy, icky, and scary" (Crawley pers. comm.).

He reported that they would only make the trip in the downstream direction from Davidson to the park. When they attempted to make the trip in reverse, there were too many branching pipelines feeding into the underground passage. Some of the braver neighborhood boys would explore upstream into the pipe labyrinth, but they, either blessed with fertile imaginations or steeped in the lore of Tom Sawyer, were afraid that they might make a wrong choice going upstream and never be heard from again. "Culvert crawling" and "inner-pipe travel" appear to have been common in Salem. Some of the kids would push popsicle sticks up around the edges of the manhole covers in the streets so that when people walked or drove by they would see a little circle of popsicle sticks sticking out of the manhole covers with the unspoken message "I was here" (Crawley pers. comm.).

Other stories tell of boys crawling through underground passageways carrying the West Fork of Pringle Creek beneath Arlene Avenue at the north edge of Cannery Park to where it reemerges three blocks later at Coloma. Now the routes are used primarily by raccoons and other nocturnal travelers. In the later 1970s, Pringle Creek was placed into its current underground culvert instead of running along Arlene. The culvert travels under people's houses and storm water is reported to have broken loose into homes and garages during larger-than-usual seasonal storms (Rollings pers. comm.).

One Salem resident doesn't remember the exact date that the creek was entombed along Davidson, but he remembers that he was "still a young kid." After the city ran the creek through culverts and backfilled the ditch, his grampa was extremely upset to lose access to his irrigation source for the garden. Grampa would send the boys down into the new tunnel from the entrance at Howard Street. Their mission was to crawl through the culverts until they were under the drain in his driveway, and then they would carefully position a foot pump (with rocks to secure it) so that Grampa could draw water from the creek to water his vegetable patch. The high water flows every winter would knock the foot pump loose, requiring that the boys (or rarely Grampa) make their way again from Howard Street to the driveway drain to reposition the pump each spring for another growing season (Crawley pers. comm.). It is understandable that neighbors in the area like their gardens and fight seasonal high water: a large swath of hydric soil associated with Clark Creek runs all through the area.

A South Salem High School science teacher who taught students there between 1968 and 1972 recalls taking students on field trips to where Clark Creek meandered between Gilmore Field and its entry into the double 36-inch culverts at Howard and Davidson Streets (Smith pers. comm.). According to the City of Salem Public Works Department, meandering Clark Creek was placed into an "engineered concrete lined channel" as a "flow conveyance improvement" somewhere between June, 1975 and February, 1977. That same project also "improved" Clark Creek three blocks upstream to Hoyt Street immediately north of Gilmore Field (Downs pers. comm.).

Another resident has lived on Wilbur Street next to Pringle Creek for 30 years. Her house was built in 1954-55 and the site previously was an empty lot. She recalled her basement flooding twice in the last 30 years. She also recalled that the water in the stream next to her house on Wilbur Street used to be "crystal clear," that watercress used to grow on it and that "big" rainbow trout (this information is anecdotal; the fish may also have been steelhead), whiting and crawdads lived in it. She remembered three to four rainbows at a time, all pan-sized. Other wildlife included falcons, opossums, blue herons, hawks, owls, raccoons, muskrats, and wood ducks. Also noted were nutria and rats. Trees included cottonwoods and oaks as well as pussywillows and wildflowers. She also noted that several trees had fallen.

In her comments on how the stream and its habitat have changed, she said the water quality has declined, there are fewer fish, she has seen bags of garbage and bubbles in the stream, there are "spikes" of high water in the spring, and it has not been this dry in 47 years. She suggested that tighter controls be placed on what goes into the creek. Her example was a nearby car repair business that sprays water off the parking lot and work areas into a storm drain (Rice pers. comm.).

*W*ith a history of severe flooding along area streams, (1861, 1881, 1890 and 1964) city officials believed it to be "apparent" that a complete review of storm drainage problems in the Pringle Creek renewal project area would be required with "due consideration given" to the potential floods in Pringle Creek and Shelton Ditch where the water reached 147.7 to 148.25 feet in 1964. Residents began to notice the increase in potential loss of life and cost of infrastructure replacement as more people moved in and built up areas along the streams. However, they also believed that any problem could be solved with sufficiently good engineering.

For example, in 1916 Mennonites purchased the old Capitol Hotel at 665 Winter Street to open Deaconess Hospital, which is where Salem Hospital stands today. By 1984, the community had concluded it needed a new $2.1 million dollar, 200-bed hospital. Salem could have expanded the Salem General Hospital facility, which stood on a knoll on Center Street (or Asylum Street, as it was called in 1899). Instead, the community's resources went to the Deaconess Hospital site where, on the morning of December 23, 1964 -- after the Willamette River crested at 30′ -- water from the Willamette, Pringle Creek and Shelton Ditch flooded the basement to a depth of seven feet, knocking out heating, power, and communication systems. The National Guard was called out to evacuate 121 patients, including a woman in labor and an infant on a respirator (City of Salem Urban Renewal Agency 1972).

Later, Salem Hospital invested in dikes and high-powered pumps, and in 1986 the ground level of Winter Street and the hospital itself was raised 4.5 feet. Site expansion has continued, including multi-level parking garages, additional wings and stand-alone buildings. In the late 1980s surface parking lots expanded, shoving fill material over the edge into Pringle Creek where chunks of concrete and asphalt remain today, nestled in with various storm drains which carry untreated parking lot runoff directly to Pringle Creek (McMillan 1996).

In the spring of 2000, three large trees along Pringle Creek crashed down onto parked cars in the Salem Hospital parking lot. Nineteen large trees subsequently were determined to need either removal, pruning or rehabilitation. When the Pringle Creek Watershed Council and the City of Salem Natural Resources staff inventoried the site, they found problems common to urban streams which had, until recently, been considered annoyances rather than amenities.

The stream was deeply incised, bank slumping was apparent, landscaping debris and parking lot sweepings had been piled or blown down the bank. Norway rats are primary beneficiaries of landscaping debris piles along stream banks. Near the Mission Street bridge, Pringle Creek spreads wide and shallow in full sun. Later it is pinched between buildings and parking lots with heavy foot traffic along the top of the bank creating additional bank instability. While some native trees and shrubs still exist along Pringle Creek in this reach, many parts of both banks are overrun with non-native Himalayan blackberries, ivy and nightshade. Reed canarygrass perches well above normal water levels, an indication of flashy (or sudden) high flows.

Much of the urban area around Pringle Creek has been developed with little regard either to the stream's needs to function as a healthy waterway or to the community's drainage needs. According to the 2000 Stormwater Master Plan, by far the biggest part of Salem's stormwater system is a closed system of storm drains (456 miles) as opposed to 27.6 miles of streams within the City limits. The "stormwater system" in the Pringle Creek watershed is similar. Much of Pringle Creek is in closed pipes underground.

In the course of inventorying stream sites along Pringle Creek, the watershed council has found generally that setbacks are inadequate; impervious streets and parking lots drain to streams with little attention to water quality; many of the streams have been dammed, straightened, ditched or piped; riparian edges have been paved; slopes tend to be vertical and thus erode as water rises and falls in the streams; extensive areas receive insufficient shade; streams are "flashier," with more extreme, and faster, highs and lows; springs have disappeared; riparian vegetation is either stressed or totally inappropriate for the sites; mid-level and multi-story shrubs critical for sheltering and feeding song birds are being mowed, whacked, and sprayed with Round-Up; city "ditch-cleaning" crews are mowing down herbaceous green plants such as cattails, sedges and rushes in small streams and wet areas because of concerns about "conveyance" and fire hazard (though green wetland plants are not known for catching on fire); diverse life forms including insects, frogs and turtles expected to be present in healthy riparian zones are nonexistent in much of Pringle Creek's watershed. None disappeared overnight. Residents have consistently noted that favorite birds, deer, foxes, pheasants or fish just slowly diminished, finally and quietly disappearing. People stand for a moment, thinking, and then say, "one spring they just didn't come back." But then they disparagingly identify other current denizens: too many raccoons, dogs and neighbors' cats (City of Salem 2000).

Neighbors reminisce about their homes built near Nina and Arlene in 1971. Cock pheasants crowed from the homes' ridgelines (Rollings pers. comm.). They disappeared after homes were built along the extension of Arlene and along Clarence Court, sometime in the mid-1970s. A longtime resident on Idylwood near Judson Middle School and Woodmansee Park estimates the last time he saw a fish (cutthroat trout) under the bridge in Pringle Creek behind his home was 18 to 20 years ago (1981-1983); his daughter caught a cutthroat under the bridge about 30 years ago. He said the best time to see cutthroat was in March and April, although he recalls seeing them into June. He believed they traveled downstream (Zwicker pers. comm.).

In 1963-65, he used to go into where Woodmansee Park is now and fish, catching cutthroat. He recalled seeing one salmon "splashing around, near dead" in Pringle Creek behind his home on Idylwood, he believes in the early 1970s. A day or so later, he recalled that he and fellow workers heard "some noise about 2 o'clock in the morning" near where they were working in the vicinity of McGilchrist and the railroad tracks. He said they shined their lights into the creek and saw "about half a dozen" salmon splashing around. He believes it was in the fall because the weather was good. He thought the fish were part of a hatchery stocking program. He also recalled many

China pheasants and "hundreds of quail" which diminished after Judson School was built and finally disappeared around 1975-78. He said they used to see lots of opossums and few raccoons; now it's the other way around (Zwicker pers. comm.).

*T*he remaining natural areas in the Pringle Creek watershed are mostly publicly owned: city parks and city property, school sites and state lands such as the Oregon School for the Blind. They offer the most promise for stream protection, enhancement and restoration. Many individual streamside landowners have provided various levels of protection to the creek that runs over, through or alongside their property. But most have not provided for long-term protection through conservation easements or deed restrictions.

Arguably one of the best reaches in Pringle Creek is the publicly owned area between Deepwood and Bush's Pasture Park just south of Mission Street. Even though this is a stream in sync with its floodplain, covered with a canopy of mature native trees and healthy multi-leveled understory, it has problems. It was in Bush's Pasture Park that monitors detected traces of the herbicide dieldrin. Though itself imperfect, this reach exemplifies much of what protection and enhancement can offer urban streams.

Small reaches farther downstream below the Church Street bridge as well as some upstream in several residential areas are also potentially healthy, given urban constraints, and future potential projects include establishing criteria for and evaluating "best reaches," which in turn can be used as "reference reaches." Immediately upstream of this area and the confluence of Clark and Pringle Creeks, lies approximately 62,250 square feet of unpaved parking area called Lower LeFelle. Neighbors complain about dust in the summer. Parking lot runoff flows unabated and untreated directly into Pringle Creek.

At Pringle Park, agreements were reached several years ago for paved parking to be shared with Salem Hospital (Waitz 1976). The park itself lies between Pringle Creek to the south and Shelton Ditch to the north. The area has been flooded many times and continues to serve as stormwater detention during high flow events. In general, its natural areas along Pringle Creek exhibit mature native growth. Some of the stream bank and the bank to the east, between Salem Hospital and the park, suffer from excessive and inappropriate foot traffic.

Partway through Pringle Park, the stream itself is pinched between a wall on the Pringle Park side and decades of landscape dumping across the stream on the Oregon School for the Blind (OSB) property. Recent removal of southside riparian vegetation has opened up what used to be a shady, cool portion of the creek. OSB, Salem Parks Operations and the Pringle Creek Watershed Council are partnering to plant native trees and shrubs along this portion of the creek.

The City obtained .32 acres south of Judson Middle School in 1962 as part of a trade with the State of Oregon. In return for the Carson Springs Natural Area, the City deeded land on the south side of Pringle Park adjacent to the Oregon School for the Blind to the state. The school district agreed to the use of 2.55 acres of its land as an outdoor laboratory for Judson students (Waitz 1976). Both sites retain promise today for both site improvement and education, but in both instances the areas immediately next to Pringle Creek are victims of urban abuse or neglect: erosion, bank incision, overgrown exotic species, insufficient shading and landscape debris dumping at the Oregon School for the Blind site.

The Judson site hosts junk such as fencing, concrete blocks, bedsprings, large pieces of wood, plastic and bottles in and near the stream. Judson's lower ballfields are often too wet due to poor drainage, which is a problem similar to ballfields at Leslie Middle School and South Salem High. In addition, Gilmore Field at Hoyt and University SE has served as a regional detention basin for stormwater since 1976. Because of multiple springs in the area, a high water table, and until recently an improperly functioning drain on the detention facility, the attempt at conjunctive uses has not been as successful as everyone had hoped. Woodmansee Community Park, adjacent to Judson Middle School, recently had a Master Plan adopted which includes extensive potential for natural enhancement and stream restoration.

In 1980, the City purchased almost seven acres for a neighborhood park to serve the area east of Liberty Road, north of Kuebler to Idylwood (Regional Park and Recreation Agency of the Mid-Willamette Valley 1980a and 1980b). The land was purchased from the Stayton Cannery and is called today Cannery Park. The confluence of the West Fork of Pringle Creek is at the southwest corner of the park. Various volunteer and public works restoration and enhancement projects have been undertaken in the last several years in this park: wetland and upland plantings, partial stream restoration and riparian planting after the 1996 flood, and the creation in 2001 of a bioswale in partnership with the watershed council, Salem Public Works and ShurGard Storage Company. In 2001, Parks Operations obtained a $250,000 state lottery grant to fully develop the park, including completion of stream restoration and riparian plantings. Because the surrounding area is fully developed, the park has a lot of use. The stream banks have been damaged by overuse and minimal protection. Additional projects are needed to return the stream to optimum health.

Clark Creek Park, acquired in 1969, is a neighborhood park east of Commercial Street through which Clark Creek flows (Waitz 1976). Urban abuse, overuse of the streambanks, erosion from construction projects and incised banks have degraded the stream. Though much of the stream has trees nearby, there is little mid or lower story. Active Park Partners has participated in volunteer planting projects in the Park. Much more is needed to bring the stream and its attendant floodplain and riparian areas back to health.

A few locations along Pringle Creek such as one near 12th and Commercial manage to retain substantial native vegetation and natural stream flow. But even those areas have had sewer lines and storm drainage systems installed and have had to recover from the impact. At 12th and Commercial there has been major road construction as well. In June 1989, about 7,000 gallons of raw sewage flowed into Pringle Creek near 12th and Commercial after a boulder crushed a plastic pipe that workers were replacing (*Statesman-Journal* 1989a).

In 1993, the City approved two new developments along Pringle Creek on 12th Street, inappropriately as it turned out, because the developments went into the floodplain without widening a culvert and modifying the stream channel as required by new FEMA maps. The city had erred by using an older map. The city remedied the situation by constructing a larger culvert for Pringle Creek under 12th Street, deepening the creek where it runs through Brookside Garden Townhomes to increase capacity and deepening and widening Pringle Creek on the east side of 12th Street, south of Meadow Creek Village (*Statesman-Journal* 1993).

Other sites such as rights of way along the Union Pacific Railroad tracks next to Fairview Industrial Park offer more challenges, but the owners have indicated a willingness to partner with volunteers to mitigate some of the damage done over time along Pringle Creek. Communication between the watershed council and landowners continues.

While some business owners have been good stewards of the creek that runs through their back yards, others have sought to pipe, pave over, drain parking lots into, and dump industrial waste and refuse, into the creek. In August 1989, 50 gallons of cooking oil spilled into Pringle Creek near Davcor and 19th St. SE (*Statesman-Journal* 1989b). In 1996 and 2000, mass fish-kills were the result of industrial spills at SumcoUSA. The spills reached Pringle Creek at Fairview Industrial Park (*Statesman-Journal* 2000a). An area pilot project spearheaded by a group consisting of the watershed council, Marion County Solid Waste Management, the City of Salem and DEQ called the Watershed Enhancement Team (WET) is working to educate and change these practices. This voluntary program encourages local businesses to take a pledge to go beyond regulatory compliance. Almost 100 businesses in the watershed have signed up.

Public jurisdictions have their accidents as well. In August 2000, a major downtown water main ruptured, spilling five million gallons of water and flooding nearby businesses and eroding the north bank of Pringle Creek between Fire Station #1 and City Hall (*Statesman-Journal* 2000b). Using "state of the art" restoration techniques and within a very short time frame in order to stay within the "fish window," Salem installed below normal water level rip-rap and ran coconut fiber "blankets" up the streambank into which several hundred trees and shrubs were planted. Follow-up appeared to be a problem, however. Although native trees and shrubs adapt well to their native locations, in today's urbanized world, they need help for the first two years or so to get started. Many of the trees and shrubs at this southern-facing sunny site received no regular watering. The City replaced those trees and said the watering "problems" had been fixed. Later that same summer, most of the trees and shrubs were again dead due to lack of water.

Nor are public schools immune. In the summer of 2001, City of Salem water quality monitors noted that Clark Creek had turned a "funny color" near South Salem High School. The first thought was that someone was washing out paint rollers or brushes into the storm drain -- an all-too-common occurrence. However, from the volume of the flow, it was obvious this was a much larger incident than some homeowner cleaning up after painting the house. The cause was traced to South Salem High School's "maintenance drain." Staff and teachers have carefully used this interior floor sink to dispose of all sorts of maintenance-related substances such as products used to strip floors and clean paint equipment. Up until about ten years ago, it was also used to dispose of classroom waste or by-products such as those used in science labs and classrooms.

Everyone was "sure" the floor sink connected to the sanitary sewer system and that they were properly disposing of waste into that system. Instead, they discovered that it ran directly, without any filtration or diversion, to the storm sewer which drains into Clark Creek -- into its concrete-lined channel east of the ballfields. This portion of South Salem High School was built approximately 47 years ago and it appears that this had been the disposal practice for 47 years. The same day this problem was discovered, school staff capped off and discontinued using the floor sink. Shortly thereafter, the old line discharging into the creek was disconnected and a new connection was made to the sanitary sewer. In addition, the school district set about checking all the other schools, especially the older ones, to determine if anything similar was occurring there (Miller pers. comm.).

The City of Salem continues to struggle with conflicting goals and rules regarding treatment of Salem's riparian areas. For example, the current tree ordinance defines "intact riparian corridor vegetation" as " vegetation that is characterized by a diverse, multilayered assemblage of native trees and a vigorous, dense understory of native plants that provide any or all of the following benefits: (1) maintains or improves water quality; (2) provides fish and wildlife habitat; (3) mitigates development-related hydrologic changes; (4) mitigates flood hazards; and (5) provides other significant ecological, aesthetic, or educational benefits due to its natural conditions and functions."

The reality in Salem in 2001is: there is almost no place with <u>intact</u> riparian corridor vegetation either because of traditional stream cleaning methods which favor conveyance over water quality or habitat, or the property owners "clean up" the riparian edges for lawns and flowers. The result: an infestation of Himalayan blackberries and reed canarygrass, which is then used as proof that there is no intact riparian corridor vegetation to be protected under the tree ordinance. Additionally, the building and maintenance of various public infrastructures such as storm and sanitary sewer lines, culverts, bridges and streets often destroys intact riparian vegetation.

Many residential landowners have enjoyed having Pringle Creek or Clark Creek in their gardens and have designed around them. Most who have lived in the area for several years are realistic about "high water events." Some homeowners take stream stewardship very seriously. For example, several Idylwood Drive homeowners have cared for Pringle Creek and enjoyed the animals and bird life that such stewardship rewards. But when properties are sold, especially between major rainstorms and to people from outside the area, new residents have no knowledge about the stream in their back yards.

Too often properties are developed in ways unfriendly to neighboring streams. For example, a 2000 lot partition immediately adjacent to Pringle Creek has resulted in at least a 30′ high "hill of fill" over a spring on which two lots have been created and which now block the sun from those north of the "hill." Some homeowners dump grass clippings and landscape debris at creekside. Others use herbicides and fertilizers with inadequate protection for aquatic life. Some have dammed the creek or built concrete walls as dikes. Some have scraped the soil bare or installed fences at the stream's edge. Some have dumped in cars and tires allegedly to reinforce the bank during high water. One watershed council member asked, "I wonder if all the homeowners on the east side of Davidson are aware that everything that enters their driveway drains falls immediately into the creek? I bet that many have no idea" (Crawley pers. comm.).

In addition to streamside residents, all residents of the watershed need more help understanding the interactivity of the watershed. For example, there are several hundred individual detention basins on private property in Salem and, according to Salem's 2000 Stormwater Master Plan, the majority probably are not working as intended. Many residents profess ignorance about catchbasins draining directly to streams and express surprise when told that the stormwater and sewage treatment systems are separate in Salem. Homeowners, pesticide applicators, businesses, and public facilities groundskeepers all add to the current urban use of insecticides such as Sevin, lindane, malathion, diazinon and chlorpyrifos, and herbicides such as dichlobenil, prometon, tebuthiuron, 2,4-D and MCPP. These blend with the consequences of primarily agricultural pesticide use in years past. Because of overuse, certain weeds now "break" from the herbicide used to control them. One pesticide, dieldrin, has not been legal for more than 25 years, but measurable amounts were found in the last two years in Pringle Creek.

Under Commercial Street SE and Boise Cascade's buildings water roils around bridge and building footings in part because trees downed upstream have floated into the gabions protecting the structures and broken away the wire baskets. This is the first major barrier to fish passage in Pringle Creek. Other issues concern impacts of changes at the mouth of Pringle Creek. Across the Willamette Slough from the mouth of Pringle Creek are Boise Cascade's old settling ponds. Upstream are eroding revetments adjacent to Minto Brown Island Park. At Eola Bend there are active gravel mining operations, and inland, near the closed hazardous waste dump, sinkholes appeared on Brown's Island. Across the Willamette, there are proposals for major riverfront development requiring massive fill to raise the site above the 100-year flood level. All these actions accumulate into measurable consequences for Pringle Creek and the Willamette River.

While watershed councils began garnering public support and thousands of trees have been planted in the last few years on behalf of salmon and riparian areas, much more is needed. Education, continued project development and community involvement are keys to protecting, enhancing and restoring our urban watershed.

The Pringle Creek Watershed Council was formed in 1995 as an advisory committee to Salem's Department of Public Works. After the State of Oregon passed legislation that created watershed councils, PCWC became an independent watershed council. PCWC is currently served by a 19-member board of directors who reflect major stakeholders in the watershed, including educational/academic, business/economic, environmental, government, residential/property owners, scientific/technical advisory, five Neighborhood Associations, and other/general interest.

Just as a trickle at the top of the watershed is the beginning of a stream that becomes a river, so too are local preservation, enhancement and restoration efforts the beginning of a larger network. The Oregon Plan for Salmon and Watersheds seeks change in the basic relationship between people and natural resources, urging people to work together to build communities that will be sustainable in the long term and profitable in terms of cultural, environmental, recreational, and spiritual values. Awareness and a willingness to change must occur at the local level (Oregon Watershed Enhancement Board 2001).

Conclusion. In 1851, The Willamette Valley was covered mostly by savanna and prairie. These ecosystems have given way almost entirely to intensive agriculture and urban development. Originally, there were an estimated 877,240 acres of prairie; in 1995 an estimated 2,000 acres remained in the entire 3.4 million acres of the Willamette Valley Basin. Today even areas considered to be of marginal economic value (e.g. wetlands), are being lost to human encroachment. One of Oregon's benchmarks for a "livable environment" called for maintaining 100% of the 1990 Wetland Resource Base (Kagan et al. 2000).

In the Willamette Valley, wetland losses continue at an average annual rate of approximately 546 acres a year, despite regulations, programs and policies designed to curb wetland losses. Net wetlands lost between 1982 and 1994 in the Willamette Valley equaled almost ten square miles. While much of that loss is attributed to conversions to upland agriculture, most of the rest is the result of urban development. By any measure, the extent of loss of the Willamette Valley's primary ecosystems is dramatic. (Kagan et al. 2000).

About 27.6 miles of Salem's streams run above ground. Salem's Stormwater system includes 456 miles of pipes and culverts in addition to 54.6 miles of open ditches. Catch basins funnel whatever we let fall or flow from our yards, streets and parking lots into that "closed" system. Eventually, the "closed" system joins our streams and the Willamette River -- and brings with it much of what we have placed in it.

What our future looks, sounds, smells, and feels like requires broad ranging community discussion because whatever we do -- or don't do -- will have far-reaching and irretrievable consequences. Determining "highest and best use" surely deserves consideration on behalf of both the past and the future.

WATERSHED CHRONOLOGY

1500 BC	Kalapuya Indians begin Willamette Valley burning
1792	Cpt. Robert Gray of *The Columbia* enters the mouth of the Columbia
1805	Lewis & Clark trace the Columbia from its source to its mouth
1809	M. Gervais, member of Lewis & Clark party, settles at French Prairie
1812	Fur traders William Wallace & J.C. Halsey explore the Willamette Valley
1833	Missionary Jason Lee appointed to mission in Oregon Territory
1834	Jason Lee arrives on the Willamette, 10 miles upstream from Salem
1838	First wagon train crosses the Plains
1840	Grist and sawmills built in Salem, followed by a Mission school
1840-42	Salem called "The Mills" because of the Mission Mills
1841	Missionary Lewis Judson arrives to begin surveying new town
1842	Rev. Gustavius Hines preaches at the Indian Manual Labor School
1843	Marion County created; orginally called Champooick County
1843	Jason Lee home built, in part by native Hawaiians
1843	People adopt measures to protect flocks & herds from wild animals
1846	Dr. William H. Willson plats City of Salem
1846	Virgil & Phernie Pringle & family arrive in Salem on Christmas Day
1847	Fabritus and wife Virgilia Pringle Smith file Donation Land Claim #47
1848	Almost every able-bodied man leaves Salem for California's gold fields
1849	Champooick renamed Marion County honoring Gen'l Francis Marion

1850	Rev. L.H. Judson names Salem after his home town of Salem, Mass.
ca. 1850	Dr. William H. Willson files Donation Land Claim
1851	Oregon's Capitol moves to Salem
1851	*Oregon Statesman* newspaper moves to Salem from Oregon City
1851	First steamboat arrives, takes agricultural goods for Calif. gold miners
1852	Willamette University incorporates during Oregon's first legislature
1853	Original First Methodist Church dedicated
1853	Dr. William H. Willson establishes first drug store in Salem
1853-1861	First South Commercial Street bridge over Pringle Creek
1841	Pioneer Cemetery established in part by Leslie donation
1856	Salem given Charter by Oregon Legislature
1857	City Charter addresses standing water, unwholesome, offensive substances
1857	City Charter not enforced "with determination"
1859	B.M. Durelle's sawmill downtown burns down
1861	Disastrous flood wipes out much of downtown and bridge
1861-1892	Second Commercial Street bridge, a covered one, built over Pringle Creek
1863	Suspicious fire set in saloon causes major damage
1864	Another major fire burns entire city block
1864	Voters choose Salem as state capitol by 79 votes
1860's	Salem Flouring Mills built

1865	Willamette Flouring Mill established at Commercial/Trade (BC site)
1865	Yet another major fire set in a saloon, also suspicious, burns entire block
1865	Two convicted killers hanged at Pringle Park
1865-1869	Several major fires during the next five years
1866-1909	Capital Lumbering Company established
1868	William Graves becomes Salem's first known undertaker
1869-74	Sam Clark, is editor of *Oregon Statesman*
1869-1900	Reed Opera House open
1869	Ladd & Bush Bank opens for business
1869	Four new coal oil street lamps placed, including one at covered bridge
1869	Special City Council meeting convened regarding spread of smallpox
1869	1,000 cases of measles hit Salem
1869	City's first calaboose planned
1869	Common drunkenness ordinance passed
1869	Posh Chemeketa House opens, "a credit to our young State"
1870	First Water Works consisting of a 150,000 gallon cistern built
1870	Gas Works built
1870	First Train bearing mail/passengers chuffs from Portland to State Fair
1871	Susan B. Anthony speaks on women's suffrage at the Reed Opera House
1875-95	City of Salem steamboat excursions on the Willamette River
1876-1952	First Marion County Courthouse on High Street
1878	Bush House built

1878	Barrick Funeral Home opens
1881	Salem's first sewer carrying both sanitary and stormwater is constructed
1881-1927	Continued construction of Salem's sanitary and stormwater systems
1883	Kalapuyan Chief Quinaby dies during Christmas week
1886	First bridge built across Willamette River
1886	Electric lighting comes to Salem
1889	Yew Park Addition established
1890	Sanborn map shows island off mouth of Pringle Creek
1890	World-renowned prune industry begins in Salem area
1898	Deepwood Mansion built by Dr. Luke Port
1892	Third South Commercial Street bridge built over Pringle Creek
1896	Salem Memorial Hospital opens at 12th and Ferry with 5 beds
1896	Life Expectancy: 46 years; infant mortality rate: 15%
1903	Salem Library formed by Salem Women's Club
1903	First major annexations quadruple Salem, south to Hoyt, east of 25th
1905	Dan Fry moves to Gaiety Hill
1907	Five blocks on Court Street are first five blocks paved in Salem
1908	Liberty School built
1909-1941	C.K. Spaulding Lumber Co exists on old Capitol Lumber site
1913	Railroad bridge built across Willamette River
1916	Mennonites purchase former Capital Hotel, 665 Winter St., for hospital
1917	Bush's Pasture Park's first parcel deeded to City

1918	State evicts Salem Hospital, just in time for influenza epidemic
1919	Virgil T. Golden begins city's first ambulance service
1920	Miller's Department Store opens on Reed Opera House site
1921	Cornerstone of Salem General Hospital laid
1923	First municipal full time fire department established
1923	Pringle Creek Park purchased
1924	Mysterious monoliths discovered on Cunningham farm
1926	Elsinore Theatre opens
1940	Salem celebrates centennial with 30,908 citizens
1941	First airline flight out of Salem
1942	OR Pulp & Paper Lbr Division Takes over Spaulding Lbr Co site
1940's	OR Pulp & Paper Lbr Division Expands to Salem Flouring Mills site
early 1950's	Bennett Field constructed; Kalapuyan sweathouse obliterated
1952	Woodmansee Park's first parcel purchased
1961	Salem wins coveted national "All American City" award
1962	Carson Springs Natural Area purchased
1962	Most of hangar at McNary Field destroyed by Columbus Day windstorm
1962	Willamette (University) Urban Renewal Project (22 acres)
1964	City annexes 2807.6 acres in South Salem
1964	Salem Memorial Hospital evacuated during 100-year flood at Christmas
1964	Concrete box culvert 5'x5'x230' placed under Commercial near 12$^{th\ St}$.
1968	Fred Meyer opens 93,000 SF store in South Salem

1969 Clark Creek Park purchased

1969 Fire at Fairview Training Center kills three residents

1970 Central Salem Development Plan completed

1971 Pringle Creek Urban Renewal Project (78 acres)

1972 US Army Corps of Engineers stops annual dredging of the Willamette

1972 Boise Cascade ceases dumping effluent directly into Spaulding Slough

1972 New Salem Civic Center dedicated in August

1973 Riverfront Park's first of seven parcels purchased

1975 Clark Creek at South Salem High placed into concrete lined ditch

1976 Riverfront/Downtown Urban Renewal Project (254 acres)

Neighborhood Renewal Projects:

1. South Central (760 acres)
2 Mission-Lee (85 acres)
3. Lee-Hines (36 acres)

1980 Front Street bypass Built

1980 Cannery Park property purchased

1982 Mission Street bridge and freeway not built

1982 Shoreline Drive - South River Road highway not built

1984 Fairview Industrial Park Urban Renewal Program begins

1984 Salem voters approve purchase of riverfront property from Boise Cascade

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Glenn-Gibson Watershed

History of Glenn-Gibson Creeks Watershed

By Dorald Stoltz and Jim Castle

Introduction

The Glenn and Gibson Creeks watershed drains approximately 10.4 square miles of agricultural and residential land above West Salem in the South Eola Hills. The upper portion of each creek runs through farm and large-scale residential acreage, while the lower portion of each cuts through some densely-built residential areas. There is no industry, other than agriculture, within the Glenn-Gibson creeks drainage basin. Other than a few small specialized nurseries, businesses and retail stores are limited to a handful of operations along Wallace Road. The extensive commercial and industrial development adjacent to Edgewater and Wallace roads in West Salem proper are, technically, outside (over the hills) from the watershed.

Both Glenn and Gibson Creek run for the most part through private land, so there is very limited public access. The exceptions are Orchard Heights Park, which Glenn Creek passes through on its way to the Willamette River, and Brush College Park, which is bordered by Gibson Creek. In addition, one small branch of Glenn Creek passes near Wallace Marine Park. There is a new, as yet undeveloped, nature park near the intersection of Doaks Ferry and Orchard Heights on property donated by former Governor Straub. There are two public elementary schools in the watershed, Chapman Hill and Brush College. There are also Walker Middle School and the new West Salem High School.

Population of the watershed area is estimated at 50,000 to 60,000. Both creeks are entirely within Polk County. Glenn Creek runs within the Salem city limits for about three-quarters of its course, while Gibson Creek runs through the city for a much shorter distance.

Early Human Inhabitants

For at least 5,000 years before the first white men came to the area, the Glenn and Gibson Creeks Watershed was a small section of the range of the Yamhill band of the Kalapuyan Indians. The Yamhills' area was described in the 1851 treaty in which the band ceded its lands to the United States government as:

> Commencing at the mouth of the Yamhill River; thence, up said Yamhill River, to the junction of its North and South Forks; thence, up the South fork to its junction with Deer Creek; thence up said Deer Creek, to its head waters, thence, due west to a point on the summit of the Coast Range of Mountains; thence, southwardly, following the summit of Said Coast Range, to a point due west from the head waters of the North fork of the Luck-a-miute River at its entrance into the Wallamette River; thence, down said Wallamette River to the place of beginning (Mackay 1974).

Though no encampments, burial sites, mounds or other evidence of Indian habitation have been found within the watershed, the area shares characteristics with other areas the in which the Kalapuyans roamed. Like other members of their tribe, the Yamhills managed their land to encourage growth of wild food plants and protect the game they lived on. Through the Willamette Valley, the Indians annually set huge fires. Fires on the open areas cleared out brush so that desirable grasses and the root plants could flourish. Fire in the forested areas kept brush and tree seedlings in check and made hunting easier. As a result of this periodic burning, the Glenn and Gibson Creeks area hills, which might have been solid Douglas fir forests, are mainly open areas broken up by wooded sections, primarily on steeper terrain.

The Kalapuyans' main food was camas. They also dug and gathered acorns, wild onions, salmon berries, thimbleberries, raspberries, salal berries, blackberries, huckleberries, wild cherries, sunflower seeds and strawberries. They hunted deer, elk, bear, beaver, squirrel, gophers, rabbits and a number of birds (Mackey 1974). There are no records of any significant numbers of fish in Glenn and Gibson creeks and, according to historians (Gulick 1991), fish were neither numerous nor constant there.

Pre-Settlement – Early 1800s

The first white men to come to the area were fur trappers, settlement promoters, missionaries and explorers. They did not find a pristine wilderness, but, rather, miles of flatlands and hills that had been carefully managed by the Indians for centuries. Writers from that period commented on the beautiful landscapes, fertile soil and lush plants. The Glenn and Gibson Creek watershed area includes no significant landmarks from this era.

In 1843, the Salem and Doaks ferries began their runs across the Willamette River. The Salem Ferry was about where the Marion and Center Street bridges are now. The Doaks Ferry was where the town of Lincoln is now.

Settlement Period - 1848 to the Early 1900s

The Glenn and Gibson Creek Watershed lies almost entirely within what was then considered the Brush College farming community. According to Charlotte L. Wirfs, Brush College historian, this included the "area between just south of Lincoln to the Willamette River or where Edgewater street is now located" (Wirfs 1981).

First to arrive at Brush College was a group headed by the Rev. Jesse Harritt, a member of the Meek Cutoff party that got lost in the Cascades while attempting a shortcut from Boise to The Dalles. Harritt and his friends arrived by flat boat in December 1845.

In 1850, the Donation Land Act was passed by the United States Congress. Within just a few years, approximately 12 donation land claims made up the Brush College area, accounting for all but the upper reaches of the Glenn and Gibson Creeks drainage. The claims ranged in size from 159½ to 640 acres. The main use of the land was agricultural. As today, the farmers produced what the market demanded. They first planted wheat and oats, but by 1890 were also tending orchards of prunes and cherries. They raised cows, sheep and pigs (Leth 1980).

One of the donation land claimants, Hosford, built a mill to produce lumber. However, the project was abandoned when it turned out that Gibson Creek could supply sufficient water to run the mill only six weeks out of the year (Maynard 1981).

As Harritt and his neighbors settled in, they had few local roads to travel. What is now called Wallace Road was in place, built in 1851 from the Yamhill County line south to Rickreall and on to Benton County. Doaks Ferry Road ran from the Willamette River to Wallace Road and then turned south where it became a path (Wirfs 1981).

By 1882, there were a number of other landowners in the area, though most of the donation land claims remained with their original owners. The roads were still primitive, but the county had platted and started to build a road system. Doaks Ferry was cut through from Wallace Road to Eola. Brush College Road provided transport to Bethel to the north where it joined up with other county roads (Ogilbe 1882).

Between 1886 and 1889, Robert Stewart Wallace purchased a donation land claim from Lewis Parkhurst and established Wallace Farm. Wallace, whose business were based across the river in Salem, graveled what is now called Wallace Road to improve wintertime access to the Salem ferry and, later, the first bridge connecting Salem and West Salem. The bridge, however, was washed away during a flood in 1890. Salemtowne is located on what was the Wallace Farm and the Wallace home is now the Farmhouse wing of the retirement complex's clubhouse (Week 1983).

The year 1890 was significant for the area that was to become West Salem. The flood washed out much of the townsite of Eola, located just south of the Glenn and Gibson Creeks area, dashing that community's hopes of becoming a major city. The previous year the West Salem addition, a flat area along the Willamette River, had been subdivided. Orchard Heights, inside the watershed, was subdivided in 1892, followed in 1900 by Kingwood Heights in the hilly area that separates the West Salem "flats" from the watershed. In 1913 West Salem was incorporated, and in 1949, it merged with Salem (City of Salem 1984).

Years of Development

The major residential development in the watershed area began in the 1960s when a local developer, Larry Epping, purchased the Koehler property in the hills above West Salem in 1963. As the lots were subdivided, Glenn Creek often formed one border of the newly-platted lots. There was a building boom in the late 1960s and 1970s, resulting in subdivisions of residential homes scattered throughout the watershed. After a lull in the 1980s, the building resumed, both infilling in the existing subdivisions and establishing new developments.

Creeks -- Water Quality and Change

Though there is no evidence that development has resulted in significant changes in the streambeds of either creek, it has impacted the riparian areas. First, in many cases vegetation is removed down to the creek level in the course of construction. Then, after the homes are built, homeowners plant lawns and non-native plants. Residents are not encouraged to restore natural riparian areas. Water quality is impacted by the use of pesticides and herbicides and street run-off that all drain, through the storm water system, into the creeks.

Aside from the portion close to the Willamette River, only narrow, streamside ribbons along Glenn and Gibson creeks are listed as floodplains. Floods, such as the one that struck the area in 1996, do damage to obstacles that have been placed in the creeks' way, like culverts and landscaping. However, the high water levels in the winter months and the occasional flooding allow the creeks to refresh themselves and reclaim their courses.

According to reports from farmers who have lived in the area for a number of years, water quality in the two creeks is better now than in than in the past when farmers were not concerned about water runoff from their lands. Don Meyer, a member of the local watershed council who farms on Gibson Creek, said "Agriculture takes much better care of the land now than in earlier years." He also pointed out that logging practices have improved and are monitored where there were no controls in the 1940s and 1950s (Meyer pers. comm.). This view was substantiated by another council member, Wayne Simmons, whose family has farmed land in the watershed since 1912. He said there was much more siltation in the creeks 70 or 80 years ago because of erosion of topsoil from the orchards (Simmons pers. comm.).

Meyer and Simmons said that there are many more coyotes than there used to be, resulting in decreases in both the deer and fox populations. Neither has ever seen bears locally, though they were reported by the earliest visitors to the area. Meyer said that there are significant increases in the number of hawks, beavers, cougars, raccoons and blue herons in the area where he farms. Both men said there have never been many fish in the creeks and never any salmon. They attributed much of the reduction in the number of salmon in the Willamette, and all fish in private ponds, to the blue herons which, they report, are much more prevalent than they used to be (Meyer pers. comm.; Simmons pers. comm.).

Lowell Ford, who farms on Wallace Road, says there are "far more fish in our stream (Glenn Creek) than 30 years ago." He credited the increase to restoration efforts he has undertaken, including replanting of native trees and removal of silt and reed canarygrass, to allow the stream to meander and form shallows and deep areas (Ford pers. comm.).

Summary

Land uses in the Glenn and Gibson Creeks watershed have evolved through the years from the nomadic ways of the Native Americans through farming and logging of the early settlers, a mix of residential and farming through much of the 1900s, to a virtual explosion of growth from the mid-1960s to the present as farmland is converted to subdivisions of single-family dwellings.

Over the years stream quality has varied, though there is no evidence that either creek, Glenn or Gibson, ever supported large fish populations. Riparian zones along the streams have been replaced by lawns and garden plantings, thus eliminating much of the watershed's wildlife habitat. There has been no major re-direction of either creek, and the landforms remain much as they were when the first white settlers arrived, except that they are now covered with streets and homes.

There is increasing awareness among residents of the watershed's fragility, and its importance to West Salem's quality of life. Hopefully this interest will expand, enhanced by governmental support of restoration projects and enactment of regulations governing land use.

Glenn-Gibson Watershed Place Names

Brush College School and Road – Named for the vegetation at the site of the school. After the Indians stopped their annual burning, shrubs and trees grew profusely. The use of the word "college" referred to use of the site as an elementary school. There is no actual college in the area. Land for the school was deeded in 1867. Until 1975, what is now Brush College Road was called Spring Valley Road.

Chapman Corner, Hill, and School – Named for the Captain Chapman family that lived in the area (Sec. 17, T7S, R3W). Chapman Corner was the site of their home; the 400-foot elevation Chapman Hill is nearby. It was earlier called Schindler Hill after a different landowner. Chapman Hill School, which opened in 1986, is nearby.

Chatnika Heights – Named by developer Larry Epping after the Indian word of unknown origin applied to a nearby branch of Glenn Creek.

Doaks Ferry Road – Named for Andrew Jackson Doaks who operated a ferry on the Willamette River at what later became the site of Lincoln. The road was also known as Military Road.

Eola – This is an adaptation of Aeolus, the Greek god of winds. Lindsay Robbins, a local musician, is said to have suggested the name. The townsite of Eola was incorporated in 1856. Eola County Park, now part of Chemeketa Community College, includes land set aside for a town square when it was hoped that Eola might become the state capital. The Eola Hills, which includes the Glenn and Gibson Creeks watershed, is named for the townsite.

Gehlar Road – Named for Max Gehlar, a local landowner.

Gibson Gulch, Road, and Creek – Named for Davies Gibson, a pioneer settler in the area (Sec. 12, T7S, R4W).

Glenn Creek and Glen Creek Road – Named by a local resident, C. A. Park, for the narrow valley or glen the stream flows through.

Grice Hill – Named for L. Grice, who owned nearby land. It was once a major source of stone for building in Salem.

Orchard Heights and Orchard Heights Road – Named for the orchards that grew on the slopes.

Salemtowne – Named by Landmark Townes, the developer of the retirement community. The name reflects the location near West Salem and the name of the developer.

Spring Valley Road and Creek – Named for the numerous springs found in the area. Brush College Road was called Spring Valley Road prior to 1975.

Wallace Road – Named for R. S. Wallace, owner of a large farm that is now the site of Salemtowne.

West Salem – Named after the city of Salem with the directional modifier. The city of West Salem was incorporated in 1913 and merged with the city of Salem in 1949. The name, Salem, is an Anglicization of the Hebrew word “shalom,” which means peace. (Source: Clarke, Gordon W. 1977. *Polk County, Oregon Place Names*. Oregon College of Education. Monmouth, OR).

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Claggett Creek Watershed

History of Claggett Creek Watershed

By Lee Hettema

Approximately 20, 000 years ago the Willamette River flowed in a more easterly course through the Willamette Valley. There is evidence that the old channel between the southern and northern Willamette Valley ran through the narrow gap at Mill Creek and the Waldo Hills (Orr, Orr and Baldwin 1992; Orr pers. comm.). This evidence consists of the gravel quarry at the bridge over Mill Creek on I-5 (course pebbles) and Lake Labish. Lake Labish is the remnant of a bend in the ancient Willamette River. The former river course was cut off during the Pleistocene Epoch when a natural dam of sand from Silver, Butte and Abiqua Creeks blocked the channel. The resulting shallow lake slowly filled with silt and organic matter to become a marsh. Thick peat deposits in the old lake reflect a long period as a swamp and a bog. In this organic layer, bones of mammoths, mastodon, giant sloth and ancient bison are frequently found. The carcasses were probably washed in and covered, allowing the remains to be preserved in the oxygen-poor bog. Because these remains sank into the bog, they could not be eaten by scavengers and so remain as a fossil record (Orr, Orr and Baldwin 1992).

Archaeologists have been conducting a dig at two sites in Woodburn. At one site, called the Stafek locality, in Front Street Park, they have recovered a human hair and two flaked stone artifacts. These were found in undisturbed marshland clay that directly overlay Missoula Flood silts. This clay is contemporaneous with sphagnum bog deposits that have been carbon-dated to 11,690-12,000 years B.P. These artifacts were recovered in 1999. (Stenger pers. com.; Hibbs pers. comm.).

In 2000, at another site, Legion Park, a human hair was recovered from the upper portion of Missoula Flood stratum. This stratum has been carbon dated to 12,000 years B.P. William Orr has identified fossils from these sites (e.g. ground sloth, mastodon, dire wolf, bear, big horned sheep, horse and the largest known Pleistocene bird, the teratorn, with a 14-16 foot wingspan). If human hair and artifacts were found at a fossil-rich site in Woodburn, human artifacts might also be found at the fossil-rich site we call Lake Labish. Both sites show an abundance of fossils indicating the presence of game or prey. Hibbs believed that the Woodburn results would be replicated in studies throughout the lower Willamette Valley because of silts and gravels from the Missoula Flood that preserved early organic materials in a perfect anaerobic soil environment (Hibbs pers. comm.).

The next reference to the area near Claggett Creek is in 1812/13. John Jacob Astor's Pacific Fur Company established two trading posts in the Willamette Valley. The southernmost outpost was Wallace House on the Wallace Prairie. On old maps from the 1800s the west Keizer-Mission Bottom area is named Wallace Prairie. A few years later the trading post was transferred to Hudson's Bay Company. In 1818, the United States and Great Britain agreed to joint occupancy of the Oregon Country. All Hudson's Bay outposts south of the Columbia River were abandoned by 1824. In 1834

Jason Lee and the Methodist Missionaries settled at Mission Bottom. Salem began in the 1840s.

Two of the settlers from the Jason Lee Mission give the first account of a major Willamette River flood in 1843. On January 16, 1843 Gustavius Hines and L.H. Hudson set out from Salem by canoe to paddle up to Fort Vancouver. They arrived on January 18, 1843.They describe their voyage as quite cold; rain and hail fell constantly. It continued to storm without interruption until February 2, 1843 (Marion County Historical Society undated).

In 1841 Lieutenant Charles Wilkes of the US exploring expeditions noted that "generally the valley's prairies were one-third greater than the forests; some (of the prairies) were 15-20 miles across." He also noted that Indian tribes inhabited the area (mid-Willamette Valley) but only sparsely due to disease (Marion County Historical Society undated).

After Wilkes' reports and reports from the Willamette Mission began to filter back to the populated area of the then-United States the rush to settle was on. In 1843, the father of Keizer, Thomas Dove Keizur, came to the Oregon territory with the Applegate expedition. Thomas Dove Keizur was the first settler in the Oregon Territory to have his deeded land claim surveyed (Loudon pers. comm.).

In 1852, Charles and Mary Claggett arrived in the Keizer area (Wallace Prairie) and settled on their deeded land claim near the current intersection of River and Lockhaven Roads. Their son William Claggett accompanied them. Charles was born in 1813, and William was born in 1840. William Claggett was one of Willamette University's first students. Some of the other early settlers of the Keizer area were the Pughs, the Fords and the Smiths. By 1917, more than 70 years after the first settlement in the Keizer Bottom, there were fewer than 70 families in the entire area. The Smith graveyard became the Claggett Cemetery (at the end of Bolf Terrace). The first school in the area was a log cabin on the Claggetts' farm near the intersection of River and Wheatland Roads. The first schoolmaster was Hugh McNary, son-in-law of Charles Claggett.

We can now see how the first name for Claggett Creek was Ford Creek; it flowed across the Ford lands in the vicinity of what we now call the McNary Golf Club. The name was later changed to Grierson Creek and then finally Claggett Creek, although some stubborn Keizer old-timers still refer to part of Claggett Creek as McNary Creek.

As the first settlers arrived the General Land Office of the United States began the preliminary surveys to establish the sections for the townships and ranges that Claggett Creek flows through. Since I once was a surveyor, I decided to check the surveyor's notes from 1851 and 1852 to get the most detailed early account of Claggett Creek. We will proceed from Clear Lake to Claxter Corner. First, some old surveyor measurements must be translated into terms we are more familiar with. A chain is 66 feet long, while a link is 1/100 of a chain (0.66 feet =7.92 inches). There are 80 chains to a mile and a section is one mile by one mile.

It was important to the General Land Office to complete these surveys because people tended to settle where the land was flat and the soil was good. Generally, flat land in the Willamette Valley was surveyed before the Cascade foothills, because this land was more likely to be settled first and was easier to survey.

In Township 6 South, Range 3 West, the surveyors encountered a stream that was 40 links wide. The course of the stream was northwest for 3 chains, then southwest into Clear Lake. In other words, this is the mouth of the Claggett at Clear Lake. The surveyor noted lots of ponds on this traverse (Ives 1852).

On the line between sections 26 and 27, the survey crew encountered a stream that was 30 links wide. The Alvis Smith farmhouse was near the creek. At 50 chains north of the section corner, the surveyors encountered a bank. At 56.2 chains north of the section corner, they encountered the creek again. The surveyor noted that the Willamette River overflowed in most places. The soil of the bottoms was first rate, sandy loam and mostly prairie soil. East of the bottoms was first-rate clay soil. Timber was fir, white ash and maple, with undergrowth of hazel (native filbert), vine maple and rose briars (Ives 1852).

On the section line west from the section corner between sections 26 and 35, the survey crew encountered the west bank of a creek. At 23.50 chains west of the section corner, they encountered a stream, 15 links wide, flowing southwest near the intersection of Labish (flowing out of Lake Labish) and Claggett Creek. At 25.50 chains west from the section corner, the party encountered a road--the current River Road (Ives 1852).

On the township line between Township 6 South and Township 7 South, Range 3 West, bearing due west, the survey party descended the bank of a creek, and entered a swamp. Then they encountered a stream 10 links wide, its course northwest. After first entering the swamp 16.00 chains west of the section corner, the surveyor noted that the traverse went through swampland until they were 56.00 chains west of the corner, where they encountered nearly level prairie, which was cultivated. The soil was first-rate clay loam and sandy with short grass (Ives 1852).

The surveyors described the land near Clear Lake as gently undulating bottoms, overflowed in highest water by the Willamette River. The west side of the bayou was swampy with a sloping bank. The east side had a bold bank. The soil was first-rate clay loam. The timber was fir, white ash and maple, with undergrowth of hazel, vine maple and briars. The bayou was 36.00 chains wide and apparently very deep (Ives 1852).

At 27.00 chains west of the section corner the survey crew encountered the outlet stream of the bayou (Clear Lake). The stream was 30 links wide and its course was southwest. Shortly the party encountered the same outlet stream again, but the course was northwest and the current brisk. The stream meandered back and forth, flowing sometimes faster, other times slow. This survey was done very quickly: begun on December 8, 1851, it was completed January 1, 1852 (Ives 1852).

In Township 7 South, Range 3 West, on the section line between Sections 11 and 12, heading north from the section corner, the survey party descended a bank. They then encountered a shoal pond, dry in dry season. It was 370 links wide. At 60.00 chains from the section corner, they encountered a stream, 4 links wide, its course northwest. At 67.50 chains from the corner the party encountered another stream, 6 links wide and also flowing northwest. These were two branches of Claggett Creek. The land was slightly undulating. The north and south quarter sections were mostly covered with water in the wet season. Soil was first-rate clay loam, with fir and white ash. The undergrowth was rose, vine maple and hazel with grass and fern (Ives 1852).

On the section line between sections 2 and 11, heading west from the section corner, the survey party left the prairie. They encountered a stream 10 links wide. The course of the stream was north, through gently undulating land. The soil was first-rate clay loam and sandy loam, timbered with thinnish fir and white oak. The undergrowth was hazel, oak, willow and grass. A little further west was prairie land, high bottom, partly overflowed in high water. This survey too was finished quickly. Begun on November 14, 1851, it was completed December 6, 1851 (Ives 1852).

On the range line between Range 3 West and Range 2 West, walking north, the surveyors encountered a swamp with willow on the west side, while most of the other parts were wet prairie, which overflowed in wet seasons. It had a very rich alluvial soil and was called Lake Labish (Hyde 1852). This survey was begun February 2, 1852 and was completed February 24 of the same year.

The surveys were usually completed quickly, often in winter. The surveyors were recording wet season conditions, and guessing at dry season conditions. They emphasized soil, timber and undergrowth, focusing on resources and problems.

Aside from the cryptic description of Claggett Creek and the surrounding lands in the General Land Office Field Notes, the only other mention of Claggett Creek in history is when the creek flooded. The bulk of my narrative will deal with the recent major floods of the Willamette River and Claggett Creek.

1861-62	Willamette River crest estimated at 47 feet in Salem. Champoeg was swept away.
1881	River crested at 36.3 feet. Flood water reached downtown Salem.
1891	Crest at 45 feet. Floods swept away Marion-Polk County Bridge.
1943	January floods following 60 days of heavy precipitation and 26 inches of snow. Crest at 38.6 feet.
1964-65	Flooding caused $2,240,000 worth of damage. Christmas week crest at 45.3 feet. Flood receded, then rose again the last week of February doing $47,200,000 more damage. 12.4 inches of snow fell in mid-December, then a Chinook wind blew in and melted all the snow. 8.16 inches of rain fell in January 1965. From November to January 23.58 inches of rain fell. The annual total for the year was 36.94 inches. Considered to be a 100-year flood.
1996-97	Four day cold spell with 17-degree lows and 35-degree highs followed by five days in the 50's. 7.58 inches of rain fell. Some claim this was also a 100-year flood event (Hanson 1998).

Some of you flood fans might wonder about the Flood of 1948 that washed away Vanport. This was not included because it was more of a Portland-area flood of the Columbia.

The flood of 1861 is often characterized as the worst flood to hit Salem. The Keizer Bottom has been subject to flooding throughout its history. The flood of 1861 was the worst flood to hit Keizer. The flood came as far east as the current fire hall site on Chemawa Road. Keizer was isolated from Salem. The then unnamed Claggett Creek flooded lowlands at the current Claggett Creek Park and closed Chemawa road to the east. The creek swelled to the proportions of a river. The *Oregon Statesman* reported in 1862, "The flood of 1861 went down in history as the most disastrous ever experienced in the Willamette Valley" (Lossner 1990). Earl Byrd's grandmother told him that people went to their rooftops with cattle horns so they could be found and rescued during the flood of 1861 (Hanson 1998).

Paul Townsend of Mission Bottom stated that the flood of 1891 was comparable to what he had been told about the 1861 flood and what he experienced in the flood of 1964: "There were pigs in the attic" (Lossner 1990). In Salem in 1891, two feet of snow fell. Then a Chinook wind melted everything. The Willamette rose so high that the bridge to West Salem was washed out. Don Durette said, regarding the flood of 1891, "There was a legend about that flood that I heard repeated many times and that is the River was so high, that Keizer Creek reversed itself and most of Keizer was under water" (Lossner 1990). Keizer Creek was another name for Claggett Creek.

Not all the floods involving Claggett Creek occurred during the major floods of the Willamette River. In 1909 Thressa Hall, a student at the then two-room schoolhouse at School House Square, said that the flood waters of the Willamette River poured through the ravine behind the school. Claggett Creek rose above the footbridge at Chemawa Road. Whenever the creek rose above the footbridge, Keizer School would close (Lossner 1990).

In 1923, Paul Townsend of Mission Bottom observed that the flood water in the bottoms was the highest that he had ever seen (Lossner 1990). During the flood of April 12, 1931, Jack Chapin talked about fishing with a shovel (Lossner 1990).

During the flood of 1943, a US Coast Guard cutter floated onto the Rehfuss farm on Cherry Avenue through the draw where the Keizer Elks Club is now situated. The purpose of this cruise was to rescue people stranded by the flood. The flood crested at 30.6 feet. The 1943 flood was characterized by a rapid rise in water level, six inches per hour. This was a major problem; coupled with no advance warning, this flood was very destructive to the farms in the Mission Bottom area. People have speculated in hindsight that there was no advance warning due to the war effort. Flooding in the Willamette Valley was classified information -- if the enemy had been aware of limited harvest from the Willamette Valley, it could have constituted a tactical advantage.

On Christmas Day in 1953 electric power to Mission Bottom was out, since most of the Bottom was under water.

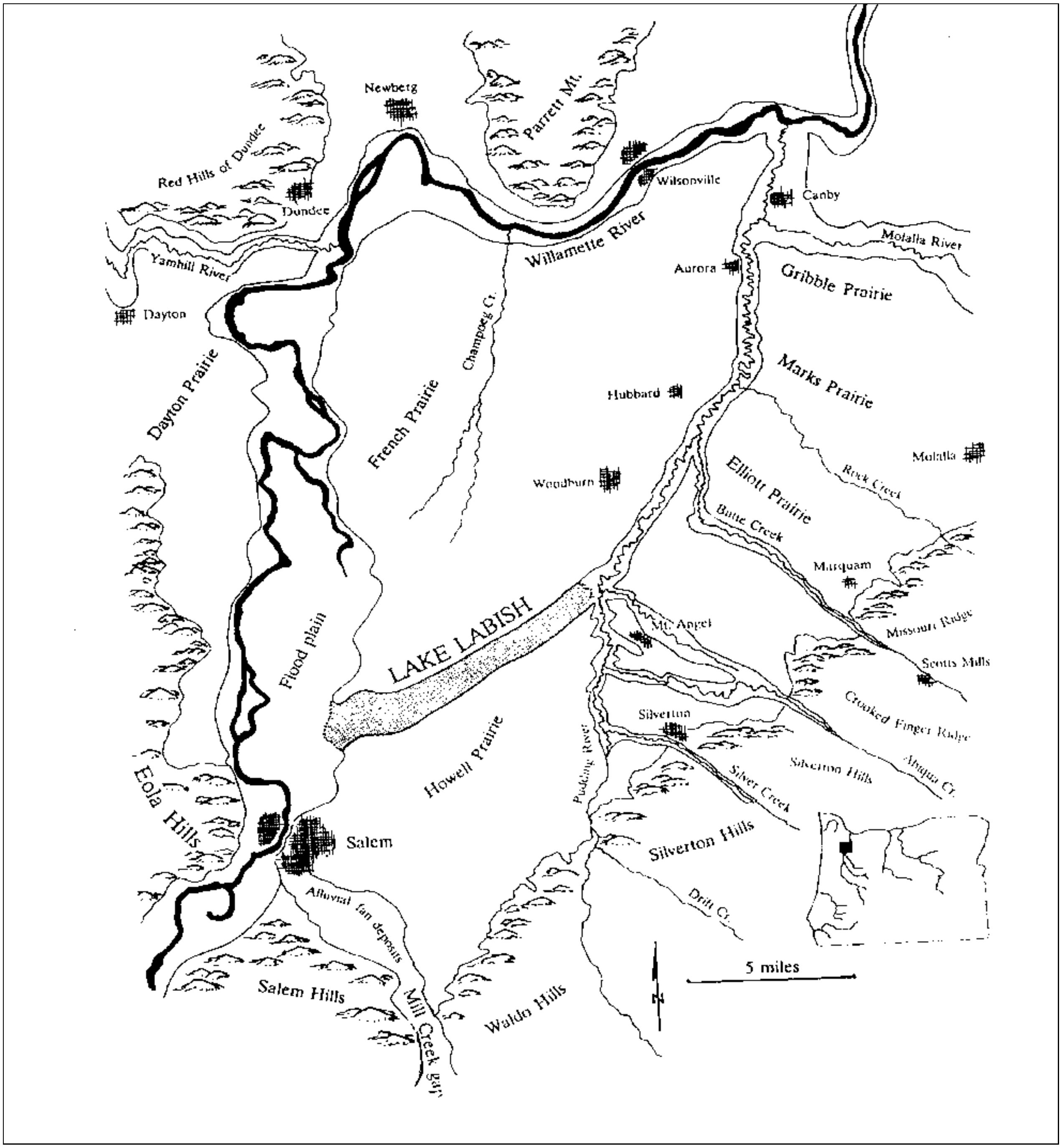
During the flood of 1964/65, water from the Willamette River swept away the new football field at McNary High School (Backlund pers. comm.). Other accounts of this incident give Claggett Creek the credit for the theft of the football field. Flood waters covered Chemawa Road past Keizer School into the Safeway parking lot (Lossner 1990). Volunteer fireman Otis Anderson said that the water from the backed up Claggett Creek came in from across McNary High School. This flood was devastating because people had 15 minutes' notice to evacuate their homes, which were decorated for Christmas. Many of the photos of this flood show soggy Christmas trees and presents at the high water mark. 4,200 of Keizer's 7,000 residents had to evacuate, as the flood waters rose four inches every 15 minutes (Morgan 1994).

History of Lake Labish

Mt. Mazama erupted 6,800 years ago, thus forming Crater Lake. Ash covered all of Oregon east of the Coast Range, Washington, Idaho, Montana, and part of British Columbia and Alberta. Lake Labish still has an ash layer more than two inches deep, some three feet below the lake surface (Tryk 1996).

French Canadian fur trappers discovered Lake Labish in 1848 (**Figure 3-1**). The name of Lake Labish comes from the French word “la biche,” meaning “female deer or elk” (Tryk 1996). The Pudding River, which drains into Lake Labish, purportedly got its name when two French Canadian fur trappers shot an elk about three miles west of Mt. Angel. Their Indian wives made blood pudding from the kill; hence, the name Pudding River (Tryk 1996).

Figure 3-1. Location of Lake Labish



Lake Labish drains into Clear Lake and the Willamette River from a natural divide about three miles from the western end. The Little Pudding River drains Lake Labish's eastern end. Marion County gave permission in 1875 for construction of a two-mile ditch from Clear Lake. This was the first attempt to drain Lake Labish, though it failed because of the many surrounding springs. The federal government gave the lake bottom to the state of Oregon, as no private landowners were interested in it until 1890

(Tryk 1996). The federal government retained about seventy acres of Lake Labish for the Chemawa Indian School's classes in agriculture. They grew onions, pole beans, and sweet corn.

Salem suffered a major flood in 1891. The railroad crossed Lake Labish on a trestle a little north of Chemawa. The trestle gave way under the southbound train, dumping part of it in the water. There were five fatalities. The engine could not be salvaged; it kept sinking in the soft lake bottom, where it still lies. The railroad filled in that section of the lake to cover it (Tryk 1996).

The western end of Lake Labish was drained about 1911. A ditch through the middle section was completed in 1915. In that same year, M.L. Jones dug a ditch from the east side of the divide, which allowed the lake to be cleared of brush. This was mostly willows and buck brush, with some small ash and alder. Lateral ditches were then dug by hand to drain the fields (Tryk 1996).

Two millionaires, A. F. and J. O. Hayes from California, became interested in the northern end of Lake Labish in 1913. They wanted to farm the rich bottomland. The Parkersville Dam prevented the draining of the lake. Hayes and other landowners who wanted the land bought out the owners of the dam and removed it (Tryk 1996). Hayes then began dredging the Little Pudding River by steam-powered shovel, and then by tractor.

The Hayes built a steam-powered sawmill east of the Pudding River, near the lake bottom. The logs for the mill were rafted during high water by tugboat. The mill furnished all the lumber for the buildings of Hayes Labish Farms (Tryk 1996).

The crops on the Hayes Ranch in the early years included peppermint, onions, sweet corm and pole beans. In later years it also raised celery and lettuce. The ranch had a pig farm in the late 1930s and 1940s. In the early 1930s, Hayes formed the Labish Brokerage to ship the ranch's products to market. Prior to that, three shippers from Portland hauled the onions from Brooks by rail (Tryk 1996).

In the early years, horses were used for all agricultural work. The Hayes Ranch had a stable of draft horses. Even when tractors began to be used for the hard work, horses were still used to finish up and for harvesting (Tryk 1996).

A large Japanese community grew onions, celery, lettuce, and other vegetables in part of Lake Labish. Every farm had its own greenhouses to nurture the young celery and lettuce plants. The Japanese had their own churches and schools.

Onion-growing on the lake was all done by hand for many decades. The land was prepared with horses wearing special shoes clamped to their hooves to keep them from sinking into the ground. Seeding was done with a hand-pushed seeder. Two acres was a full day's work. Weeding was done on all fours. Harvesting onions by hand was slow and hard. The onions were pulled and placed in rows by people walking on their knees. One person could do about a half an acre. The onions were picked up by hand or with a fork, and hauled to the barn by horse-drawn wagon. They were shipped mainly to the California market; some were exported to places such as Panama, China, the Philippines, and Hawaii (Tryk 1996).

The Japanese community of Lake Labish continued to farm until 1942, when the U.S. government moved all the Japanese from the West Coast to the interior, for security purposes during the war. Only a few families returned after the war to grow onions. The Hayes Ranch operated until 1945. Then it was sold, and subdivided into ten and twenty acre lots, most of which are still farmed to some degree (Tryk 1996).

Guide to the Upper Claggett Basin

For those of you interested in following the upper portions of Claggett Creek in its urban environment, the following text describes how to best view the creek.

One block east of the intersection of Lancaster Drive and Market Street, at the corner of Market and Clay, on the north side of Market St., is the outfall of a culvert that begins at Lancaster Mall and flows under I-5. What I call the McKay branch of Claggett Creek begins here. The best way to view this reach of Claggett Creek is to park in the Bible Center Fellowship parking lot. The creek is on the east side of the parking lot. The creek flows north for one block to Sunnyview Road.

At Sunnyview, the creek is diverted underneath Sunnyview Road to Scotsman Lane, the southern entrance to McKay High School and a potential wetlands mitigation site on Claggett Creek. The creek continues to flow in a northerly direction on the McKay High campus. Again it is piped underneath the McKay High baseball and soccer fields to re-emerge near the playground in McKay Park. The creek continues to flow northward. Claggett Creek can be seen at the end of Glendale Avenue. Glendale is between Sunnyview and Silverton Roads on Lancaster Drive. The creek can also be accessed by turning off Lancaster Drive at Devonshire Court. This is the big intersection near Wal-Mart. Drive to the end of Devonshire Court and park. By walking through the Devonshire Court Apartments, you can view this reach of Claggett Creek. To access the northern end of this reach, head eastward on Silverton Road from the intersection of Silverton Road and Lancaster Drive. Just past Double H Western Wear turn right onto Tierra Drive. Claggett Creek is clearly visible here.

Behind the Double H store, the creek is again piped into a culvert and diverted to the west underneath Lancaster Drive, where it re-emerges east of Fisher Road. This reach of Claggett Creek is easily accessible from Hornbeam Street. There are large fields here, so you can wander along the creek. If you are lucky you will see the red-tailed hawk that hunts from the big tree by the creek. This reach of the creek passes underneath Cooley Drive. Cooley Drive is a connector between Lancaster Drive and Fisher Road near the west entrance of Chemeketa Community College. The final access point of this reach of Claggett Creek is the Boy Scout cabin at 4160 Fisher Road. This is the only log cabin on Fisher Road with an American flag in front of it. If you are approaching the cabin on Portland Road, proceed in a northeasterly direction on Portland Road, until you cross I-5. At the first traffic light, turn right onto Ward Drive. Ward Drive will go through an S-curve. Take the first right onto Fisher Road. As you proceed south on Fisher Road you will drive through two swales. The first or northern-most swale is the Chemeketa branch of Claggett Creek. The second or southernmost swale is the "main stem" of Claggett Creek. If you park in the lot at the Boy Scout cabin you can walk back to the creek course at Fisher Road. If you follow the creek westwards, towards I-5, you will encounter the confluence of the "main stem" and the Chemeketa branch. This is one of the most beautiful places in the upper Claggett Basin.

The aforementioned Chemeketa branch of Claggett Creek flows from the north side of the northernmost parking lot of Chemeketa Community College. It passes by the Tierra Apartments between Ward Drive and the Chemeketa campus. It also flows near the Jan-Ree swimming pool.

Finally, there is the Hawthorne branch of Claggett Creek. Just like the McKay branch of Claggett Creek, the headwaters of the Hawthorne branch is in Lancaster Mall. The Hawthorne branch is primarily piped underground. This branch briefly emerges at the northeast corner of the intersection of Sunnyview Road and Hawthorne Avenue, just west of I-5, at a detention basin. The Hawthorne branch finally emerges at the southern end of Eastgate Park, which is off Hawthorne Drive just south of Silverton Road. This branch then flows north to its confluence with the main stem of Claggett Creek near the bridge the creek passes through under Portland Road.

To access the mainstem of Claggett Creek, park in the lot at the intersection of Hawthorne Dive and Hyacinth Street. You will be just west of I-5. You can also access this reach of the creek by parking in the empty lot, near the bridge on Portland Road. This lot is two lots southwest of Stuart's Auto Supply on the east side of Portland Road. This reach of Claggett Creek is the most shaded and least disturbed. We need to preserve this reach of the creek as a template with which to gauge our success in restoration efforts.

The reach of Claggett Creek from the Union Pacific Railroad tracks to the Salem Parkway is mostly in private hands, so you must get permission from the owners to check out this reach of the creek. It has been heavily impacted by gravel extraction and the Salem Industrial Park.

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Mill Creek Watershed

History of Mill Creek Watershed

By Sue Geniesse and Jon Yoder

Introduction

The Mill Creek watershed was once a land of open prairie and scattered forest. Mill Creek flowed through braided channels and wetlands, and was joined along the way by smaller waterways. Trees along stream banks provided shade and a source of woody debris to nourish the stream. Watershed habitats supported a variety of plants and animals.

As development occurred over time, Mill Creek was pumped for water supplies, harnessed to generate energy, and used to carry wastes. It was altered both to move water closer to where it was needed, and to move flood waters away quickly. Urbanization, industrialization, agriculture and timber harvesting, have all affected the natural stream environment.

Mill Creek's Sources and Diversions

The source of Mill Creek is the Cascade foothills in Coon Hollow just north of Mehama. The maximum elevation in the watershed is approximately 2,200 feet above sea level, but most of the basin lies at lower elevations. Only 6.5 square miles of Mill Creek's approximately 110 square miles is over 1,000 feet elevation (City of Salem 1996). The watershed is approximately 24 miles long and 6 miles wide.

From its source, Mill Creek flows west through forests, agricultural land and the cities of Turner and Salem. Along the way, it adds to its flow with water from the North Santiam River (diverted via the Salem Ditch), and from Beaver, McKinney, Battle, and Rogers creeks. It enters Salem near Kuebler Boulevard, a short distance upstream from I-5. Within Salem, the creek flows through commercial and residential areas, its water diverted at two sites, and joins the Willamette River north of "D" Street at Willamette River Mile (RM) 84.

The Beaver Creek tributary drains approximately 31 square miles. It joins Mill Creek about a mile east of Turner at Mill Creek RM 11.9. McKinney Creek drains hill country and agricultural land south of Salem, joining Mill Creek just west of Turner at RM 9.4. Its tributaries include Battle Creek (and its tributaries, Jory, Waln, and Powell Creeks) and Rogers Creek.

Water is diverted from the North Santiam River through the Salem Ditch, also known as the Salem Canal, in Stayton. The water is diverted through a control gate located at the east end of Stayton near Pioneer Park, and joins the natural flow of Mill Creek in the Santiam Golf Course next to Highway 22 near Aumsville (RM 17.7). The amount of summertime base flow contributed by the Salem Ditch to Mill Creek is actually larger than the amount of flow contributed by the natural Mill Creek headwaters (City of Salem Public

Works Department 1995). It is the only reason that Mill Creek flows in any significant amount year-round, instead of stagnating in the late summer or drying up entirely.

Shelton Ditch, a diversion off Mill Creek in Salem, begins behind the State Printing Office east of Airport Road between State and Mission Streets near RM 3.4. The water flows due east through residential neighborhoods, along Mission Street and the Pringle Parkway before joining Pringle Creek at the Church Street Bridge about four blocks upstream of Pringle Creek's confluence with the Willamette River.

The Mill Race in Salem diverts water from Mill Creek at 20th and State Streets, behind the Duck Inn near RM 2.2. The Mill Race flows parallel to Ferry Street through Mission Mill and east through Willamette University. The water then meanders in a constructed creek habitat through the park north of the SAIF building and Pringle Parkade. Finally it flows through an elevated concrete channel or flume above the north side of Pringle Creek and eventually joins Pringle Creek just upstream of Commercial Street SE.

Other similar man-made diversion channels (mill races) existed historically, such as the Capitol City Power Ditch, but have since been paved over and eliminated.

The Watershed Before Historic Settlement

Geologists studying the Mill Creek floodplain theorize that the North Santiam River once flowed through what is now downtown Salem, rather than flowing well south of the city as it does today. One site where soil layers document this is at the Mill Creek Prehistoric Site Complex (formerly known as Hager's Grove Site), located in the Mill Creek floodplain adjacent to the Highway 22/Interstate-5 interchange. The basal, or lowest, sediment layer at the site is a gravelly layer representing a period of postglacial sediment deposition dating to around 12,000 years ago. At that time, the North Santiam River flowed through Turner Gap. As regional topography changed between 12,000 and 6,000 years ago to cut the present North Santiam River channel, the former North Santiam channel continued to serve the smaller drainage area of Mill Creek. Since that time, existing evidence is that there has been mostly localized migration of the creek channel within the relict North Santiam channel trough (Connolly et al. 1998).

When historic settlers first arrived, the Willamette Valley floor consisted primarily of open prairie with a scattering of Douglas fir and Oregon white oak trees. This ecosystem was maintained and managed by the Kalapuya Indians for camas production through intense annual fires. Forests that were present could be found in isolated groves surrounded by prairie, in higher and steeper foothills of the surrounding hills, as well as along riparian zones. Forest species consisted of Douglas Fir, Western Hemlock, Western Red Cedar, and Big Leaf Maple in moist areas and Douglas Fir, Ponderosa Pine, Western Red Cedar, Oregon White Oak, and Madrone in drier habitats.

The Mill Creek Prehistoric Site Complex, at the Highway 22/Interstate-5 interchange, has yielded some 77 cultural features. Most appear to be in-ground ovens for processing foods, notably camas, alliums, hazelnuts, acorns, and a cherry pit, which were recovered charred in association with the ovens.

No faunal remains (including fish and other aquatic resources or land-based game) were recovered at the site complex. Other than the presence of projectile points and other stone tools, no direct evidence of hunting or fishing was recovered. This is most likely because faunal remains, particularly small fish or animal bones, have not survived well in the acidic soils of the Willamette Valley and so are lacking in the archaeological record (Tasa pers. comm.).

There are four main clusters of radiocarbon dates at the Mill Creek Prehistoric Site Complex, with the earliest cluster dating back 3,800-5,000 years ago and the youngest cluster 150-600 years ago. Occupation of the site seems to have been episodic and probably seasonal. Botanical remains indicate that occupation occurred during the spring/summer (camas and cherry) and fall (hazelnuts/acorn). And because the height of Willamette Falls probably barred large numbers of salmon from migrating to Mill Creek, except during times of very high water, the inhabitants of Mill Creek sites would not have had the plentitude of fish resources that allowed some other Northwest groups to establish more permanent settlements (Pettigrew 1980; Connolly et. al 1998). Nor could they live along the banks year round due to the unpredictable and sometimes devastating floods.

The natural vegetation at the Mill Creek Prehistoric Site Complex is riparian. Most of the area is now densely wooded, with hardwood trees such as black cottonwood, Oregon ash, Oregon white oak, and willow, and a diverse underbrush dominated by wild rose and hazel. However, because many of the oak trees are widely spaced and exhibit a savanna growth habit, the archaeologist who excavated the sites presumes that they once had more room for growth (Pettigrew 1980). He speculates that now dense vegetation on the site is a result of the brush fire prevention that has been the practice since the valley was settled by Euro-Americans. Notably, archaeological remains were found only in more open grassland areas.

Historic Settlement

Rev. Ezra Fisher, a Baptist missionary, wrote about Mill Creek:

> …up the valley of Mill Creek through a picturesque and fertile part of the country.…hastened 12 miles up Mill Creek through one of the most delightful prairies surrounded by the most picturesque scenery in North America, if not the world (Maxwell 1953).

Early settlement altered the valley ecosystem as a result of agricultural and industrial growth and a move away from maritime fur trade. Mills of all sorts, such as woolen, saw, and grist, sprouted up along waterways to fulfill the distant demand for flour, lumber, and other goods. In Stayton, water was diverted from the North Santiam

River to Mill Creek to supplement seasonal low flows in Salem. In Salem, Mill Creek was diverted to power industrial uses along constructed mill races. The mill races continued to have an industrial function, but by the turn of the century, after the Willamette Woolen Mill burned and with a few exceptions, the main channel of Mill Creek took on more of a residential character.

As early as the 1840's, the Methodist Missionaries who settled in the Salem area began to change the area's character. The 1878 Historical Atlas Map of Marion & Linn Counties states: "In 1840,…the people around were chiefly engaged in stock raising. The first considerable drove of cattle brought into Oregon was brought by the mission, in 1837 (Edgar Williams Co. 1878)."

Settlement spread in the Mill Creek valley from several routes and directions. From Salem, settlers rapidly traveled up Mill Creek. The town of Turner was founded on an 1849 land claim by A. Cannon. The 1878 Historical Atlas notes that: "The site of the town is both pleasant and healthful, being located on gently rolling prairie land near Mill Creek…. A fine new mill has recently been erected on the creek (Edgar Williams Co. 1878)." The town of Sublimity was founded by 1852. Sublimity has one of Oregon's oldest post offices.

The town of Aumsville was founded in 1864 by G. H. Turner. The 1878 Historical Atlas describes it as such:

> The land adjacent is a rich prairie with scattered belts of timber to the eastward. The first settler in this neighborhood was Mr. John McHaley, who came in 1849. Mr. Turner, taking advantage of the fine water power supplied by Mill Creek, built an excellent flouring mill in 1864…which did an extensive business until the building of the railroad, since which time the prosperity of the place has declined (Edgar Williams Co. 1878).

The town of Stayton was platted in 1872. The 1878 Historical Atlas attributes the town's prosperity to its "almost unlimited" water supply for manufacturing, irrigation, and stock purposes.The authors of the 1878 Historical Atlas describe the Mill Creek valley in lyrical terms:

> The Valley of Mill Creek is from half a mile to three miles in width, the greater portion of which is prairie land. The low lands of this part are very rich, and classed among the most productive in the state, and the whole may be considered as generally productive….The part of the country between Mill Creek and the Santiam and Willamette Rivers is about evenly divided between rolling, hilly, and level lands. The level portion for the most part have a black soil, while the hills are principally a clay formation. Here, too, nature has been most bountiful in its supply of creeks and springs, affording pure water in great abundance. There are

> many groves of white oak, fir, and cedar, too, is quite plentiful (Edgar Williams Co. 1878).

Wheat, oats, cattle, and sheep became the chief commercial products of farms. The valley ecosystem was transformed into fenced, symmetrical, manicured fields. Without annual fires, shrubs invaded and open woodlands became dense forests. In addition, vegetation was removed along riparian areas where the soil was richer and water was easily accessible.

By 1982, when the Mill Creek Drainage Study was completed, watershed land uses were estimated as follows: 18% forest land (most in irregular patches), 62% cropland, 1% non-cropland pasture, and 19% urban development. Most of the land bordering Mill Creek was agricultural. The study reported as widespread various agricultural activities that contribute to unstable streambank ratings: removal of bankside vegetation, tillage practices up to the bank without a buffer, and unrestricted access by cattle to the lower bank areas (Mill Creek Watershed Task Force 1983).

Urbanization had significant effects. Industries depended on the creek for power and in return they modified and diverted the channel. Industries installed turbines, which unintentionally became obstacles for fish. Private homes and businesses were built along Mill Creek; many owners replaced native vegetation with lawn, filled natural wetlands, and reinforced the creek bank against erosion (and natural channel meandering). Creeks and the Willamette River became the primary waste disposal outlet for residents and businesses.

Channel Modifications, Irrigation, and Flooding

Over the approximately 150 years of historic settlement, there have been numerous and cumulative channel modifications, "improvements," and diversions (principally for irrigation) that have affected the course and flow of Mill Creek. Most of these were engineered with a specific well-intentioned purpose or purposes in mind, but their actual and cumulative effects have in many cases unintentionally degraded other watershed functions.

The Salem Ditch, dug in 1855-56 to increase the dry season flow in Mill Creek for Salem mills, was the earliest historic Mill Creek channel modification. The ditch has since been widened, deepened, and reinforced several times. According to the 1982 Mill Creek Drainage Study, the canal ordinarily carries 125-150 cubic feet per second (cfs) and never carries more than 170 cfs.

Ernst Lau, a Stayton historian, recounted the difficulties of maintaining the Salem Ditch and the link to the North Santiam River:

> Within a few years of the completion of the ditch, trouble was experienced in keeping it supplied. For the next 75 years those who assumed the responsibility of operating the ditch faced two kinds of challenge: a river whose flow could vary by a hundred-

> fold within a short period of time and whose course was by no means established; and, as more and bigger turbines (and more irrigation and municipal water needs) were installed on the ditch, finding ways to divert enough water from that unruly river to keep things running (North Santiam Watershed Council 2001).

For instance, in 1872, a February flood caused the main channel bend of the North Santiam River to migrate south, leaving the Salem Ditch headgates dry when the river was low. This resulted in an 1873 project to extend the north channel enough to re-intercept the river and build dams to divert water from the main channel into the north channel (North Santiam Watershed Council 2001). Again in 1909, the main channel of the North Santiam River moved south and the Salem Ditch headgates were left dry. In response, the new south channel of the North Santiam River was blocked off (*Stayton Mail* 1991).

Mill Creek also obtains water from the North Santiam River through a system of irrigation ditches operated by the Santiam Water Control District (SWCD). Most of the approximately 40-square mile district lies within an area bounded by the towns of Stayton, Aumsville, Turner and Marion, plus a corridor extending from Turner towards Salem along Mill Creek. The District was formally created in 1959, when it purchased an existing ditch system from the Willamette Valley Water Company. Prior to that, a series of private ditch companies, dating from 1909, supplied irrigation water to the area (Winebery 1981).

According to A.D. Gardiner, original manager of the SWCD, farmers along Mill Creek could not irrigate their lands because Boise Cascade held the rights to almost the entire flow of Mill Creek, and the creek was closed to new water rights filings. The SWCD and Boise Cascade entered into a water exchange agreement made possible because some of the District's irrigation ditches eventually emptied into Mill Creek. Under the agreement, farmers took water directly from Mill Creek to irrigate their fields. The District then replaced this Mill Creek water by running an equivalent amount of North Santiam River water through existing District-owned irrigation ditches that already emptied into Mill Creek (Winebery 1981).

Water from Mill Creek is sometimes diverted into the Pringle Creek system. This occurs indirectly via the complex web of irrigation drainage-ways and directly by means of the weir dam diversion structure to Shelton Ditch. Also, at times of major flooding, Mill Creek overflows into the Pringle Creek basin upstream from Interstate-5 (City of Salem Public Works Department 1995).

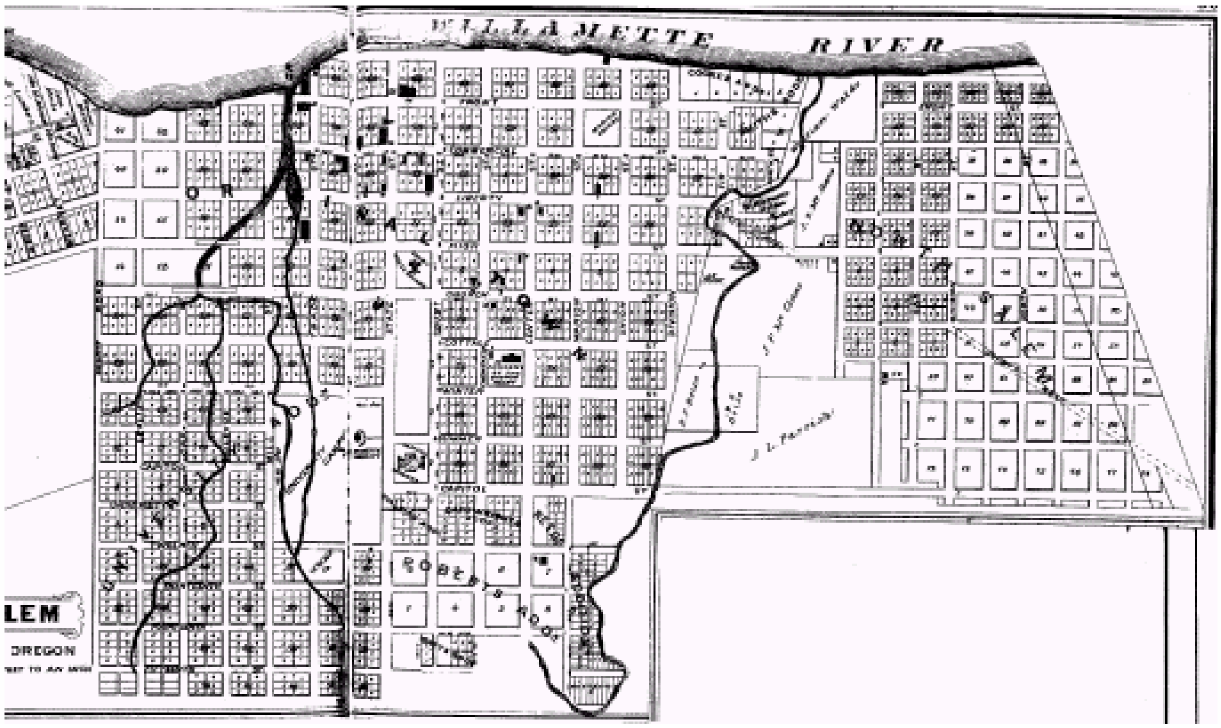
One example of how waters from Mill Creek have been diverted to Pringle Creek involves the Santiam Water Control District-operated gate structure on Mill Creek south of Kuebler Road, inside the Salem urban growth boundary. During the growing season, flows are diverted to irrigate nearby farms and the excess then goes into the East and Middle Forks of Pringle Creek near Kuebler Road. This irrigation drainage supplies much of the water in the summer to this reach of Pringle Creek. During the winter, the control gate on Mill Creek is closed and the irrigation channels become storm drainage-ways (City of Salem Public Works Department 1995).

Shelton Ditch directly diverts Mill Creek flows to Pringle Creek. Various sources differ on whether Shelton Ditch is a natural drainage channel extended and adapted to relieve flood overflows from Mill Creek or whether it is a totally artificially constructed channel. The 1878 Historical Atlas map of Salem (**Figure 3-2**) and the 1895 Sanborn Insurance Maps of Salem show a natural drainage/creek that drains into Pringle Creek in the relative location of where Shelton Ditch is today (Edgar Williams Co. 1878; Sanborn Fire Insurance Co. 1895). This natural drainage did not extend far enough to connect with Mill Creek. A 1947 U. S. Army Corps of Engineers Survey Report on the Willamette River and Tributaries states that Shelton Ditch was constructed in the late 1890's:

> …by plowing a furrow along a county road to provide relief from overflow from Mill Creek . Continuous erosion entirely destroyed the road and created the present channel. …Several years ago the city of Salem inaugurated a program of cleaning and straightening the channel to allow it to take flood waters from Mill Creek more readily. Some work was done in the early 1930's and in 1938 a concrete weir and diversion dam was built whereby the flow through the city (via Mill Creek) could be partially controlled and excess water turned down Shelton ditch (U.S. Army Corps of Engineers 1947).

In contrast, the 1968 City of Salem Storm Drain Master Plan states that Shelton Ditch was constructed in 1936 and a 1990 Corps of Engineers report states that it was constructed in 1940 (City of Salem Public Works Department 1968; U.S. Army Corps of Engineers 1990). Perhaps what occurred was that an original natural drainage was enlarged, straightened, directly connected to Mill Creek, and eventually had its flow altered through various constructions from the late 1800's to the present.

Figure 3-2. 1878 Historical Atlas Map of Salem



According to the U. S. Army Corps of Engineers Shelton Ditch, originally a shallow drainage, has over time eroded or been constructed into a 20-foot deep (average) channel (U.S. Army Corps of Engineers 1990). The 1947 U. S. Army Corps of Engineers Survey Report foreshadows this deepening:

> …Originally, the ditch passed through relatively undeveloped territory where little flood damage appeared likely. In recent years, however, the south city limits have been extended and an extensive residential area has developed south of the ditch and considerable industrial development has taken place immediately adjacent to it. Sixteen bridges now cross Shelton ditch.. …The developments along Shelton ditch have created the necessity for bank protection and greater capacity in order to reduce erosion and overflow damages along its course (U.S. Army Corps of Engineers 1947).

In rural areas of the watershed irrigation needs, combined with agricultural flooding problems, brought about various channel modifications and "improvements." Over the years, water from the Salem Ditch, the Stayton Ditch, and Mill Creek has been diverted to an expanding and interconnected irrigation canal network of over 16,000 acres in the area bounded by Turner, Aumsville, Stayton, Marion, and Salem (Trosi pers. comm.). Much of this irrigation water eventually drains back into Mill Creek carrying sediment, agricultural chemical wastes, and some urban runoff (Mill Creek Watershed Task Force 1983). The 1982 study states that over the years the canal system was:

> …made more efficient by the installation of subsurface tile systems, the addition of new canals, the widening and deepening of older canals, and the upsizing of culverts. This has had the result of reducing rural flooding, making more land available for crop production, and reducing flooding on county roads (county road drainage ditches are interconnected with the District system). It has probably also had the effect of increasing peak runoff from these lands into Mill Creek (Mill Creek Watershed Task Force 1983).

During the 1960's, the Santiam Soil and Water Conservation District embarked on a series of flood control "improvements" in the agricultural areas of the watershed. The June 1968 City of Salem Storm Drain Master Plan reported:

> [Beaver] Creek has recently been improved for flood control purposes for a length of 6.4 miles and now accelerates the discharge to Mill Creek. Plans are underway for the construction of additional ditch improvements and the annexation of approximately 3500 acres to the district, both of which will tend to increase the rate of discharge to Mill

> Creek. ...With the flow in Mill Creek now being accelerated by channel improvements in tributary streams, the flow reaching the diversion dam East of Airport Road will continue at an increasingly high rate until such time as storage reservoirs and channel stream flow control facilities are provided. ... The trend in improvement of land management practices being developed by agricultural agencies to provide better drainage systems, accelerates the flood waters in the City. This coupled with the gradual urbanization of suburban areas increasing the volume of runoff, point to the need for the City to work toward the provision of means to alleviate the overloading of Mill Creek and subsequent excessive diversion to Shelton Ditch. ... The City should begin financial planning to provide its share of the cost of constructing a paved flume in Shelton Ditch (City of Salem Department of Public Works 1968).

Similarly, a 1967 report by the U.S. Soil Conservation Service reported that:

> Channel scouring is occurring on Mill Creek below Turner. During periods of high flows, bank cutting is taking place in localized areas. A channel stabilization program is needed to reduce the erosion of the channel and to maintain a relatively uniform channel and velocity between Turner and Interstate 5 (U.S. Soil Conservation Service 1967).

In other words, these are examples of well-intentioned channel engineering to accomplish one purpose (agricultural irrigation and drainage) that then causes a problem downstream (accelerated discharge), which leads to a call for more channel engineering to address the unintended problems of downstream flooding and erosion.

As major highways were constructed through the Mill Creek floodplain, the channel was modified to better fit the engineers' design. For example, when Interstate-5 was constructed in the vicinity of the Highway 22 interchange, an artificial channel was constructed that keeps the creek on the west side of the interstate highway and, for the most part, moves it out of the interchange area.

Numerous floods have characterized Mill Creek over the years. The creek drains a mostly low-lying, shallow basin and so is sensitive to rains or sudden snowmelt. Most of the larger historic floods resulted from heavy rains supplemented by snowmelt at a time when the soil was near saturation from previous rains.

Major floods occurred in 1861, 1888, 1909-10, 1937, 1949, 1964, 1972, 1974 and 1996. The U. S. Army Corps of Engineers rate the highest recorded floods as the 1964 flood (about a 50-year event), the 1974 flood (about a 75-year event) and the 1996 flood, estimated to be about a 90-year event (City of Salem Public Works Department 1997).

Water Quality

Historical water quality data for the Mill Creek watershed is scarce prior to recent decades, but a few anecdotal sources give clues about the quality of the water. These sources indicate that, generally, industrialization and lack of sanitary sewers resulted in a degradation of area waterways.

In 1868, Salem City Council passed an ordinance requiring that residences hook up to rudimentary "sewers" that dumped into the Willamette River, Pringle Creek, and Mill Creek. By 1885, the privately owned Salem Water Works had to move its water intake from the Willamette River at Chemeketa Street to off Minto Island, because of pollution entering the Willamette from Pringle Creek (Chapman 1995). The 1878 Historical Atlas Map noted about Salem: "This city is peculiarly favored in the manner of drainage, as without having any steep gradients it offers ample slope for carrying off all sewer and surface water. This fact, no doubt, contributes largely to the remarkable healthfulness of the place" (Edgar Williams Co. 1878).

In the late 1880's sewer lines were laid on Court Street, Ferry Street, and in North Salem. These all dumped into the Willamette River and Mill Creek. The State Penitentiary and Asylum dumped raw sewage into Mill Creek (Chapman 1995). The *Oregon Statesman*, in 1900, stated that the city had a "good system of sewers." A later 1903 article describing the widespread pollution in the creeks expressed the downside to this sewer system (Chapman 1995).

On the other hand, Salemites reportedly had their favorite swimming places on Mill Creek. According to a *Capitol Journal* article, one such place was the old Live swimming hole between 14th and the railroad trestle, where Olinger pool now sits, which was used by youth as early as the 1880's and 1890's: "There youth acquired a swimming hole wisdom and their four lettered words and predatory habits used to shock stiff-necked guardians of youthful morals and police would be summoned" (Maxwell 1953).

The Oregon Sanitary Authority was established in the 1940s to clean up the Willamette River. The City of Salem's first sewage treatment plant was built in the 1950s at what is now River Road Park in north Salem. The City's current Willow Lake Wastewater Treatment Plant was initially constructed in 1964, has subsequently been expanded and upgraded several times, and now treats all the wastewater generated in the greater Salem/Keizer urban area.

Watershed Chronology

1834 Jason Lee, a Methodist Missionary, and his party arrive and build a mission about 10 miles north of Salem at Mission Bottom, on the Willamette River.

1840-41 The central mission site, including the Lee House and parsonage, is moved to Mill Creek in what is now Salem. Mill Creek is named by the Methodist missionaries, who established a saw and grist mill called Mission Mill located near present day Boon's Treasury. The mill is inoperative during the dry season due to insufficient water supply.

1844-45 The Mission is disbanded and Mission landholdings sold, including an Indian Manual Training School that subsequently became the Oregon Institute, and then Willamette University. The original mills are sold to John Force.

1850 The town of Chemeketa (now Salem) is platted within a triangle bordered by the Mill Creek, Pringle Creek, and the Willamette River.

1852 Sublimity Post Office established.

Early 1850's Realizing the potential to increase the amount of summer flows at his Mill Creek mills by diverting water from the North Santiam River, John Force purchases a right-of-way for a connecting canal from Stephen Porter (documented on the original 1852 GLO map). According to Henry Brown:

> ...in the summer of 1850, the proprietors of the North Salem Mills commenced opening a race ...but the work was stopped by a mob from Santiam City and the neighborhood of Jefferson, and from the vicinity of Mill Creek below the proposed race. The North Salem Mill owners expended in that effort hundred dollars, when their operations were thus summarily suspended by what all unprejudiced persons now see was a blind and suicidal act of a mob (Brown 1871).

1856 Willamette Woolen Manufacturing purchases the mill site, paying $400 to John Force for a claimed water right to divert water from the North Santiam River, and including the right-of-way for the connection between the river and Mill Creek. Although the water right is in dispute, the company begins work on the canal. Disagreement about the water right brings the issue to the territorial legislature, which incorporates Willamette Woolen Manufacturing and grants the company exclusive right to water taken from the North Santiam—up to 254 cubic feet of water per second. Some members of the legislature object to the lack of limitations on the amount of water that could be taken from the Santiam.

1856-1876 Willamette Woolen Manufacturing is Salem's leading industry. Mill Creek's increased volume powers a 48-inch double turbine wheel and the company has up to 100 employees (Maxwell 1953).

1861 A major flood in December carries the Salem Ditch headgate 1.5 miles downstream.

1861 Trustees of Willamette University agree to let a mill stream be dug across the campus for use of a nearby woolen mill (City of Salem 2001).

1864 Woolen Mill investors buy land in Salem from Alvin Waller and others for a mill race. Waller dam built to divert Mill Creek to the Mill Race. The dam is reconstructed about 1915.

1864 Legislature approves removal of the state penitentiary to 147 acres lying on both sides of Mill Creek about 1 ¼ miles east of what was then the City of Salem but is now well within the city. The total cost of $9,019.17 to acquire the land includes the cost of acquiring a water right from the Willamette Woolen Manufacturing Company.

1865 The Mill Race powers the Willamette Flouring Mills on the Willamette River at Trade Street north of Pringle Creek (later called the Salem Flouring Mill and the Kinney Flouring Mill). The Mill burns in 1899, is rebuilt in 1901, and is finally replaced by the Oregon Pulp Company (Boise Cascade) in 1919-1920 (Chapman 1995).

1866 Flour Mill established west of Stayton on Salem Ditch.

1866 The Mill Race powers Pioneer Oil Mill, (on the site of the present Mission Mill Museum), which makes linseed oil from flax.

1868 Salem City Council passes an ordinance requiring that residences hook up to nearby "sewers" which empty into the Willamette River.

1870's	Tannery and Chair Factory operate in Salem near site of present day Jason Lee Manor near Center and 14th Streets. Excavations have uncovered turbine tubes used by the chair factory (Maxwell 1953).
1872	City of Stayton platted, named for Drury S. Stayton.
1872	February flood moves main channel of North Santiam River, leaving Salem Ditch headgates dry in low flows.
1872	Agricultural Works built along Salem Mill Race near High Street.
1873	Digging in Stayton to extend the Salem and Stayton ditches to meet the new course of the North Santiam River.
1876	Willamette Woolen Manufacturing Mill burns.
1878	Aumsville Mill, along with feed and grinding mills in Turner, is powered by Mill Creek
1880's	Salem sewer system developed; some lines discharge into Mill Creek and Willamette River.
1882	Capitol City Milling power ditch completed taking Mill Creek water from between Church and High Streets to Front Street and north. The mill produces 800 barrels of flour per day. The ditch is later paved over.
1886	Water-powered electrical plant, built along Mill Race at Mill and High Streets replacing Agricultural Works, provides electric street lighting for the Salem downtown area.
1887	Capital City Ice Works established at 1551 Center Street in Salem, behind present day Jason Lee Manor.
1888	Flood wipes out Capitol City Milling and the Mill Race is rebuilt.
1889	Thomas Kay Woolen Mill built along the Mill Race, replacing Pioneer Oil Mill.
1890's	Shelton Ditch in Salem established or expanded to improve overflow drainage from Mill Creek
1891	Sawdust dumping law declared unconstitutional. Mills are allowed to continue dumping waste into streams and canals.

1903	Pollution in creeks in Salem described in the *Oregon Statesman.*
1905	City Ice Works uses two turbines to produce 100 horsepower in high flows and 10-15 horsepower in low flows.
1909-10	A series of three successive floods washes out dams on the North Santiam River and moves the main channel south, once again leaving the Salem Ditch headgate dry.
1915	Waller dam replaced.
1921	November flood. A. D. Gardner blows up part of the intake dam for the Salem Ditch to keep the floodwaters from flowing into the ditch, and thus protects the town of Stayton.
1921-24	Road through West Stayton and Turner to Salem is paved. In 1923 the 25-year old corduroy road that had connected Stayton and Sublimity through the Mill Creek "swamp" is paved (North Santiam Watershed Council 2001).
Late 1930's	Shelton Ditch expanded to alleviate flooding problems and weir dam constructed.
1937	Major flood.
1948	Long Range Plan for the City of Salem seeks to remove much of the industrial use along the Mill Race.
1949	Major flood.
1949	Road construction on what is now Highway 22; construction of Detroit and Big Cliff dams.
1953	Big Cliff and Detroit dams come on line, regulating North Santiam River flows.
1959	Santiam Water Control District buys its ditch system from Willamette Valley Water Company.
1964	Major flood (about a 50-year event) in which an estimated 3,000 acres are flooded. As a result, the USDA Soil Conservation Service prepares a Mill Creek report that recommends dam and reservoir construction, stream

channel stabilization, vegetation clearing, channel enlargement and realignment, and obstruction removal.

1968 Introduction of fall Chinook into Mill Creek by Oregon Department of Fish and Wildlife.

1972 Major flood.

1973 Urban renewal project along the south side of Trade Street. The Mill Race had been contained in a deteriorated concrete flume flowing beneath the old buildings. In this project area, the industrial buildings are cleared, and the Mill Race is raised to the surface to flow in a new channel bed that meanders through a new park (Salzman 1984).

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1974 Major flood (about a 75-year event).

1989 Gasoline spill along Mill Creek in Salem. Hundreds of fish killed; also fish eggs in the gravel.

1996 Major flood (estimated to be about a 90-year event).

Table 3-1. Population Change in Marion County, 1870-1990.

Population	Marion County	City of Salem	City of Stayton
1870		1,139	
1880		2,538	300[1]
1890		3,398	
1900	27,713	4,258	324[2]
1910	39,780	14,094	703
1920	47,187	17,679	649
1930	60,541	26,266	797
1940	75,246	30,908	
1950	101,401	43,140	
1960	120,888	49,142	
1970	151,309		
1980	205,950	89,233	
1990	229,500	108,400	5,160

[1] Source: Edgar Williams Co. (1878)
[2] Source: North Santiam Watershed Council (2001)

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Introduction

This chapter examines the physical condition of stream channels in the four watersheds. While the extent of channel modifications differs among the four watersheds, typical human alterations to the streams include channelization; bank armoring; construction of ditches and flood control structures; construction of dams, weirs and reservoirs; stream cleaning; the construction of roads in floodplains; culverting and piping streams; and sand and gravel mining. In general, most of these changes are made to prevent the flooding and erosion of public and private property and to provide irrigation water that is used for urban and agricultural purposes.

This chapter outlines the types of channel modifications, the extent of modifications in the four watersheds, and the impact channel modifications have on fish and wildlife habitat.

Data Sources

In order to identify the extent of channel modification in the four watersheds, information was collected from watershed residents, Oregon Division of State Lands (DSL), Oregon Department of Geology and Mineral Industries (DOGAMI), the City of Salem, Oregon Water Resources Department (OWRD), and other watershed assessments in the Willamette Valley.

Types of Channel Modifications and Their Extent in the Four Watersheds

Stream Channelization and Bank Armoring

In all four watersheds, many streams or stream sections have been subjected to some form of stream channelization. This activity often entails deepening, widening, relocating, splitting, or straightening streams. Channelization is mostly done on streams flowing through agricultural and urban settings. Many of the local streams have at least some reaches that, prior to European settlement, farming and development, were braided channels. However, it is important to note that some streams flow through naturally confined channels, such as the steep and narrow ravines found in the upper stream reaches of the Glenn-Gibson and Mill Creek watershed. To keep channels in their modified form, it was sometimes considered necessary to periodically dredge out accumulated sediment and to armor the banks with either riprap or retaining walls. Riprap includes things like large rocks or wood used to stabilize banks and prevent them from eroding (Thieman 2000).

An example of stream bank stabilization/bank armoring in the Salem area occurred after the 1996 floods. The City of Salem Public Works Department contracted to repair flood damage along several streams. In some cases, gabions (rock-filled weirs) and interlocking concrete blocks were installed along stream banks. In Cannery Park in the Pringle Creek watershed, gabions were placed to "correct," contain and direct flow around a bend. Shortly thereafter, native plants were placed on top of the gabions. In addition, willow fascines were planted immediately upstream. Today, the willows grow thick and tall; the bank is stable where they were planted. The gabions have not fared as well and are deteriorating as a result of vandalism, heavy recreational use at the park, and improper installation (Kroger pers. comm.). Ultra blocks (interlocking concrete blocks) can also be seen at Hawthorn and Mill Creek, 25th and Mill Creek, and I-5 and Mill Creek. The blocks were used to stabilize the vertical stream bank where there was insufficient room for a natural stabilization solution.

The extent of channelization and bank armoring in the four watersheds is unknown. Because three of the four watersheds are mostly urban, the number of stream miles in which stream channels have been straightened and/or stream banks armored is probably extensive.

Drainage Ditches and Flood Control Structures

The construction of drainage ditches and other flood control structures is another type of channel modification. To drain fields for agricultural use, farmers dug ditches and sometimes installed drainage tiles in order to be able to plow their fields. The State of Oregon leased out the lands around Hillcrest School to local farmers before SumcoUSA built in the Fairview Industrial Park. During this agricultural phase, farmers installed drainage tiles and built ditches, to transport water into the Hillcrest

Ditch. No one ever mapped this out, partly because farmers knew their land well, and also because flow and seepage changed, often annually. The longer-term consequences were that when SumcoUSA's acid spill occurred in April, 2000, it went into a storm drain system that rested in gravel which both reached the public storm drainage system and connected to the old unmapped, underground tile drain complex. Both led to Pringle Creek.

The need for a consistent year-round stream flow for powering mills in the Salem area instigated the construction of the Salem Ditch and others in the 19th century. The Shelton Ditch diverts water from Mill Creek year-round but was initially constructed along an old stream channel to divert water into Pringle Creek during high water events. Thus, waters of the Mill Creek watershed regularly flow into the Pringle Creek watershed. The Mill Race, another human-constructed waterway, also diverts water from Mill Creek into Pringle Creek. The Race currently supplies water to the turbine at the Mission Woolen Mill and to the City of Salem's reflecting pool at City Hall.

Dams, Weirs and Reservoirs

Other common modifications in the four watersheds are dams, weirs and reservoirs. There are numerous small impoundments used for livestock watering, irrigation, recreation, and other activities. Within Salem's urban growth boundary (not including the City of Keizer), there are a total of 50 dams and weirs located in the four watersheds (**Table 4-1**) (City of Salem 2001). According to OWRD, there are 94 *registered* reservoirs (impoundments) located within the four watersheds (**Table 4-2**) (see Hydrology chapter for location of dams, weirs and reservoirs). The OWRD database does not include small weirs, which are found in several places in the Pringle Creek watershed.

Table 4-1. Dams locations by watershed

Watershed	Dams
Pringle Creek	31
Glenn-Gibson Creek	12
Upper Claggett Creek	0
Mill Creek	7
Total	**50**

Source: City of Salem Fish Passage Survey (City of Salem 2001).

Table 4-2. Number of registered reservoirs by watershed	
Watershed	**Reservoirs**
Pringle Creek	6
Glenn-Gibson Creek	25
Upper Claggett Creek	1
Mill Creek	62

Source: Oregon Water Resources Department

Stream Cleaning and the Removal of Large Woody Debris

Another common practice in both urban and rural streams is stream cleaning. The OWAM defines stream cleaning as the removal of large wood or fine organic matter (i.e., branches, twigs, leaves, etc.) from stream channels (Watershed Professionals Network 1999). Another term often used for organic matter is "leaf litter." In the past, the primary purpose for stream cleaning was to remove flow obstructions and to maintain the stream's flow carrying capacity, as well as to minimize flooding. In addition, it was considered beneficial to remove debris jams that were thought to block fish passage, or to remove fine organic matter that was thought to cause water quality problems such as reducing aquatic oxygen levels. More recently, biologists began to understand the importance of large woody debris (LWD) and now, under certain circumstances, recommend leaving large wood in streams. Current research considers LWD and leaf litter as extremely valuable habitat areas for aquatic wildlife and leaf litter alone serves as an important energy source in the aquatic food web (Schueler and Holland 2000).

LWD is not tolerated in streams flowing through urban areas due to localized flooding hazards. Rural property owners may remove large woody debris to prevent flooding on farm fields. In urban areas LWD is removed to prevent local flooding and prevent damage to in-stream infrastructure such as culverts, pipes and bridges. LWD was successfully incorporated into a fish habitat enhancement project in Salem. The project is located in Mill Creek near Summer Street. In this instance, the LWD is partially buried in the stream banks, severely limiting the movement of the LWD, thus posing little threat to downstream structures.

The City of Salem continues to use traditional stream cleaning practices that include mechanical and manual methods. Seasonal stream cleaning remove trash, garbage and debris from Salem's streams. In a change from past practice, before removing natural debris, the teams now check for potential flow obstructions and try to leave natural debris such as tree branches and stumps as fish habitat enhancers. In past instances watershed council members question the City's techniques. For example, in the summer of 2001, a ditch (some would argue that it is actually a small intermittent stream) near an electrical substation was scraped down to bare soil, removing wetland plants such as reeds, rushes and cattails. According to the City of Salem, the stream cleaning was necessary to improve flood conveyance and reduce fire hazard (Kroger pers. comm.). Removing LWD eliminates habitat for macro invertebrates and can encourage the growth of invasive species.

Roads Within Floodplains

Roads that run parallel to streams and rivers and are within their floodplain are also potential channel modifications because they can limit the extent of flooding. To protect the extensive network of roads from inundation and erosion, many roadbeds in floodplains are elevated while stream banks are armored. Elevated roadbeds can act like a levy, limiting the extent of flooding. Please refer to the FEMA maps in the Hydrology chapter to examine the extent of roads within the 100-year flood plain of local streams.

Construction of Culverts, Pipes, and Bridges

Channel modifications related to development and transportation infrastructure include culverts, pipes (storm drains) and bridges. The City of Salem estimates that there are 128 stream crossings (includes all streams) within the city limits of Salem (City of Salem Public Works Department 2000). Culverts and pipes convey and sometimes relocate streams underground. These structures confine stream channels and can eliminate the channels' ability to migrate within their floodplains.

As in many urban settings, Salem and Keizer's streams have been extensively piped and culverted. In the four watersheds, over 457 miles of storm drains and 17.93 miles of culverts convey water underground. **Table 5-9** in the Hydrology chapter breaks down the open and closed stormwater systems for each watershed within the Salem Urban Growth Boundary. The City of Salem's Fish Passage Survey (2001), reports a total of 62 bridges located in the four watersheds (**Table 4-3**) (see Hydrology chapter for location of bridges).

Table 4-3. Bridge locations by watershed within the Salem UGB

Watershed	**Bridges**
Pringle Creek	14
Glenn-Gibson Creek	2
Upper Claggett Creek	2
Mill Creek	44
Total	**62**

Source: City of Salem 2001.

Sand and Gravel Mining

Sand and gravel mining can alter both the shape of a stream channel and its bottom substrate (i.e. gravel, rock, sand and silt). The result of such changes include increased water velocities above the mined areas, causing local channel scouring and erosion. Sand and gravel operations typically occur adjacent to stream channels in our area. Dikes are built between the stream and the active mine in an attempt to protect the stream from any adverse impacts associated with mining. The Department of Geology and Mineral Industries (DOGAMI) regulates all upland and underground mining activities in Oregon.

The largest number of active aggregate mining operations is located in the Mill Creek watershed. Four aggregate mine sites are active in this watershed. Claggett has two active sites while Glenn-Gibson and Pringle have no active mine sites (see Water Quality chapter for location of active mines).

General Channel Modifications

Both the Oregon Division of State Lands (DSL) and the U.S. Army Corps of Engineers regulate soil, sand and gravel moving activities in wetlands and waterways. According to Oregon's Removal-Fill Law (ORS 196.800), a removal-fill permit is required if 50 cubic yards or more of material are moved within streams or wetlands, with the exception of "essential indigenous anadromous salmonid habitat" when there is no minimal quantity threshold (DSL 2001). Beginning in 1996, work in streams designated as essential for salmonid survival required a permit for any amount of removal or fill work.

While current records indicate 97 removal-fill permits were issued in the four watersheds over the last 30 years, records do not indicate what type of soil, sand or gravel moving events (i.e., construction of culverts, bridges, bank armoring, stream channelization) occurred (**Table 4-4**). The total number or cumulative effects for removal-fill practices below 50 cubic yards and for those performed prior to 1970 are not known. In addition, Oregon's Removal-Fill Law does not cover floodplain development. Floodplain development is allowed within certain parameters and is regulated by local land use ordinances. For example, the City of Salem revised code (SRC) Chapter 140 regulates floodplain overlay zones, establishes development standards and provides administrative and procedural direction and remedy.

Table 4-4. Removal-fill permits by watershed from the early 1970's – December 2000.

Watershed	# of Removal-fill permits
Glenn-Gibson	2
Claggett Creek	9
Pringle Creek	42
Mill Creek	
Mainstem	33
Beaver Creek	4
Battle Creek	7
Total	**97**

Source: Oregon Division of State Lands.

Negative results of channel modifications

Stream channelization in the form of diking, ditching and riprap can cause channels to deepen by the process of incision. This confinement of the channel limits the stream's ability to meander within its natural floodplain and in response, the stream length shortens, water velocities rise, and the stream power increases. Sediment transport processes and stream-floodplain interactions are disrupted (Hood River Watershed Group 1999). Without lateral movement of water, the flow is concentrated to the deepest part of the streambed. In time, natural drainage systems respond negatively by deepening and downcutting the channel. This type of streambank erosion is observed along sections of the Shelton Ditch in the Mill Creek watershed, according to the US Army Corps of Engineers (1990). An example of this type of stream bank erosion can be observed in the upper reaches of the West Fork of Pringle Creek. Here, the creek has incised to a depth of at least six feet, draining nearby lands that were historically wet meadow (Kroger pers. comm.).

A road paralleling a stream can affect the stream in two ways. First, by constraining the flow to one channel bed, the stream loses its ability to meander and disperse energy. Second, due to being constrained, the stream maintains a high velocity and begins to down cut and erode the channel (Yamhill Basin Council 2000). The disconnection of the stream from its floodplain results in a loss of side channels, lateral pools, and riparian function. Old stream crossings or undersized culverts have limited capacity to handle storm flows, which can cause the beds and banks of streams to wash out during peak flows. Peak flows in turn can exacerbate erosion of fill material around culverts or bridge abutments, which can become a source of sedimentation for the stream channel as well as weakening the infrastructure.

Stream channelization and other flood control structures such as dams, levees, and dikes allow people to develop floodplains. Without sufficient detention, development on floodplains decreases flood storage capacity and increases peak discharge rates. The decreased flood storage capacity leads to more severe floods farther downstream. The higher flows associated with urbanization erode stream banks and channels, devaluing both stream and riparian habitat values. The higher rates of erosion lead to more channel modifications in order to protect homes and property.

Placing streams in culverts and storm drains eliminates aquatic habitat by changing the substrate of the stream bottom from natural sediments to an artificial substrate. Pipes and culverts can also increase stream velocities, which can cause bank erosion downstream and potentially create fish passage barriers (see Fish and Wildlife chapter). If pipes and culverts are undersized, these structures can act as a bottleneck in the stream system, causing upstream flooding.

In rural areas, irrigation needs, combined with agricultural field flooding problems, have brought about various channel modifications and "improvements" (see Historical Conditions chapter). According to the 1982 Mill Creek Basin Study (Mill Creek Watershed Task Force 1983), approximately 90 miles of irrigation canal, supplied primarily by the Salem and Stayton Ditches, had been built throughout the Turner, Aumsville, Stayton, and Marion County area. Some urban runoff from the City of Stayton, combined with much of the irrigation canal water, eventually drains back to Mill Creek. Over the years the canal system has been modified with the addition of drainage tiles, new canals, the widening and deepening of older canals, and the upsizing of culverts. The report emphasizes that the ultimate effect of these changes is the increase in peak runoff from these rural areas into Mill Creek. As stated in the History chapter on page 91:

> …these are examples of well intentioned channel engineering to accomplish one purpose (agricultural irrigation and drainage) that then causes a problem down stream (accelerated discharge), which leads to a call for more channel engineering to address the unintended problem of downstream flooding.

Sand and gravel mining may modify a stream by relocating the channel, limiting the stream's ability to meander in its floodplain, and/or by constructing dikes that separate the mining area from the stream. The largest threat to streams adjacent to sand and gravel operations is the possible failure of the dike. If a break in a dike occurs, the erosion from the break may cause increased turbidity and sedimentation in the stream. If the dike failure is not stabilized, bank erosion can be extensive.

Channel Modifications and Fish and Wildlife

Stream components such as meanders, pools, runs, riffles, and the composition of the streambed provide feeding, breeding, and cover areas for aquatic wildlife. According to the Portland Multnomah Progress Board (2000), changes to the stream caused by development in the floodplain, small water impoundments, removal of trees, and the straightening of the channel greatly modify these stream components. These changes alter the depth and rate at which water flows through the system, reduce the number of pools and habitat niches, and impede nutrient cycling.

Different types of channel modifications affect fish and wildlife habitat in distinct ways. As stated in the Long Tom Watershed Assessment:

> Channelization and dams that control flooding have contributed to a reduction in wetland habitat and other benefits that flooding provide to fish and wildlife. Historically, flooding was very common in the lower elevations of the watershed during the winter months and was a natural function of stream systems. This cycle of flooding and the wetland habitat it creates provides many "ecological functions." For example, floodwaters carry and deposit sediment across the floodplain, which both removes sediment from the water and replenishes these areas with soil nutrients. When floodwaters can spread out over the floodplain, it decreases the intensity of flooding downstream and enhances the "recharging" of groundwater. Flooding provides juvenile fish and other aquatic organisms access to wetlands, side channels, backwaters, and oxbow ponds for winter rearing and feeding. In turn, when the floodwaters recede in the spring, they carry nutrients and plant matter with them, which supplies food for organisms in the stream for the coming summer (Horne and Goldman 1994).
>
> Dams and impoundments can prevent upstream and downstream migration of adult and juvenile fish in a number of ways. If a dam is too high, it may be a permanent barrier to upstream migration. Even a dam that is less than a foot high can be a barrier if there is no pool below the dam from which fish can jump. High summertime water temperatures in shallow impoundments can also discourage or prevent trout from swimming upstream during the summer when they are seeking the cooler water of tributary streams. They can attract fish during the winter months and discourage them from migrating the following summer. When temperatures rise later in the summer, or the landowner drains the pond, the fish die. Dams can also result in fish injury or mortality as downstream migrating juveniles attempt to negotiate them (Thieman 2000).

Natural stream channels may be altered by channel deepening and straightening. These actions reduce aquatic habitat. Streambed composition is affected when a channel is dredged. Straightening a channel reduces its overall length and also the quantity of aquatic habitat. While straightened stream channels facilitate faster stream flows and may reduce flood impacts, straightening tends to excavate the streambed, reduce available organic matter, and dislodge sediments containing toxics, pesticides and heavy metals (Thieman 2000).

When streams are placed in culverts and pipes, a corresponding amount of aquatic habitat is eliminated. Culverts and pipes may also be fish passage barriers in some cases. Current fish passage standards generally limit culvert length to no more than 200 feet, depending on the grade. If the culvert is large, small weirs can be placed inside to create small pools that fish can jump into and rest.

Reducing large woody debris (LWD), such as complete trees, in streams has significant impact on fish and wildlife. LWD creates channel complexity by reducing stream flow speeds, diverting water into side channels, and creating pools. Many aquatic species, including native fish, benefit from these conditions. When stream flows slow down gravel tends to be deposited, creating spawning habitat. Juvenile fish survival requires cover as hiding places from predators, and resting areas out of the main flow. LWD in the stream provides both. Decaying woody debris also serves as a base for the stream's food chain (Thieman 2000).

Historic Conditions and Modifications

It is difficult to assess the extent and location of historic modifications in the four watersheds. For a description of the historic condition and early modifications of Pringle, Claggett, Glenn-Gibson and Mill Creeks, we refer the reader to the Historical Conditions chapter of this document.

Summary

A review of the current conditions of our streams reveals that channel modifications are extensive. Because the study area has been drastically modified due to urban development and agricultural activities, a more appropriate question to ask may be, where isn't the channel modified?

Channel modifications have had and continue to have a significant impact on water quality and aquatic habitat in our local streams. In summary, channel modifications can (Thieman 2000):

- alter and reduce the total amount and quality of in-stream habitat;
- disconnect rivers and streams from their floodplains;
- reduce wetland habitat;
- increase the intensity of peak flows;
- eliminate the opportunity for water to be filtered by adjacent wetlands; and
- hinder or prevent fish migration.

Despite the multiple impacts that channel modifications have on our watersheds, it would be difficult and expensive to totally remove them. Urban and rural residents rely on these modifications for flood protection, irrigation, power generation, and recreation.

To improve channel conditions within an urban setting will require careful planning. Returning a channel to its historic conditions may not be possible; however, it may be possible to improve channel conditions on a site-by-site basis. Appropriate restoration may include such activities as the elimination of small impoundments or weirs that are no longer in use, tolerating the activities of beavers, or modifying stream crossings to allow both fish passage and an active channel width.

In rural areas options for channel modifications may include restoring the surface water connection between streams and isolated wetlands and oxbows, restoring flow from channelized ditches to their historic channels, and tolerating LWD in streams.

Recommendations

All Basins

1. Conduct a survey to determine the location and extent of bank armoring along local streams. Prioritize bank armoring locations based on factors such as importance of the site to water quality and habitat, accessibility of the site, and property owner characteristics. Take steps to improve highest priority areas by incorporating bioengineering techniques, including the planting of native vegetation. Apply for grant funding as needed.

2. Conduct a survey to determine the location and extent of stream bank erosion. Prioritize these locations. Work with local governments and private owners to improve highest priority areas by use of bioengineering techniques when feasible. Apply for grant funding as needed.

3. Work with local governments and property owners to identify and remove dams and weirs that are no longer in use. Work with OWRD to determine who owns in-stream structures. Apply for grant funding to help fund the removal of privately owned structures.

4. Develop outreach programs to inform rural landowners about the benefits of LWD and work with municipalities to determine if there are opportunities to incorporate LWD in stream/fish habitat enhancement projects.

5. For all new transportation infrastructures, recommend to state and local agencies that stream crossings be designed to accommodate an active channel width.

6. Recommend to state and local agencies that they build bridges for stream crossings instead of culverts.

7. Support land use planning on a watershed scale. Get involved with City of Salem, City of Keizer, Marion County and Polk County planning efforts to meet Statewide Planning Goal Five which protects open spaces, scenic and historic areas and natural resources.

8. In areas planned for, lobby local government officials to require adequate detention, extensive upland buffers and flow diversion to reduce channel impacts.

9. Lobby appropriate government agencies having permitting and over-site roles to require wide buffers between active mine sites and stream channels when reviewing permit applications and reclamation plans for mining.

10. Reduce the number of stream crossings.

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Chapter 5 - Hydrology

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Introduction

This chapter of the watershed assessment will focus on hydrology: how human modification of the natural hydrology has impacted Pringle, Glenn-Gibson, Claggett, and Mill Creek watersheds. The various aspects of hydrology will be discussed as they relate to water rights and water use, land use, diversions of waterways, flooding and weather cycles, stream flows and aquatic use, in-stream use, and water level and water controls.

Data Sources

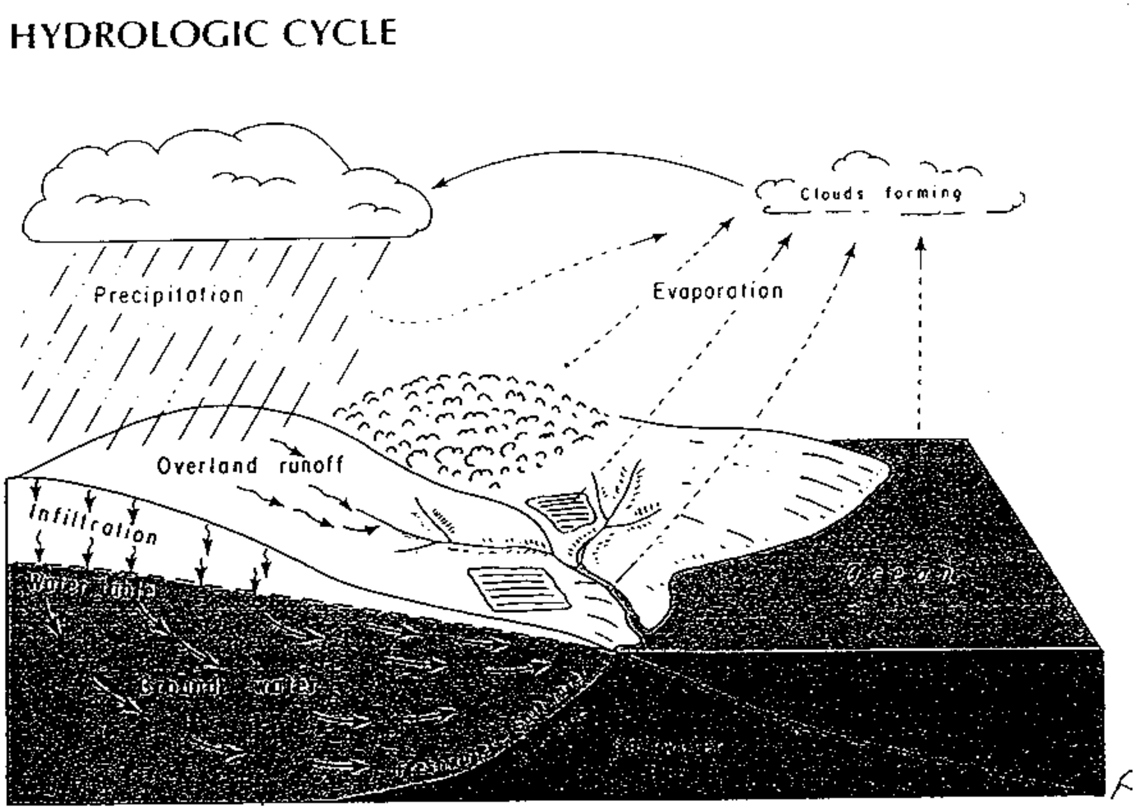
Data sources include Oregon Water Resources Department (OWRD), Oregon Department of Fish and Wildlife (ODFW), U.S. Geological Survey (USGS), City of Salem, Keizer Service District, Mid-Willamette Valley Council of Governments (MWVCOG), the Salem Public Library and Oregon Climate Service.

Hydrologic Cycle

The term hydrologic cycle is defined as the constant movement of water above, on, and below the Earth's surface (**Figure 5-1**). This drawing demonstrates how the cycle includes the following components: evaporation, precipitation, infiltration and overland flow. *Evaporation* occurs from vegetation, the ocean and other exposed moist land surfaces. The moist surfaces develop into clouds, which return the water to the land surface (i.e. oceans) in what is known as *precipitation.* The cycle is completed after precipitation, typically in the form of rain for the Willamette Valley, wets the surface and then enters the groundwater in a process called *infiltration.*

The rate of infiltration is not only dependent on the intensity or duration of rain but is also influenced by soil moisture, soil permeability and land use (Oregon State University Extension Service 2001). *Overland flow* occurs when the rate of precipitation exceeds the rate of infiltration. Water makes its way to streams both by ground-water discharge and overland flow, continuing the cycle as water is once again evaporated. This distribution and movement of surface and sub-surface water (i.e. hydrology) throughout all four of these watersheds is necessary for the protection of water quality, fish and wildlife habitat, and use of surface and ground-water. The City of Salem stores municipal water underground within city limits.

Figure 5-1. The Hydrologic Cycle



Source: Oregon State University Extension Services 2001

Why Streamflow is Important for Salmonids

Modifications to natural stream flows often diminish the capacity for a watershed to function properly, which may in turn threaten the viability of many fish populations. There are two significant problems associated with streamflow that may adversely impact salmonids. One is that high flows scour the channel and wash out the spawning gravels and redds. The other main factor is that decreased streamflows in the summer can limit the accessibility of juvenile salmonids to good habitat. In urban areas, stream flows are typically "flashy," meaning flows alternate between intense and short to longer durations of trickle-like flows. Both flow regimes place stress on salmonid species.

Although most species of salmonids appear to have adapted their life cycle to suit the specific flow patterns associated with their natal stream, increased winter flows can affect adult steelhead during their spawning and nesting times. For instance, during the winter months, salmonid swimming ability decreases as the water temperature decreases, which make the fish especially vulnerable to higher water velocities. As a result, over-wintering salmon typically seek areas of low water velocity such as marshes and wet meadows adjacent to the channel, or spaces formed between rocks along the channel. Loss of active floodplains and healthy riparian corridors has significantly decreased the availability of off-channel and in-stream habitats (Portland Multnomah Progress Board 2000).

Low flow conditions exacerbated by a loss of floodplain and wetland habitat, and an over-allocation of surface and groundwater to diversions, can negatively affect juvenile salmonids. Extremely low summer flows coincide with juvenile rearing times. This may force salmon into pools and intermittent tributaries that dry up and can ultimately strand them. (Portland Multnomah Progress Board 2000). Low creek flows may also cause stream temperatures to rise, negatively impacting salmonid spawning and rearing activities.

In addition to directly affecting salmon, altered stream flows can affect the aquatic insect and invertebrate community, the food source for salmonids. (See the Water Quality Chapter for more information on the aquatic invertebrate community of local streams).

Local Climate

The Salem-Keizer area has a modified marine climate (Schott and Lorenz 1999). Typical weather patterns originate in the Pacific Ocean and tend to move west to east across the region. As air masses move in the easterly direction, the Coast Range tends to modify temperatures and precipitation. The land elevations range between 150 feet (downtown Salem) to 1,093 feet (Eola Hills). Most of the higher elevations are located in the South Salem Hills and portions of West Salem. There is an elevated river terrace marking the edge of the modern floodplain (100 to 500 year recurrence intervals) of the Willamette River in the north end of Keizer (Schott and Lorenz 1999). The Willamette Valley floor is flat with slopes of three percent or less.

Annual average precipitation is about 41 inches, 90% of which falls between the months of October and the end of May. The monthly precipitation averages between six to seven inches from November through January. According to an Oregon State

University report, long-term wet-dry cycles are prevalent in the state of Oregon (Taylor 1999**).** These wet and dry “cycles” generally span 20-25 years. The report indicates that the dry years tend to be warm (most likely due to cloudiness) and the wet years cool. The dry (and warm) periods are estimated from about 1920-1945 and 1975-1994, with the wet periods taking place before and after (Taylor 1999). The data indicates that we may be entering another wet cycle. However, being in a wet cycle does not preclude the chance of having a dry year. This is evident when Oregon experienced a drought year in 2001. Salem recorded 21.97 in the 2001 water year. This is the second driest year on record for Salem. The record low for Salem is 20.37 set in 1976-77 (Oregon Climate Service 2001).

Typically, there are five or fewer days with snow cover each year. Average daily minimum temperatures range from 33 to 52 degrees Fahrenheit. Average maximum daily temperatures range from 46 to 82 degrees Fahrenheit. In July 1941 a historical high temperature of 108 degrees Fahrenheit was recorded. The high was met again in August 1981. On December 8, 1972, a historical low temperature measured minus 12 degrees Fahrenheit (City of Salem 2001c).

Concept Of Flood Frequency

Flood recurrence levels are the way to express the likelihood of a given flood event occurring in a given year. Flood frequency is based on historic records of flow at stream gauging stations. It is a measure of probability. There is a one percent statistical chance of having a 100-year flood each year. Over the course of 30 years (the average length of a residential loan), there is a 26% chance that there will be a 100-year flood. The severity of a flood depends on many factors, including the drainage area and its characteristics and antecedent moisture. Smaller streams are much more sensitive to short duration, high intensity rainfall than larger basins (City of Salem 1996).

Since Euro-American settlement, the Willamette River has experienced 10 major flood events (**Table 5-1**).

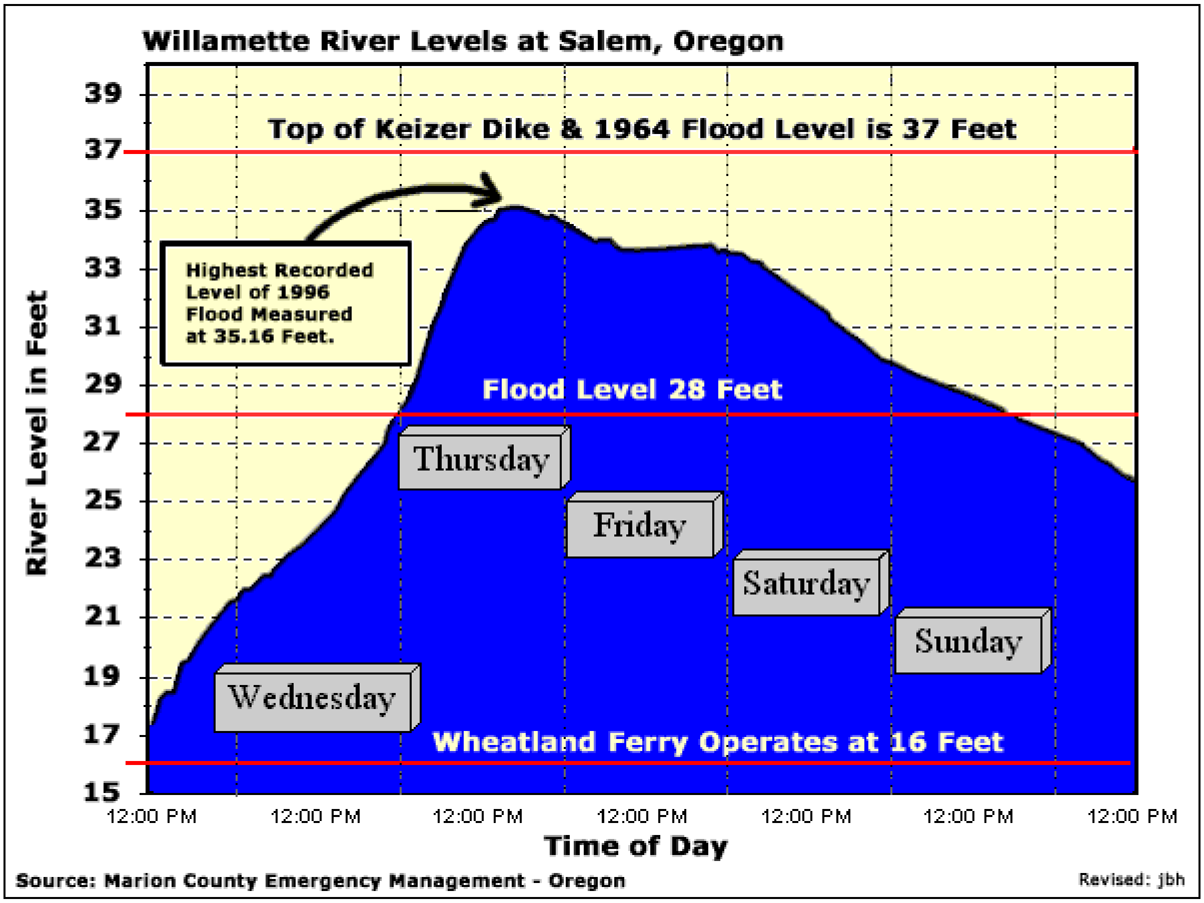
Table 5-1. Willamette River Flood Events at Salem.

Month/Year	Gauge Height	Discharge sec./ft.	Notes
Dec 1861	About 47′	500,000	Salem's great flood occurs, waters reach as far inland as the courthouse. Heavy snow falls on Salem in November and heavy rain in December, cresting the Willamette River at 47 feet in Salem.
Jan 1881	44.3′	428,000	-
Feb 1890	45.1′	448,000	-
Jan 1901	31.5′	329,000	-
Feb 1907	31.3′	325,000	-
Nov 1909	30.5′	315,000	Maximum discharge observed.
Jan 1923	38.3′	348,000	-
Jan 1943	38.6′	291,000	January floods after 60 days of rain and 26 inches of snow make the Marion Street bridge inaccessible. Willamette River crests at 38.6 feet.
Dec 1964	37.8′	308,000	The Salem area was flooded at Christmas time and described as one of the most significant and extensive Pacific Northwest flood events in recorded history. The Willamette River crests at 37.8 ft., caused by warm rain on top of snow and frozen ground.
Feb 1996	35.16′	244,000	On February 7, 1996, the Willamette River experienced a flood similar to the 1964 flood event; the storm occurred further north in the valley.

Source: USGS (1998); notes were compiled from City of Salem (2001c).

The 1996 flood was the most recent high water event experienced in the Salem area. A series of storms that extended from Hawaii to Oregon followed a week of extremely cold weather, which froze the already saturated ground. The winter of 1995-96 had already produced well above the average rainfall for the year, and many people experienced problems with high groundwater and runoff they had not seen before (City of Salem 1996). Flood level is 28 feet. The Willamette River reached well above flood level on February 7, 1996 (**Figure 5-2**). The rainfall that caused the flood of 1996 was the greatest three-day total for the period 1928 to 1996. For a more comprehensive documentation of the February 1996 flood and how it compares with previous floods in the Salem Area, please consult the Post Flood Report prepared by City of Salem Department of Public Works (City of Salem 1996).

Figure 5-2. Graph of daily flood levels of the Willamette River at Salem, February 1996.



Source: Salem Oregon Community Guide, **http://www.oregonlink.com/flooding/**

While the 1996 flood did cause property damage, it wasn't considered an extreme event in the history of the Willamette River (Corvallis Environmental Center 1998). Prior to the construction of dams in the mid 1900's, many larger floods have occurred as indicated in **Table 5-1**. Reservoirs and dams constructed in upper watersheds have limited the extent of flooding in the Willamette Valley. Flow has been regulated since 1941 by Fern Ridge Reservoir, 1942 by Cottage Grove Reservoir, 1949 by Dorena Reservoir, 1953 by Lookout Point and Detroit Reservoirs, 1961 by Hills Creek Reservoir, 1963 by Smith River Reservoir and Cougar Reservoir (Hadden pers. comm.). Although dams have successfully helped reduce flooding over the years, they have also presented major obstacles for safe juvenile fish passage and have limited accessibility to spawning habitats. At the time dams were constructed, it was not widely appreciated that flooding is a natural process that actually has many beneficial aspects for the river ecosystem. Flooding recycles nutrients through the floodplain, redistributes sediments, and recruits large woody debris into the stream that helps form habitat for salmonids. Floods flush sediment and re-create gravel bars, which are spawning habitat for salmonids and good substrate for some stream insects (Corvallis Environmental Center 1998).

Hydrologic Features of the Watersheds

Pringle Creek

Southeast Salem is drained by Pringle Creek. The Pringle Creek watershed is 13.3 square miles and is located almost entirely within the City of Salem's urban growth boundary. The basin terrain is moderate in slope, the topography consisting of flat lands and hillsides (City of Salem Public Works Department 2000). There are five main tributaries in the Pringle Creek system (City of Salem 2001b). These include Clark Creek, Pringle Creek, East Fork, Middle Fork and West Middle Fork. Mill Creek (which overflows during flood conditions to the East and Middle Forks of Pringle Creek) and Shelton Ditch (upstream of Pringle Creek's confluence with the Willamette) also contribute water to Pringle Creek during flood events (City of Salem Public Works Department 2000). Culverts under Liberty Road South at Skyline were doubled in size in 1999-2000, based in large part upon modeling done for the Stormwater Master Plan, to handle increased flow expected from future Skyline area development. During peak storm events, considerable water is stored in fields in the vicinity of the Salem Airport. A 1983 USGS study reports that some minor channel storage also occurs in the upper parts of the basin and is probably the result of man-made constrictions (Laenen 1983).

The Salem Local Wetland Inventory (Schott and Lorenz 1999) shows that wetlands are typically located along streams in the Pringle Creek watershed (**Map 5-1**). Larger areas of wetlands are located along the eastern portion of the watershed, where land use is primarily industrial.

The Pringle Creek watershed has suffered from the historical use of drainage tiles in the eastern portion of its watershed. Before the Fairview Industrial Complex was built, the land was once drained by a series of ditches and tile lines for farming purposes. Information regarding the location of these tiles lines was lost when the land was developed for industrial uses. The long-term consequence of these abandoned tile lines became evident when SumcoUSA spilled acid on its property in the April of 2000. The acid seeped into the ground and traveled along an abandoned tile line and directly into the creek. A fish kill was the result (see Fish and Wildlife Chapter for more details).

A map of the Pringle Creek watershed and its floodplain as determined by the Federal Emergency Management Agency (FEMA) has been included (**Map 5-2**). A comparison of the land use map (**Map 5-3**) with the FEMA map shows that both industrial and public land in the eastern portion of the watershed lie completely within the FEMA floodplain. High and low density residential development is located adjacent to the floodplain just south and west of Turner Road. Commercial and public land use practices are found along the northern borders of the FEMA floodplain. Most of the upper watershed is residential.

Pringle and Mill Creek have been channelized in numerous locations in the downtown area. According to Schott and Lorenz (1999), flooding is relatively infrequent in the lower reaches of these creeks with riparian wet spots restricted to undeveloped reaches, such as Pringle Creek through Bush Park. Historically, the area near Salem Hospital, Pringle Park and Bush's Pasture Park was subject to flooding. Pringle Hall, in Pringle Park, was destroyed in the 1996 flood. Residents of the watershed claim that the lower reaches of Pringle Creek now experience seasonal flooding, not infrequent flooding, as claimed by Schott and Lorenz (1999). Flooding has reached proportions in which streets have been impassible and, homes and businesses have incurred damage during seasonal flood events, such as businesses between 12th and 25th streets, and along Strong Road. Flooding also occurs higher up in the system, including Cannery Park and Idylwood Street near Woodmansee Park.

Glenn and Gibson Creeks

The Glenn-Gibson basin drains 10.4 square miles of West Salem, with approximately half of the watershed located within the urban growth boundary (City of Salem 2000). The basin terrain is steep, particularly in the upper reaches, with flatter slopes near the basin outlet. Creeks flow down steeper gradients than on the valley floor and stream channels tend to be narrow and generally lack broad floodplain or riparian areas (Schott and Lorenz 1999). The 1983 USGS study reports that the basin has a moderate amount of storage and that elimination of storage, by improving channels and draining topographic depressions, would increase peak flows approximately 70 percent (Laenen 1983). While over 20 small tributaries exist in the basin, Glenn and Gibson Creeks are considered the two main drainage channels for the watershed (City of Salem Public Works Department 2000).

Many wetlands identified in the local wetland inventory are associated with streams in the Glenn-Gibson watershed (**Map 5-4**). Due to the hilly nature of the landscape, only linear segments of wetlands are found adjacent to Glenn and Gibson Creeks. Land use adjacent to most segments of streams in this watershed are either single family or vacant residential (**Map 5-5**). A map of the Glenn-Gibson watershed and the floodplain as determined by the Federal Emergency Management Agency (FEMA) has been included (**Map 5-6**). Because of the steep terrain, the 100-year floodplain is restricted to a narrow band along Glenn and Gibson Creeks.

Claggett Creek

The Claggett Creek basin drains approximately 20 square miles in Marion County, including east Salem and the City of Keizer. The Upper Claggett Creek basin is located within the City of Salem's urban growth boundary and drains east Salem in the upper reaches of the watershed. The Lower Claggett Creek basin includes the lower reaches of the watershed in the City of Keizer and agricultural areas in the northern portion of the watershed. The basin slope of Lower Claggett Creek basin is very flat which contributes greatly to widespread ponding in streets, parking lots and yards, particularly in areas draining into dry wells (Keizer Service District 1982). Lower

Claggett Creek basin also includes Labish Ditch, a ditch that drains a portion of Lake Labish. Historically, Lake Labish was an old channel of the Willamette River (Orr et al. 1992). The area is now intensively farmed and drained by a network of ditches. Lake Labish drains in two directions, west to Claggett Creek and east into the Little Pudding River. During normal rain events the two watersheds remain distinct. However, during severe flood events such as occurred in December 1995, February 1996, and January 1997, the Pudding River backed up, contributing to headwater flooding of the ancient lake (Schott and Lorenz 1999). The use of tiles to drain agricultural areas has been extensive in the Claggett Creek basin, which affects both peak flow and runoff volumes in the watershed. According to a USGS study (Laenen 1983), runoff volume in Hawthorne Ditch and Claggett Creek were 100 percent and 180 percent higher, respectively, than predicted due to extensive tiling in east Salem. This would indicate that these two waterways are very "flashy" and experience intense short-duration high flows during and after precipitation events.

Locally identified wetlands are found along Claggett Creek (**Map 5-7**). The largest parcel of contiguous wetlands exists along Claggett Creek in the City of Keizer. Land use along this reach of the creek is a mix of public and residential (**Map 5-8**). The upper portion of the watershed is dominated by commercial, industrial and residential land uses.

A map of the Claggett Creek watershed and its floodplain as determined by the Federal Emergency Management Agency (FEMA) has been included (**Map 5-9**). The FEMA 100-year floodplain map indicates that the northwestern portion of the Claggett Creek watershed lies completely within the designated Willamette River floodplain. North of Chemawa Road and west of River Road, the land use practices are a mix of single and multi-family residential, public, commercial and agricultural.

Mill and Battle Creeks

The Mill Creek watershed is about 24 miles long and six miles wide and drains approximately 110 square miles. Headwaters of Mill Creek are located east of Salem, in the foothills of the Cascades. Within the City of Salem, the basin includes over ten miles of waterways draining an eight square mile area. Mill Creek has several natural and man-made tributaries. The three major tributaries are Beaver Creek, McKinney Creek, and Battle Creek. The Mill Race and Shelton Ditch are the two main channels of the Mill Creek system. Several smaller tributaries drain into Mill Creek, contributing some natural flow, but the main source of water for the creek during the summer is the North Santiam River. Water from the North Santiam is diverted into the Salem Ditch at Stayton. The Salem Ditch is approximately four miles long and flows west through Stayton, then heads northwest before flowing into Mill Creek west of Golf Club Road. The creek then flows mainly west through Aumsville and Turner. At Turner, Mill Creek begins to flow in a northwest direction. Mill Creek flows in a northwesterly direction through Salem until it empties into the Willamette River north of the intersection of D Street and Front Street.

The Mill Race, a man-made channel, was originally constructed in 1864 for power generation. Stream flow in the Mill Race is conveyed through a concrete-lined sluice (Schott and Lorenz 1999). Portions of the Mill Race consist of open channels, as in the segment that flows through Willamette University. The "headworks" are located at 20th and Ferry S.E. (at Mill Race Park, across from a small restaurant). The inlet control structure has three adjustable slide gates which are controlled by the City of Salem's Parks Operations, and are kept locked at all times. There is a siphon inlet at the downstream western end of Willamette University that feeds the "waterway"/water feature through Pringle Plaza. This waterway also feeds the Civic Center's mirror pond via a gravity pipeline across Pringle Creek behind the Main Fire Station (Downs pers. comm.).

A portion of Mill Creek is diverted into Shelton Ditch just east of Airport Road. Shelton Ditch is used by Salem as an overflow for flood control (City of Salem 2001b). Following an earlier natural stream course, Shelton Ditch was constructed as a drainage channel in the mid 1930's to help relieve flooding in the lower reaches of Mill Creek. In 1984, the section of Shelton Ditch between Winter and Church Street was re-developed in part to provide for an urban pedestrian walkway. (See Historical Conditions chapter for further information).

According to Salem's Stormwater Master Plan, drainage improvements for the Mill Creek basin will need to be compatible with efforts to protect native fish runs (City of Salem Public Works Department 2000). The U.S. Army Corps of Engineers (COE) recently studied potential flood reduction within the system, and it was hoped that the study would identify several potential flood mitigation projects for future implementation (City of Salem Public Works Department 2000). However, no potential improvements met the COE's minimum cost benefit ratio.

Battle Creek basin drains approximately 10 square miles. Slightly less than half of the basin lies within Salem's urban growth boundary. The creek flows southeast out of Salem over steep terrain. The five main tributaries to Battle Creek include, Jory Creek, Powell Creek, Waln Creek, Scotch Creek, and Cinnamon Creek (City of Salem Public Works Department 2000). The 1850 General Land Office survey indicated a sizeable wetland at the confluence of Waln and Battle Creeks. The basin had considerable storage, which should be expected in a primarily rural basin. The elimination of this storage would increase peak flows an average of 150 percent by model estimate (Laenen 1983). According to the 1983 USGS report, the impervious area of the Waln Creek basin nearly doubled from 1938 to 1980. Since 1983, growth has exploded throughout the basin, with numerous completed subdivisions. Waln Creek is also rare in having an undeveloped riparian corridor in its midsection, which serves to lessen water movement, thus decreasing peak flows (Laenen 1983).

Locally identified wetlands are found along certain reaches of Mill Creek (**Map 5-10**). The 1999 Local Wetland Inventory (LWI) did not identify any riparian wetlands along the reach of Mill Creek located on State penitentiary farm property. Several isolated farmed wetlands are located on the southeast portion of the farm property. Between Kuebler Blvd. and Hwy. 22, including Cascade Gateway Park, there are several ponds created by gravel mining (Schott and Lorenz 1999). The LWI also indicates that the best examples, in terms of diversity of native plant species, of wet prairie and forested wetlands are found in wetlands adjacent to or near the banks of Mill Creek between Highway 22 and the Southern Pacific Railroad. Currently, there are no native wetlands in the downtown Salem area (Schott and Lorenz 1999); however, there are historical accounts of wetlands in this location (see History Chapter and Riparian/Wetlands Chapter). **Map 5-11** depicts wetland areas found in Battle Creek basin. The Salem-Keizer LWI identifies several wetland and wetland mitigation projects along Battle Creek (Schott and Lorenz 1999).

Map 5-12 and **Map 5-13** show the extent of the 100-year floodplain in the Mill Creek watershed both in the City of Salem and in the rural portions of the watershed. Within Salem's UGB, the 100-year floodplain consists of primarily industrial and public development. Some areas of commercial and multi-family residential development are also found within the floodplain. Outside of Salem's UGB, mostly agricultural and residential agricultural land uses are found within the 100-year floodplain. Parts of Turner, Aumsville and Stayton, small cities within the watershed, have also been mapped within the 100-year floodplain.

Effects of Land Use on Hydrology

Alteration to the natural landscape changes the way water travels across the land, how the land retains the water, and how it empties into a stream. Such flow alterations are driven primarily by changes in type and density of vegetation and by infiltration rates. These changes can affect the magnitude, duration and impact of floods. An increase in the amount of impervious surface (e.g., removing natural vegetation and replacing it with rooftops and transportation networks) and channel modifications (e.g., filling wetlands associated with a stream, channelization, rip-rapping stream banks, placing streams in closed pipes) are examples of how human activities have decreased infiltration rates of precipitation and impacted the flow of water across the landscape. The result of channel modifications and an increase in impervious surfaces in a watershed is an increase in peak discharge for the receiving stream. A stream responds to increased flows by expanding its width or by cutting deeper into its streambed. These responses in turn contribute to channel instability, stream bank erosion, and habitat degradation. In the Pacific Northwest, the combined effect of increased precipitation in the winter and the modifications to drainage patterns listed above, create stream flows often described as "flashy." A stream experiencing "flashy" stream flow will typically move large volumes of water for a short duration immediately during and after a precipitation event. Due to decreased infiltration rates of the precipitation, the same stream may experience none to very low flows between precipitation events.

Impervious Surfaces

According to Schueler (1994), the definition of "impervious surface" is the sum of roads, parking lots, sidewalks, rooftops and other impermeable surfaces of the urban landscape. Other impermeable surfaces would include compacted soils and semi-impermeable lawns. During each stage of land development, this variable can be easily quantified, managed, and controlled, which makes it a valuable tool to measure the extent of urbanization. Many past scientific studies have related imperviousness to specific changes in hydrology, water quality, and the habitat structure and biodiversity of streams.

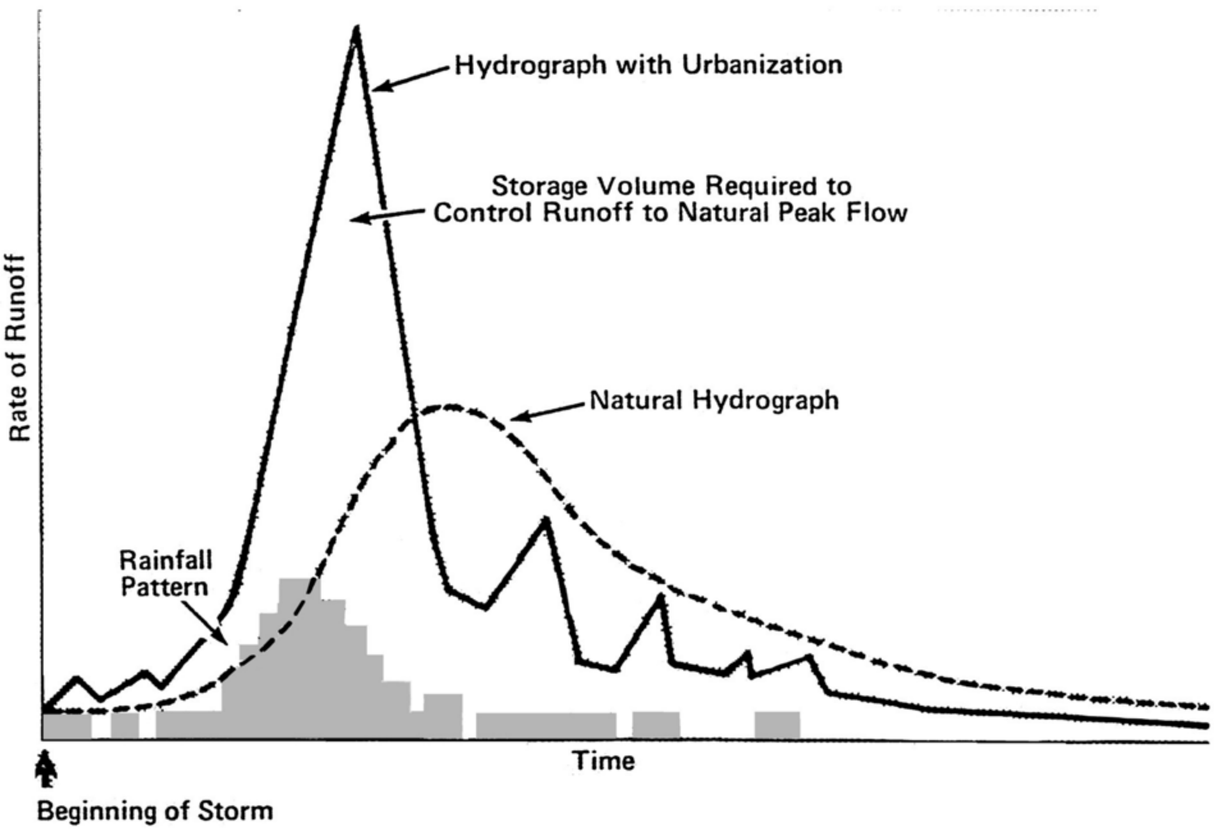
Hydrology

Without stormwater detention, urbanization, as reflected by downstream flood hydrographs, causes higher flood peaks and impacts to fish habitat as well as increases the risk of flood damage to property (City of Salem Public Works Department 2000). **Figure 5-3** shows the standard urban hydrograph that can be applied to any urbanizing area. (Warren 1978). The change caused by urbanization from a rural basin to a fully developed basin will increase peak discharge more than three-fold and storm runoff by two-fold. (Laenen 1983). However, a model relating stormwater runoff and urbanization in the Willamette Valley (Laenen 1983) shows that storage of stormwater can reduce peak flows. According to USGS calculations, if one percent of the land in a watershed is used for stormwater storage, peak discharge may be reduced by approximately 40 percent.

According to Salem's tree canopy analysis," communities that use increased tree cover to help manage stormwater can reduce the cost of constructing stormwater infrastructure" (City of Salem 2001a). This is because trees and soil both retain water and so reduce runoff. Salem's average canopy cover in 2001 within the urban growth boundary was 17.54%, well below the suggested standard of 40% tree cover. Even with that, however, the one-time value of existing tree canopy benefits for Salem were estimated to be in excess of $148 million. Its annual benefit to stormwater management is estimated at almost $965,000 (City of Salem 2001a).

For streams with high restoration potential, stream restoration and/or increasing channel capacity (e.g. laying back banks, creating wetland benches in stream channels) can be used to mitigate for higher than normal rates of channel erosion/scouring and riparian damage associated with high flows. The City of Salem's Stormwater Master Plan (City of Salem Public Works Department 2000) outlines how development policies, attenuation (detention) facilities, and channel alterations can mitigate the impacts of high flows. Details on stormwater management for the Pringle, Glenn-Gibson, Claggett, and Mill Creek watersheds will be provided at the end of this chapter. For additional information, please consult the City of Salem's Stormwater Master Plan.

Figure 5-3. A Typical Urban Hydrograph



Source: Urban Land Institute – Environmental Comment. Adapted from the article *Drainage as a Municipal Utility* (Warren 1978).

Water Quality

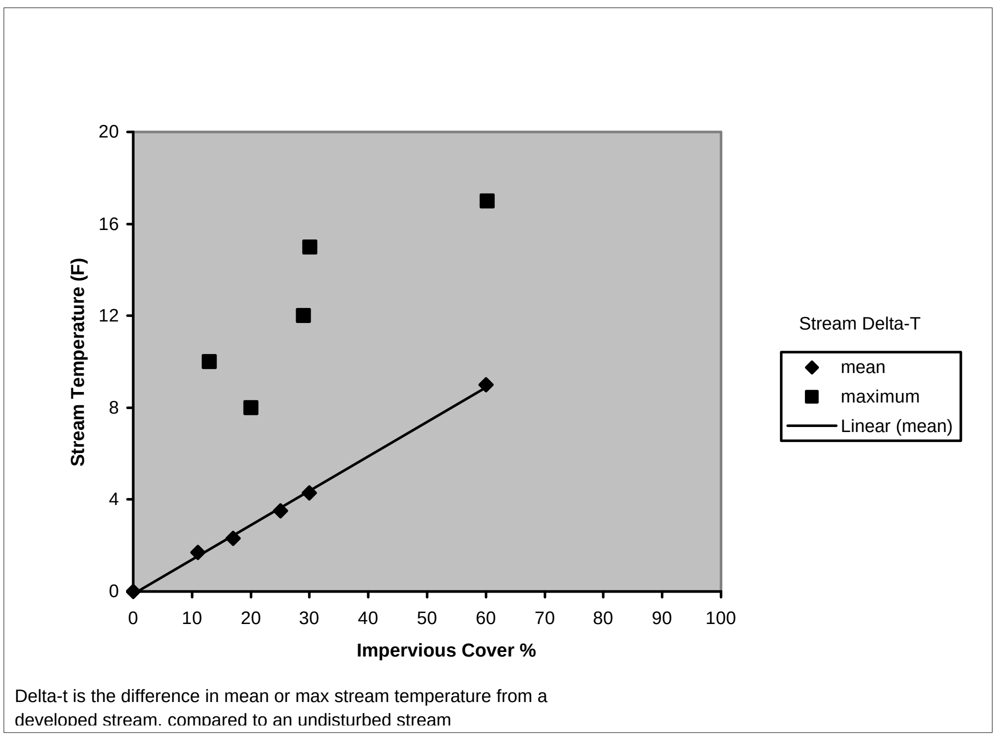
During storm events surface runoff from impervious areas is quickly washed into streams either directly or via stormwater systems. Monitoring and modeling studies have consistently indicated that urban pollutant loads are directly related to watershed imperviousness (Schueler 1994).

The best way to reduce the amount of pollutants in a stream is to prevent the pollutants from entering the stream in the first place. Best Management Practices (BMPs) include structural or nonstructural devices designed to temporarily store or treat stormwater runoff in order to mitigate flooding, reduce pollution and provide other amenities that help prevent pollutant runoff. Some BMPs already implemented by the City of Salem include practices such as educating the public on improving water quality through small everyday changes in behavior (e.g. the Watershed Enhancement Team Program), and a new erosion control ordinance and riparian buffer ordinance. City staff is drafting standards, criteria and policies for construction of parking lot bioswales. The City of Salem is also planning to expand regional stormwater detention facilities (City of Salem Public Works Department 2000). BMPs for Marion County have recently been outlined in the *Marion County Salmon Recovery Plan* (Marion County Public Works Department 2001). The areas to be focused on include, vegetation management, ferry maintenance and operations, maintenance of bridges, fleets, and parks as well as service districts and engineering designs (Marion County Public Works 2001).

Further study is needed to assess which pollutant loads (i.e., phosphorus, nitrogen, etc.) can be reduced when BMPs are implemented. Depending on the practice selected, past monitoring studies of phosphorus loads showed decreases of 40 to 60% (Schueler 1994). Please refer to the Water Quality chapter of the assessment for additional details on what types of pollutants are found in the watershed.

Increases in urban stream temperatures in summer appear to be directly related to the amount of impervious cover found in a watershed (**Figure 5-4**) (Galli 1991). Galli (1991) also reports that other factors, such as lack of riparian cover and in-stream ponds, amplify stream warming, but the primary contributing factor still appeared to be the amount of impervious cover in the watershed.

Figure 5-4. The Effect of Impervious Cover on Stream Temperatures



Source: Center for Watershed Protection (1998).

Habitat Structure and Aquatic Biodiversity

Changes in the hydrologic regime, channel morphology and water quality of an urban stream impact habitat structure. Changes in habitat structure ultimately lead to changes in the aquatic community. Research conducted in many regions and using different methods has concluded, "stream degradation occurs at relatively low levels of imperviousness (~10%)" (Schueler 1994). Research performed on stream quality in the Pacific Northwest demonstrates how aquatic communities are adversely impacted by urbanization (**Table 5-2**).

Table 5-2. Review of Key Findings of Urban Stream Studies Examining the Relationship of Urbanization to Stream Quality in Seattle, Washington.

Researcher(s)	Year	Location	Biological Parameter	Key Finding
Booth	1991	Seattle	Fish habitat and channel stability	Channel stability and fish habitat quality declined rapidly above 10% imperviousness.
Luchetti and Fuersteburg	1993	Seattle	Fish	Marked shift from less tolerant Coho salmon* to more tolerant cutthroat populations noted at 10-15% imperviousness at nine sites.
Pedersen and Perkins	1986	Seattle	Aquatic insects	Shifted to chironomids (midges and mosquitoes), olgliochaetes (aquatic worms) and amphipods (scuds) species tolerant of unstable conditions.
Steward	1983	Seattle	Salmon	Marked reduction in Coho salmon populations noted at 10-15% imperviousness at nine sites.
Taylor	1993	Seattle	Wetland plants/ amphibians	Mean annual water fluctuation was inversely correlated to plant and amphibian density in urban wetlands. Sharp declines noted above 10% imperviousness.

* Coho salmon have not been documented in the Salem area watersheds.
Source: Adapted from Center for Watershed Protection (1998).

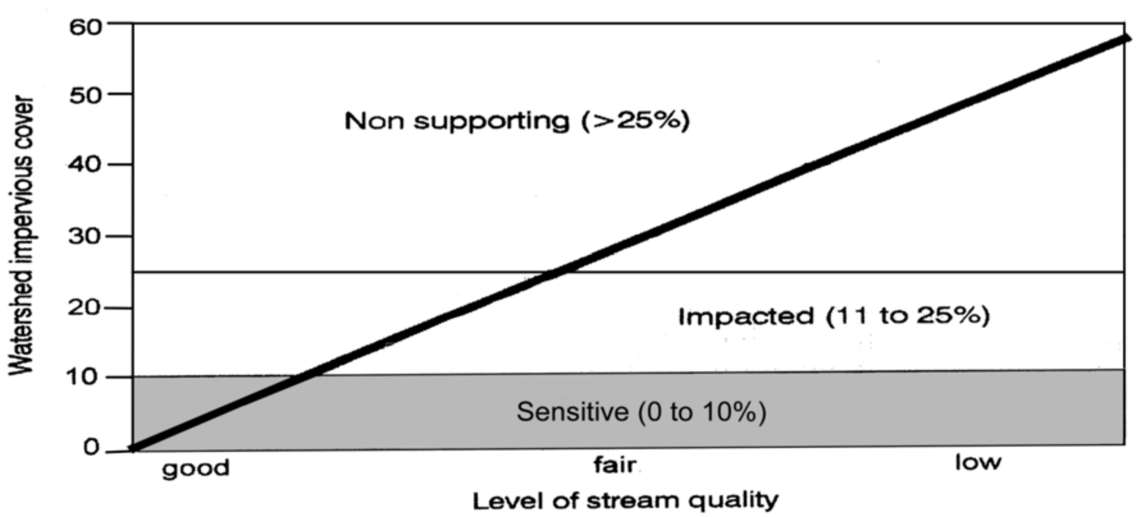
In addition to the studies mentioned in **Table 5-2**, a 1979 macroinvertebrate study conducted by the American Water Resources Association reveals that biodiversity in urban streams drops rapidly when imperviousness exceeds 10 to 15% (Klein 1979). Species more tolerant of pollution and hydrologic stress such as chironomids, tubificid worms, amphipods, and snails replaced resident species such as stoneflies, mayflies, and caddisflies. (Please refer to the Water Quality Chapter for additional information on stream macroinvertebrates).

After reviewing many articles relating stream health to impervious cover, Schueler (1994) suggests the following classification of streams based on percent impervious area in a watershed:

1. Sensitive streams (one to 10 % impervious cover)
2. Impacted streams (11 to 25% impervious cover)
3. Non-supporting streams (26-100% impervious cover)

A graphic representation of this index is shown in **Figure 5-6.** The resource objective and management strategies in each stream category differ to reflect the potential stream quality that can be achieved (Schueler 1994). The most protective category is "sensitive streams" where steps should be taken to preserve pre-development stream quality. "Impacted streams" are above the 10% threshold and can be expected to experience some degradation after development (i.e., less stable channels and some loss of aquatic diversity). The key resource objective for these streams would be to mitigate impacts to the greatest extent possible, using effective stormwater management practices. The last category, "non-supporting streams" recognizes that predevelopment channel stability and biodiversity cannot be fully maintained, even when stormwater practices or retrofits are applied. The biological quality of non-supporting streams is generally considered poor, and is dominated by insects and fish that are tolerant of pollution (Center for Watershed Protection 1998). The primary resource objective for "non-supporting" streams shifts to the protection of water quality downstream by removing urban pollutants. However, efforts to protect or restore biological diversity are not abandoned. In some subwatersheds intensive stream restoration techniques can be employed to attempt to partially restore some aspects of stream quality.

Figure 5-6. Impervious Cover vs. Stream Quality for Sensitive, Impacted and Non-Supporting Streams.



Source*:* Center for Watershed Protection (1998)

Impacts of Urbanization on Watersheds

Using the index provided by Schueler (1994), we attempted to determine the health of our streams by calculating the amount of impervious cover per watershed. Land use classification data was used to estimate the impervious area within each watershed (**Table 5-3**).

Table 5-3. Impervious Area Percentages Used to Calculate Total Impervious Area for Salem-Keizer's Watersheds.

Percent Impervious by Land Use		
Land Use	**Percentages in Salem SWMP**[1]	**Revised Percentages (%)**[2]
Single Family Residential	50	50
Medium Density Residential	60	
High Density Residential	75	
Multi-Family Residential	- -	67 [3]
Commercial	90	90
Industrial	90	90
Agricultural	Existing Imp. Area Used	2 [4]
Public (parks, schools, gov. offices)	Evaluated Individually	25[4]
Residential Ag/Urban Transitional	25-50	8 [5]
Parking Lots	- -	100[6]

[1] These impervious area percentages were used to calculate total impervious area in Pringle, Glenn-Gibson watersheds, and the portion of the Mill Creek watershed within the Salem UGB only.

[2] These revised impervious area percentages were used to determine total impervious area for the Claggett Creek and Mill Creek watersheds. Revised percentages were used due to time limitations and mapping constraints.

[3] This percentage is the average of the Med-Density and High-Density percentages.

[4] These estimated percentages were used by reviewing existing percent impervious areas for catchment basins as presented in the Model Development and Methods section for the SWMP (City of Salem 2000).

[5] Figure for Residential Agriculture was taken from the Marion County Public Works zoning data and is based on a 5000 square foot area and a minimum lot size of 1.5 acres as suggested by Lisa Milliman, an Associate Planner with Marion County. Urban Transitional was also given the same estimate of percent impervious.

[6] We estimated parking lot coverage to be 100% impervious.

The impervious cover percentage for an entire watershed is calculated by multiplying the percent impervious for a land use category with the total acreage of that land use in the watershed. The total impervious area for each land use in the watershed is then added up and divided by the total area of the watershed, as displayed in this equation: Watershed Impervious Cover (%) = Total Impervious Area / Total Area.

The Salem Futures criterion on impervious surface shows 55% of the already-developed acres in Salem as being impervious surface. 42% of the land inside the urban growth boundary is covered by impervious surface today (Parsons Brinckerhoff 2001). Impervious coverage was determined by the City of Salem for Pringle and Glenn-Gibson watersheds.

Since land use inventory data was not available for the Mill Creek watershed outside Salem's urban growth boundary, zoning data was used. According to Marion County staff, the county zoning data closely resembles actual land use (Milliman pers. comm.). Zoning information was used in the same manner as land use data to determine impervious cover.

Both existing impervious cover and future impervious cover, assuming maximum build-out, were calculated for some watersheds (**Table 5-4**). Maximum build-out calculations are estimates of the percent of impervious cover that would result if all land was developed as planned. This estimate was calculated by assuming that all land currently vacant (i.e., vacant residential, vacant industrial, vacant commercial) was developed. Vacant residential land was categorized into single family residential even though the type of residential development on any single piece of property is unknown at this time.

Table 5-4. Percent Impervious Surfaces by Watershed

	Total		Within Salem UGB Only	
Watershed	**Existing**	**Future**	**Existing**	**Future**
Pringle Creek	22.3%	51.6%	23.8%	51.7%
Glenn-Gibson	7.8%	25.5%	15.1%	43.7%
Claggett Creek	Not available	35.9%	Not available	Not available
Mill Creek	Not available	8.2%	26.6 %	49.2%[1]

[1] Includes portion of Battle Creek Basin within UGB.
Source: Adapted from City of Salem Public Works Department (2000).

Diagnosis of Stream Health for Each Watershed

The Pringle Creek basin contains a variety of land uses ranging from the central business district of Salem to single family residential and agriculture (**Map 5-3**). Most of the basin is developed. The southern portion of the basin contains currently undeveloped areas, which are zoned for industrial, commercial, and residential uses (City of Salem Public Works Department 2000). Bush's Pasture Park, a 100-acre community park adjacent to Willamette University, is the largest area of parkland/open space in downtown Salem (Schott and Lorenz 1999). With 22% existing impervious cover within the watershed, Pringle Creek ranks as an "impacted stream" according to the index proposed by Schueler (1994). Future development will easily push this stream into the "non-supporting" category.

Land use in the Glenn-Gibson basin is primarily single-family residential, vacant residential and general farm development (**Map 5-5**). The Glenn-Gibson basin is experiencing rapid growth in the upper-western reaches inside the urban growth boundary (City of Salem Public Works Department 2000). Rapid growth in Polk County, the rural portion of the watershed outside of the UGB, is also projected to occur within the next forty years (U.S. Bureau of Reclamation 1996). Existing impervious cover for the watershed is only 7%, which rates the creeks as "sensitive streams". The percent of impervious cover in the Glenn-Gibson watershed that lies within the Salem UGB is 15%. If land is developed as proposed by the City of Salem's land use inventory, the amount of impervious cover within the UGB will increase by almost three-fold. With maximum build-out, Glenn-Gibson watershed will reach 25.5% of impervious cover, thus changing the rating of the stream from "sensitive" to "non-supporting."

The Claggett Creek basin is highly developed. Land use includes single and multi-family residential, industrial, commercial and agricultural areas (City of Salem Public Works Department 2000) (**Map 5-8**). Undeveloped areas in the northeastern portion of the watershed are primarily in agricultural production growing a variety of crops including vegetables, grass seed, nursery stock, fruit and nut orchards (Schott and Lorenz 1999). No calculation was determined for existing impervious cover for the Claggett Creek watershed. However, the City of Salem did calculate percent impervious cover for the Upper Claggett Creek basin. This basin is found in the eastern portion of the watershed and contains a high proportion of commercial and industrial land uses. The western boundary of this basin is defined by the Salem Parkway and Portland Road (see City of Salem Stormwater Master Plan). The basin makes up approximately 33% of the entire watershed. Existing impervious coverage is estimated at 41.63% for the Upper Claggett Creek basin. Future impervious cover for this basin is calculated at 64.71%. Our estimate of future impervious cover for the entire watershed, assuming maximum build-out, is 35.9%. The existing impervious cover of the upper basin and the estimated future impervious cover of the whole watershed imply that Claggett Creek is a "non-supporting" stream.

Within the Salem urban growth boundary, the Mill Creek basin includes residential, commercial and industrial land uses (**Map 5-14**). Land use within the basin upstream of Salem is primarily agricultural (**Map 5-15**). Growth in the Mill Creek basin is occurring rapidly, particularly in the towns of Stayton, Aumsville, Sublimity, and Turner (City of Salem Public Works Department 2000). The city of Salem's Stormwater Master Plan indicates that stormwater flows from the above listed towns, including the Battle Creek basin, and empty into Mill Creek. Aumsville also seasonally discharges treated wastewater into Mill Creek waters (City of Salem Public Works Department 2000). A few large parcels of vacant land in the watershed are targeted for development. One area currently being considered for sale and development is land owned by the State of Oregon Department of Corrections. It is currently designated as public land on the City of Salem's land use inventory and is located in the southeast part of Salem. This land may eventually be converted into an industrial park.

According to our calculations, the portion of the Mill Creek watershed, including the Battle Creek basin, which lies within the Salem UGB will have a future impervious cover of 49.2%. Because most of the watershed is dominated by agricultural uses, maximum build-out will result in a total of just 8.2% impervious cover in the watershed. While the lower portion of Mill Creek will be impacted by urbanization, Mill Creek will still rank as a "sensitive stream".

In summary, streams can be classified into one of three categories based on the relationship between amount of impervious surface in a watershed and stream health. The categories are: sensitive, impacted, and non-supporting. Often, the most sensitive fish and aquatic insects disappear from impacted streams. Once watershed impervious cover exceeds 25%, waterways are typically categorized as non-supporting streams. Calculations for existing and future impervious cover indicate that Pringle, Glenn-Gibson, and Claggett Creeks are already or may in the future become non-supporting streams. Because land use is dominated by agriculture in the Mill Creek watershed, Mill Creek is and will remain a "sensitive stream" if current land use designations remain unchanged.

Effects of Water Use on Hydrology

The use of water for drinking, irrigation, industry, commercial and other activities competes with the needs of salmonids and the aquatic community. Each of the four watersheds diverts both surface and ground water for human uses. How much impact these water diversions are having on the aquatic community is not known. This section of the Hydrology Chapter will attempt to identify water users in the four watersheds. As will become evident later in this chapter, much work needs to be done to answer our questions on the affects of water use on salmonids in our local streams.

The majority of salmonid activity occurs during the fall, winter and spring when urban channels typically carry a large volume of stormwater (Galovich pers. comm.). During the summer months, most streams have reduced flow and higher temperatures. Higher stream temperatures in the summer months can restrict many species of fish to isolated stream reaches. How much of the flow and temperature change is "natural" (i.e. due to small, low elevation stream basins) and how much is due to human landscape alterations can be difficult to assess. However, historical data indicate more area springs and wetlands, as well as more gallery forest cover along streams. This, combined with less impervious surface, would have resulted in higher summer flows and lower summer temperatures.

Currently, Claggett Creek is believed to be warm throughout its entire reach during summer months. The same applies to the lower reaches of Glenn/Gibson and Pringle Creeks. The upper reaches of these latter two streams typically have enough flow to at least sustain fish (particularly cutthroat) throughout the summer months. The difference between Claggett Creek and the other two creeks' ability to maintain sufficient flow for fish may be due to the presence of groundwater resources such as springs in the upper reaches of the latter two creeks (Galovich pers. comm.). In some places, tributaries and upper reaches are placed into pipes, as Clark Creek is from South Salem High School until it joins Pringle Creek in Bush's Pasture Park. The result was a 10-degree reduction in temperature from point of entry to the point of discharge (Andrus 2000).

Flows through Mill Creek basin are incredibly complex and involve several upstream diversions for irrigation and industry (City of Salem Public Works Department 2000). Currently, the Santiam Water Control District actively monitors the water levels and flows in the Salem Ditch, which diverts water from the North Santiam River into Mill Creek. The district diverts up to 180 cubic feet per second (cfs) and utilizes about 90 miles of canals to service 17,000 acres of farmland west of Stayton (MWVCOG 2000). The Santiam Water Control District estimates that 130-150 cfs are added to natural flows in Mill Creek from June through September. The Perrin Lateral Canal and Mill Creek carry diverted water through the city of Turner and into Salem. The City of Salem manages the water level and flows for the Mill Race and Shelton Ditch within the confines of their water rights.

Water Rights and Water Use

Under Oregon Law the beneficial uses of water include: Agricultural and Land Management, Industrial/Commercial Uses, Drinking Water Supply, Community Water Supply and Environmental benefits (**Table 5-5**).

Table 5-5. Beneficial Uses of Water Under Oregon Law

Agricultural and Land Management	Industrial/ Commercial Uses	Drinking Water Supply	Community Water Supply	Environmental Benefits
Gen. Agricultural uses Irrigation Cranberry use Nursery operations Stockwater Temperature control Forest and range management	Industrial Commercial Fire protection Mining Power development	Human consumption Domestic use Domestic use expanded (for watering up to ½ an acre of lawn or noncommercial garden)	Municipal Quasi-municipal Group domestic Storm water management.	Aquatic life Pollution abatement Recreation Wetland enhancement Wildlife

Source: Oregon Water Resources Department (1997).

The Oregon Water Resources Department (OWRD) is the state agency charged with the administration of laws governing surface and groundwater resources. All water in Oregon belongs to the public, thus before any surface or groundwater can be used, a water right must be obtained. Cities, farmers, factory owners and other water users must obtain a permit or water right from the Water Resources Department to use water from any source (OWRD 1997). Since 1909, the Appropriation Doctrine has been in effect, which essentially means that the first person to obtain a water right on a stream is the last to be shut off in times of low streamflows. This person is called the "senior user," and the "junior users" are described as having been issued a more recent-priority water right. Information on how water rights are determined and the application process is available at the Oregon Water Resource Department.

If the "water rights" come into conflict (i.e., the rights have the same day of priority) then Oregon law states that domestic use and livestock watering have preference over all other uses. If a drought is declared by the Governor, OWRD can give preference to stock watering and household consumption purposes, regardless of the priority dates of the other users (OWRD 1997). Oregon water laws include some exempt uses of both surface and groundwater (**Table 5-6**). An exempt use does not need a water right. The water user can use as much water as desired, unless local ordinances provide further restrictions.

Table 5-6. Exempt Uses of Water Under Oregon Law

Surface water exempt uses	Groundwater exempt uses
Natural springs (collection and use) Stock watering directly from source Salmon (raising salmon, fishways, etc) Fire control Forest management Land management practices (where water use is not the primary intended activity) Rainwater (collection and use)	Stock watering Lawn or non-commercial garden watering Single or group domestic purposes Single industrial or commercial purposes Down-hole heat exchange uses Watering (the grounds, ten acres or less, of schools located within a critical groundwater area)

Source: Oregon Water Resources Department (1997)

The proper management of water use requires the combined effort of state, county and municipal officials and private landowners. For example, ODFW's role is to manage the protection of fish and wildlife (i.e., construction of effective fish ladders and fish screens), while the Oregon Water Resource Department's duty is to enforce water rights within the watershed. The permit holders (i.e., local water control districts, municipalities, private landowners) are responsible for operating within the limits of their water rights. They manage the day-to-day use of their water without close oversight by OWRD.

As more people move to the Willamette Basin, the major water uses (agriculture, industry, and municipalities), are likely to take even more water (Willamette Restoration Initiative 1999). A majority of the basin's water supply is allocated for out-of-stream uses (e.g., irrigation and drinking water) and subsequently competes with in-stream uses, such as fish protection, pollution abatement, and recreational opportunities. Competition between the existing water uses will continue to intensify as the seasonal water demands exceed the water supply.

To understand how water resources are used in our watersheds, one needs to look at both the distribution of water users and the type of water use. The terms Point of Diversion (POD) and Place of Use (POU) are explained below as they relate to the following discussion and interpretation of **Tables 5-7 and 5-8** and **Maps 5-16** through **5-19**:

Point of Diversion (POD): Each point on the map represents a surface or ground location where water is diverted (i.e., pump station, well, reservoir) for use by the water right holder under the terms of their water right. More than one point may appear at a given location on the map for each water right served by that particular POD. In other words, the same point of diversion may serve two different water uses, such as irrigation and livestock watering.

Place of Use (POU): Places of Use are areas, usually fields, where water is applied under the terms of the water right. They are represented by polygons on the map. The polygons can overlap one another, as in the case of one water right being supplemental to another for the same piece of land.

One Place of Use (POU) can be served by several Points of Diversion (POD). For example, a farmer may divert water from both a creek and a groundwater well to irrigate the same field. Rates of diversion are measured in either cubic feet per second (cfs) or in acre-feet (af). Cubic feet per second is a measurement of an instantaneous rate. Acre-feet is a measurement of volume that is used for PODs that are reservoirs.

Summary of Permitted Water Use by Watershed

Determining if water rights are over-allocated based on streamflow can be accomplished through hydrologic modeling. No such modeling has been done to determine if water rights are over-allocated in any of the four watersheds. For small watersheds such as these four, an accurate model is costly and requires a significant amount of time to process the data. OWRD's current policy is not to issue any new water rights in the summer months for these watersheds. It does issue new water rights for other times of the year.

Water rights information was obtained from the OWRD web page, using the Water Rights Information System (WRIS) (OWRD 1997). Unfortunately, the water rights database has not been thoroughly updated. All current users are in the database, but so are all historic users, who may or may not be using their water rights. Water rights no longer being used have not been purged from the system. For this reason, an accurate measurement of water currently being diverted from a watershed is unknown.

To get a general idea on how water is allocated in the four watersheds, we summarized all the water rights records in the WRIS database (**Table 5-7**). The information provided in **Table 5-7** and **Map 5-16** through **Map 5-20** represents all historic and current records of permitted water rights in the four watersheds. Many of the water rights may not be in use today.

Table 5-7. Number of Current (2001) and Historic Water Allocations by Water Use Type

	Pringle Creek Watershed		Glenn Gibson Watershed		Claggett Creek Watershed		Mill Creek Watershed	
Water Use Type	**#POU[1]**	**%POU[2]**	**#POU**	**%POU**	**#POU**	**%POU**	**#POU**	**%POU**
Agriculture								
Agriculture	?	?	3	2.9	2	0.6	2	0.5
Nursery Use	2	2.4	?	?	6	1.9	2	0.5
Domestic								
Domestic – Inc lawn and garden	5	6.0	3	2.9	2	0.6	7	1.9
Domestic	1	1.2	8	7.8	16	4.9	21	5.8
Stock	2	2.4	3	2.9	?	?	15	4.1
Group Domestic	?	?	2	2.0	1	0.3	?	?
Industrial								
Commercial	?	?	1	1.0	2	0.6	?	?
Manufacturing	10	11.9	--	--	8	2.5	4	1.1
Municipal								
Municipal	4	4.8	?	?	2	0.6	? [2]	?
Quasi-Municipal	?	?	1	1.0	5	1.5	?	?
Irrigation								
Irrigation	41	**48.8**	46	**45.1**	260	**80.2**	219	**60.0**
Irrigation & Domestic	4	4.8	3	2.9	6	1.9	2	0.5
Irrigation and Stock	?	?	1	1.0	?	?	3	0.8
Supplemental	1	1.2	5	4.9	5	1.5	19	5.2
Miscellaneous								
Air Conditioning	1	1.2	--	--	3	0.9	1	0.3
Aesthetic	2	2.4	?	?	?	?	?	?
Fire Protection	?	?	?	?	3	0.9	?	?
Storage	1	1.2	17	16.7	1	0.3	14	3.8
Aquaculture	?	?	?	?	--	--	1	0.3
Recreation								
Recreation	1	1.2	6	5.9	1	0.3	10	2.7
Power								
Power	3	3.6	?	?	1	0.3	3	0.8
Livestock								
Livestock	1	1.2	1	1.0	?	?	28	7.7
Fish								
Fish	5	6.0	1	1.0	?	?	12	3.3
Wildlife								
Wildlife	?	?	1	1.0	?	?	2	0.5
TOTAL	**84**	100	**102**	100	**324**	100	**365**	100

[1] POU refers to Place Of Use.

[2] %POU is a percent of the total number of POUs that fall into a type of water use. It is NOT the percent of the actual amount of water being used for that type of water use.

Source: Oregon Water Resources Department (2001)

Irrigation is an important use of water in the Pringle, Glenn-Gibson, Claggett, and Mill Creek watersheds. Water is made available for irrigation purposes in the Pringle, Glenn- Gibson, and Claggett Creek basins from March 1– October 31, and from May 1 - September 30 for the Mill Creek basin (Ferber pers. comm.).

The following maps show the locations of water diversions and indicate the water use. The maps identify both current and historic points of diversion.

Pringle Creek

Map 5-16 shows the types of water uses at different points of diversion (POD) in the Pringle Creek watershed. A majority of the diversions is groundwater wells. Diversion rates range from 0.0025 - 44.50 cfs. The map indicates that reservoirs are used for agriculture, fish, recreation and miscellaneous uses. Reservoirs store water at volumes between 1.0-44.5 acre-feet.

Glenn-Gibson Creeks

Map 5-17 shows the types of water uses at different points of diversion (POD) for the Glenn-Gibson watershed. Within the urban growth boundary, approximately a half-dozen PODs for irrigation and two for recreation are located on Glenn Creek. Diversion rates range from 0.0030 to 137.00 cfs. Reservoirs are prevalent outside the UGB and are used for livestock, irrigation, fish, recreation and miscellaneous purposes. Inside the UGB, a few reservoirs along Gibson Creek are used for irrigation. Reservoirs used for miscellaneous purposes exist either on or near Glenn Creek. Reservoir storage ranges from 0.10–137.00 acre-feet in the Glenn-Gibson watershed.

Claggett Creek

Map 5-18 shows the types of water uses and points of diversion (POD) for the Claggett Creek watershed. Within the UGB, water is diverted for several uses including irrigation, municipal, and industrial uses as well as some recreation, agriculture and power. Diversion rates are low in the watershed and range from 0.0080-5.00 cfs. The OWRD database indicates that there is one reservoir in the Claggett Creek watershed with maximum storage of 1.2 acre-feet. The reservoir in question may actually be located just outside the watershed boundary on a slough of the Willamette River.

Mill Creek

Map 5-19 shows the types of water uses and points of diversion (POD) for the Mill Creek watershed. Outside the UGB, most water diversions are used for irrigation, municipal, domestic and livestock. A few points of diversion for power and miscellaneous are also depicted on the map. **Map 5-20** shows water use within the UGB. Irrigation, industrial and miscellaneous water uses predominate within the UGB.

Diversion rates vary for the Mill Creek watershed and range from 0.0020-230.00 cfs while reservoir storage ranges from 0.100-60.00 acre feet.

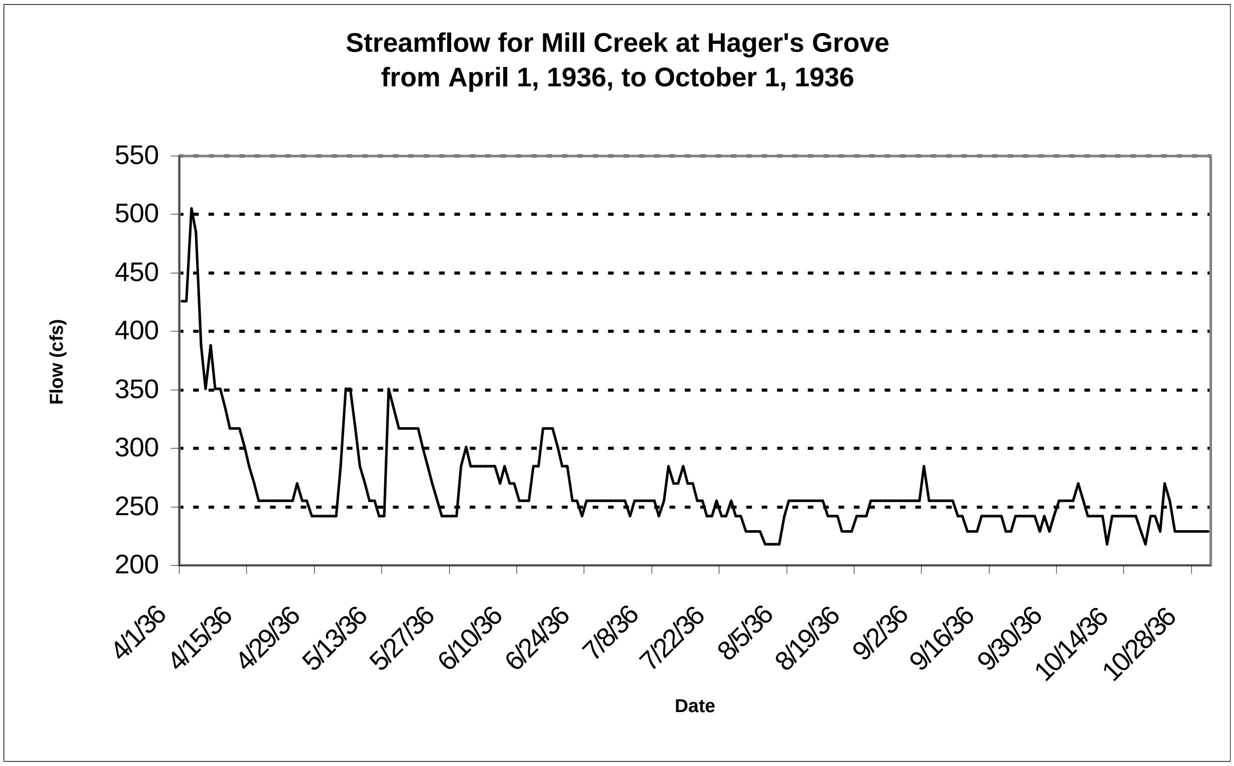
For more detailed information pertaining to discharge rates or reservoir storage within all four watersheds, please refer to the WRIS section of the OWRD website (OWRD 1997).

Streamflow and Water Diversions--Special Concerns

While the Oregon Department of Fish and Wildlife has not quantified any site-specific concerns such as lack of water in spawning reaches, inadequate adult fish passage, or insufficient flows for juvenile migration in Mill Creek (Galovich pers. comm.), watershed residents remain concerned about adequate streamflow and safe passage for fish in Mill Creek. The following section discusses these topics in relation to fish.

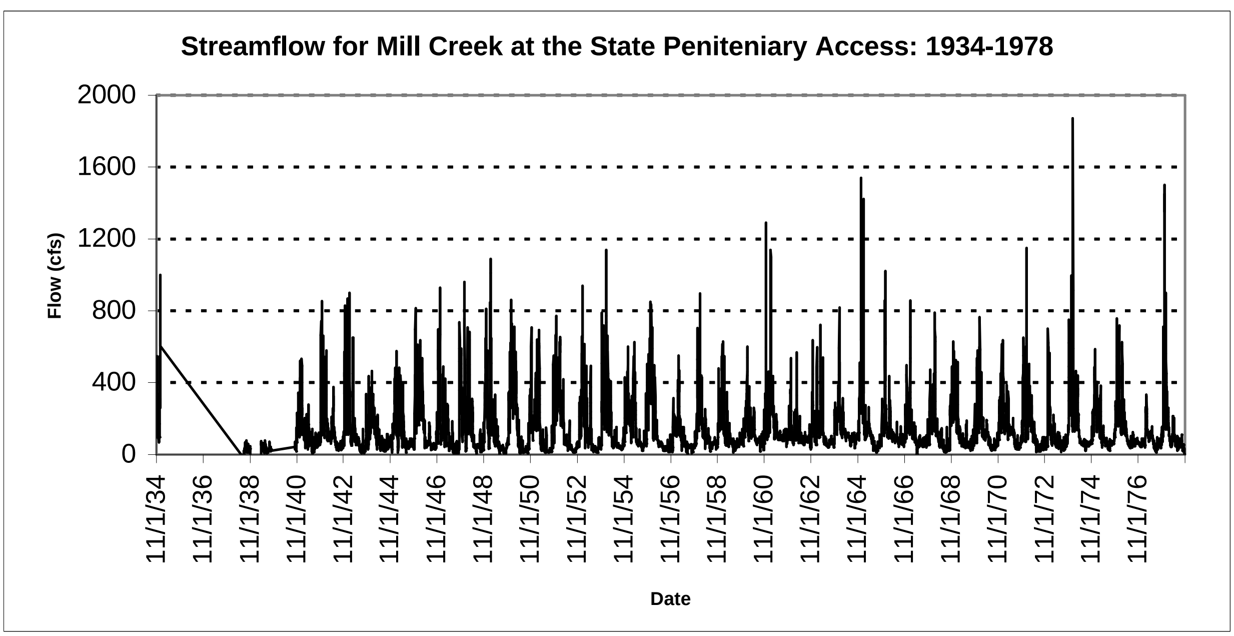
The presence of USGS and OWRD gauging stations within the Mill Creek watershed has allowed us to examine streamflow in Mill Creek. Streamflow records at Hager's Grove, the State Penitentiary and Shelton Ditch were used to examine flow patterns over time in Mill Creek. The flat line sections depicted on the graphs are the result of stage recorder malfunction (Ferber pers. comm.). **Figure 5-7** depicts streamflow at Hager's Grove from April to October in 1936. Streamflow decreases as dry weather begins to dominate in June. **Figure 5-8** illustrates the combined effect of both human and natural influences on Mill Creek flow patterns through a period of forty years. The tallest peaks are indicative of urban runoff, followed by medium peaks that depict upstream influences, and then smaller peaks that represent typical rain events (Ferber pers. comm.). Flow patterns for the Shelton Ditch from 1938 to 1950 fluctuate with high winter flows followed by low summer flows (**Figure 5-9**).

Figure 5-7.



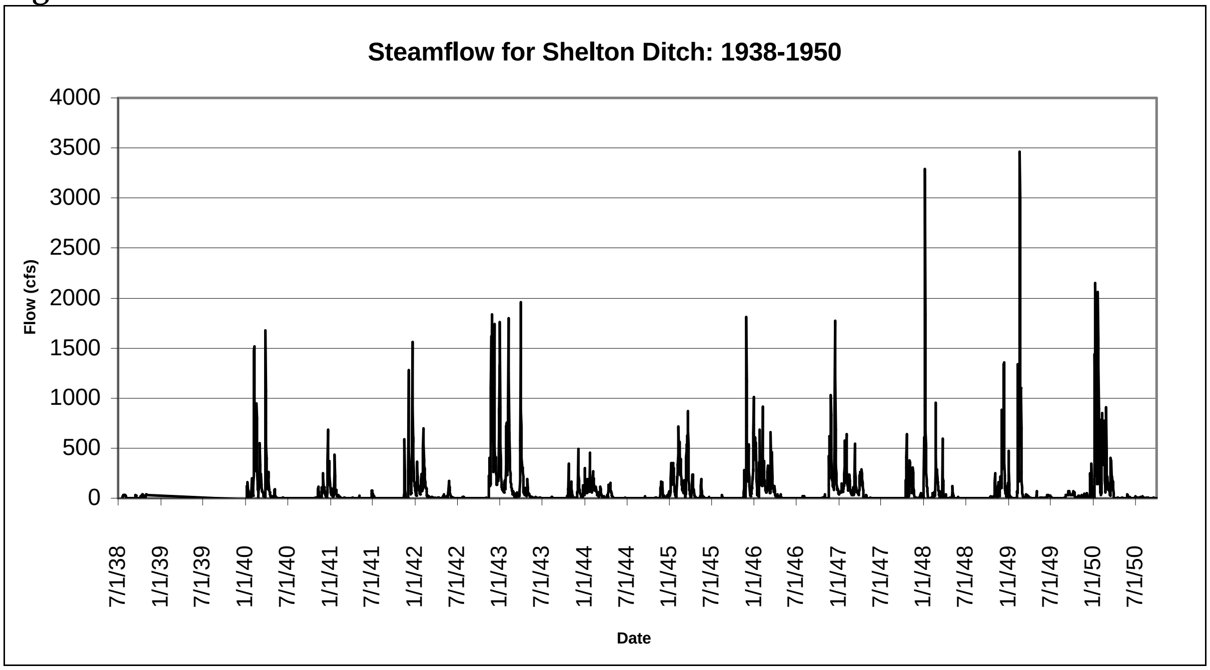
Source: ODWR (2001)

Figure 5-8



Source: ODWR (2001)

Figure 5-9.



Source: ODWR (2001)

Water diversions remove water from streams and lakes for drinking water, growing food, producing power, and many other purposes. Unprotected diversions also move fish, along with the water, out of streams and lakes. Fish that end up in unprotected diversions, such as pump irrigation systems and power turbines, frequently die (OWRD 1997).

The following areas outside of Salem's UGB are "points of interest" for safe fish passage and adequate streamflow for fish in the Mill Creek Watershed (Trosi pers. comm.; Hunt pers. comm.). These "points of interest" may require further discussion among stakeholders in the watershed (**Map 5-21**):

Points of Interest:

1. The Salem Ditch located west of Stayton
2. Irrigation dams at Kuebler Road
3. The many irrigation ditches located throughout the area approximately south of Turner and west of Stayton
4. The Power Canal and associated turbines in Stayton

The flow and channel characteristics of Mill Creek have been substantially modified by efforts to drain farmland, distribute water for agricultural and industrial uses, reduce flood damages, and provide for stormwater drainage. The long-standing diversion of water from the North Santiam River into Mill Creek has significantly changed the natural hydrology of the creek (MWVCOG 2000). Without this diversion there would be much lower summer flows in Mill Creek, making the flow more typical of similar watersheds not sustained by snow melt. Water diverted from the North Santiam River is distributed throughout the Mill Creek watershed using a combination of canals and ditches, including the Salem Ditch in Stayton and the Perrin Lateral Canal in Turner. It enters Mill Creek at Golf Club Road via the Salem Ditch. This diversion provides for the City of Salem's water rights, a portion of which dates back as far as 1856 (Trosi pers. comm.).

The diversion provides a total water right of 102 cfs to the City of Salem during summer months and is used to run Mission Mills' historict water-driven power turbine, as well as for recreation and aesthetic purposes such as the Civic Center Mirror Pond (Schweickert pers. comm.). A gauge station and meter located at the Salem Ditch allows the SWCD to regularly monitor streamflow and ensure that water levels are maintained (Trosi pers. comm.). If water cannot be released into the Salem Ditch due to low flows or high usage during the year, then the SWCD supplements water to Mill Creek at two other locations, Porter Creek and McKinney Creek. The main criterion used in deciding how much water is available to flow into the Mill Creek system is based on water rights.

An irrigation dam is located on Mill Creek at Kuebler Road. The SWCD operates the dam during the growing season. The boards used to impound the water are removed for the remainder of the year (Mauldin pers. comm.). More specifically, the SWCD places the boards at the dam during April or May and subsequently removes the boards either at the end of September or early October (Trosi pers. comm.).

The many irrigation ditches located throughout the western portion of the Mill Creek watershed have altered the way water historically flowed through the basin. The area south of Turner is a combination of natural and man-made ditches which may divert adult fish traveling upstream throughout the Mill Creek watershed (Hunt pers. comm.). Because this area serves both water users and migrating fish, further discussion is needed among stakeholders in the watershed to fully assess the impact of water diversions on migrating fish and how to provide alternatives to conflict between irrigation and fish use.

Another water diversion, which may impact fish passage, is the Power Canal. It diverts water from the North Santiam River for irrigation purposes. The canal extends from Stayton into the western portion of the Mill Creek watershed. Luckily, most pump sites located within the Power Canal system do have fish screens (Trosi pers. comm.). The Santiam Water Control District, along with two private entities, also operates four turbines in the Power Canal. The three turbines currently operating contain fish screens. The district plans to screen the entire Power Canal before the fourth turbine is placed into operation. While ODFW does not feel that the existing district screens meet current standards, it will not press to have the screens updated unless the plan to screen the entire canal doesn't work out (Hunt pers. comm.).

The Mill Race is another water diversion that may hinder the safe passage of fish. Located in the City of Salem, it diverts water from Mill Creek to feed the power-generating turbine at Mission Mill. The City of Salem plans to screen the Mill Race by 2003 (Downs pers. comm.).

In summary, adequate streamflows and well-placed fish screens could make the Mill Creek Watershed more fish-friendly. Steps to improve passage and streamflows will require a combined effort from state and local agencies and the watershed's many water users.

Stormwater Management in an Urban Environment

U.S. urban areas were originally designed to maximize land use and density. The task of city planners in the past was to plan, design and implement an infrastructure system to service the urban area. Many roads, highways, sewer lines and stormwater systems were designed to a minimum standard for the urban area. Little attention was given to upland watershed areas or the surrounding suburban and rural areas. Basically no consideration was given to future stormwater flows (Seyfert 1978).

In the 1950s and 1960s, rapid population growth spurred development in suburban areas; however, infrastructure was still designed according to older standards. Planning and zoning objectives lagged behind the times, only concerned with the placement of subdivisions, shopping malls, and commercial and industrial centers. Little thought was given to the impact of development on natural systems (Seyfert 1978).

Until recently, the goal of stormwater management in many municipalities was to get water off a site and into a receiving stream or water body as fast and efficiently as possible. This philosophy of stormwater management expedited water removal, but also increased stormwater quantities and velocities.

.Stormwater quantity and quality may be the most important factors affecting fish habitat in urban areas. The change of water flow dynamics in many urban streams has led to accelerated rates of bank erosion and channel scouring, and extreme low flows during summer months. High flow events scour the channel and flush out spawning gravels and redds. Low flows during the summer may force salmonids into isolated pools, stranding them from the rest of the creek (Portland Multnomah Progress Board 2000).

Salem's Stormwater Infrastructure

Most cities are drained by an elaborate network of storm drains and open channels that carry urban runoff from streets, parking lots, and roofs to the nearest stream or water body. Salem provides stormwater drainage service to approximately 137,000 people within the city limits. The city's overall service area encompasses 150,000 to 160,000 people within the greater Salem Metropolitan area, as represented by the City of Salem's UGB (City of Salem Public Works Department 2000). Salem's stormwater collection system consists of the following structures. Information in **bold** is current as of July 26, 2001, and is estimated for structures/stream miles within Salem's UGB (Downs pers. comm.; Pennington pers. comm.):

561 miles of storm drains ("closed system" or piped system)
12,842 catch basins
95 miles of drainage and roadside ditches ("open system")
66 miles of stream ("open system")
50 bridges longer than 20 feet (inside city limits only)
128 stream crossings (inside city limits only)
2,100 grates/trash racks (inside city limits only)

Information regarding the conveyance system by watershed is shown in **Table 5-8**. The Mill Creek watershed, including Battle Creek, has the most open miles of stream within Salem's UGB. Including ditches as part of the open system gives the Pringle Creek watershed the most extensive open system, totaling almost 50 miles of creeks and ditches. The Pringle Creek watershed also has the most extensive closed system (i.e., storm drains and culverts) compared to the other three watersheds.

Table 5-8. Stormwater collection system within the Salem-Keizer urban growth boundary for four watersheds.

	OPEN SYSTEM	--------------- CLOSED SYSTEM ------- --------------------			
Watershed	Stream Length (miles)	Open Ditches (miles)	Storm Drains (miles)	No. of Culverts	Total Length of Culverts (miles)
Pringle	18.77	31.19	164.16	1007	6.38
Glenn-Gibson	6.52	2.21	40.42	399	2.24
West Bank[1]	0.76	3.39	34.38	133	0.87
Claggett[2]	3.34	10.95	76.37	492	3.33
Mill	19.48	24.28	141.72	714	5.11

[1] West Bank is located in West Salem and drains to the Willamette River via a piped system. The Glenn-Gibson Watershed Council may include and represent residents of the West Bank as part of their council.
[2] Only includes that part of the storm drain system that is in the upper portion of the watershed, south of the Salem Parkway. No information is available for the lower portion of the watershed, including the City of Keizer.
Source: City of Salem Public Works Department (2000)

If you divide the miles of storm drains and culverts by the total number of miles in the stormwater collection system for each watershed, you get an idea of how much the natural drainage of the watershed has been modified. Approximately 85% of the drainage in the upper Claggett Creek watershed is piped. Glenn-Gibson watershed follows closely behind with 84% in a closed system. Mill and Pringle are 77% and 78%, respectively. Of course, the piping does not include channel modifications made to the actual creeks themselves, such as channelization, riprap along stream banks, diking, or the construction of levees. Modifications to the open system are discussed in the Channel Modification Chapter.

City of Salem's Stormwater Master Plan

With increasing concerns about water quality and urban stream health, communities are now demanding multi-use solutions to stormwater management. The City of Salem and its 15 member Stormwater Advisory Committee worked together to develop a stormwater master plan that could effectively balance reductions in flood damages with improvements in stream water quality.

Published in February of 2000, the City of Salem's Stormwater Master Plan addresses issues of stormwater quantity (i.e., conveyance and flood damage reduction) and stormwater quality as it relates to Salem's National Pollutant Discharge Elimination System (NPDES) Municipal Stormwater Permit. During the study, spring Chinook and winter steelhead were listed as threatened species under the Endangered Species Act. The listing has implications on how Salem manages its stormwater, though there had been no federal-rule making as of the date the Master Plan was published. Therefore, the Stormwater Master Plan only initiates the process for examining stream enhancement and fish restoration, with the expectation that amendments will follow as the ESA rules are implemented. The plan was adopted by City Council in September 2000.

The two goals of the Stormwater Master Plan are to develop a Stormwater Management Program Plan (SMPP) and a Drainage System Improvement Plan (DSIP). The SMPP deals with the institutional aspect (policies, standards, and procedures) of a stormwater management program. Aspects of the SMPP include, among many others:

- Developing an erosion control ordinance and technical guide.
- Developing stream buffer ordinances.
- Identification of "significant" wetlands that need protection.
- Expansion of a public involvement and education program on flood management.

Many of these items have been completed or are in the process of completion.

The DSIP, the second goal of the Stormwater Master Plan, includes a comprehensive list of recommended drainage system improvements It is a product of the policies developed in the SMPP, the results of hydrologic-hydraulic modeling, City staff experience and records of past flood events. The DSIP includes a list of improvements for the storm drains, culverts, open channels, streams, detention storage, and conjunctive use water quality facilities. Project prioritization and design will be influenced by Salem's Best Management Practices to meet Clean Water Act requirements, the Endangered Species Act listings and the water quality status (i.e., 303(d) streams) of several of Salem's streams.

The types of drainage system improvement projects in the DSIP range from replacing undersized pipes to making stream habitat improvements. **Table 5-9** lists project types and the number of proposed projects per watershed. There is no analysis of the effects of the proposed stormwater improvements on the local hydrology or stream channel conditions.

Table 5-9. Drainage System Improvements by Watershed[1]

	Pringle	Glenn-Gibson	Upper Claggett[2]	Battle	Mill[3]
Add or Improve Bridges	17	5	3	6	0
Replace Undersized Pipes	12	5	37	0	27
Replace/Remove Undersized Culverts	18	8	18	10	13
Channelization/Bioengineering/Special Stream Habitat Improvements	21	2	10	13	4
Add Regional Detention Facilities	3	6	1	2	0

Source: adapted from City of Salem Public Works Department (2000)
[1] Proposed drainage system improvements are only for the portion of Claggett Creek watershed within Salem-Keizer UGB south of the Salem Parkway.
[2] The study focused on the portion of Mill Creek watershed within the urban growth boundary.

The category entitled "Channelization/Bioengineering/Special Habitat Improvements" is of special interest to watershed councils because stream enhancement is a project priority for watershed councils. The purpose of stream enhancement is to improve water quality and aquatic habitat conditions for salmonids and other species adapted to cold, clean water. Where the priorities of the watershed councils and the DSIP overlap, project coordination between the councils and the City of Salem will help advance the implementation of the project.

The different components are defined in the Stormwater Master Plan as presented below:

"Channelization" refers to capacity-increasing and erosion-preventing types of projects in waterways and ditches. It generally involves widening of channels by gently sloping the (usually) incised banks back away from the waterway to create a more stable, less steep slope; and removing obstructions such as accumulations of trash and debris, non-native brush, diseased or unstable trees, old concrete walls or riprap which impede the free flow of water. Channelization will result in improved "capacity" but can have adverse ecological effects. While channelization is generally done in combination with bioengineering or stream habitat work, it can also be done as a stand-alone project.

"Bioengineering/Habitat" refers to restoration efforts primarily aimed at stabilizing waterway banks through the use of mostly living materials as ground cover, such as closely planted/densely rooted trees or low-growing hardy native species; placing tree trunks, larger rocks or small constructed flow-diverting structures at critical erosion-prone locations and creating velocity dissipaters or meanders in the waterway bed. Temporary stabilizing materials to help prevent erosion or slumping are used until the plants can take hold and include burlap or coconut fiber blankets.

"Special Stream Habitat" refers to more extensive waterway restoration efforts to restore or enhance both the stream channel and the riparian zones. It includes both in-stream restoration of waterway channels (spawning gravels, riffles, backwaters, and woody debris cover areas), and attention to stream shading through selected native tree planting, brush cover and habitat areas.

Stormwater detention facilities are another capital improvement of interest to watershed councils. Stormwater detention facilities can be either ponds, underground tank vaults or oversized pipes specifically designed to capture, store and then slowly release stormwater runoff downstream. In addition to helping prevent flooding and erosion, detention facilities help protect water quality by incorporating features that filter or remove sediments, excess nutrients and toxic chemicals. In some cases ponds (and other open air structures for improving water quality) provide feeding, nesting and hiding places for many species of fish, birds and reptiles (King County Department of Natural Resources 1999).

Drainage System Improvements by Watershed

The locations of potential DSIP projects involving channelization, stream enhancement, bioengineering, and detention facilities are summarized below. The main goal of DSIP projects is to improve drainage. Projects were **not** specifically chosen because of their potential for stream enhancement. Where feasible, stream enhancement is included as a secondary goal of DSIP projects. The project numbers on the following maps refer to specific projects identified in the DSIP. For more detailed information on specific projects, please refer to the Stormwater Master Plan.

Pringle Creek Watershed

Many of the proposed stream enhancement projects are located on the East Fork of Pringle Creek along the railroad right-of-way (**Map 5-22**). More work remains to be completed throughout Fairview Industrial Park on the Middle Fork. Other protections should be undertaken for portions of the West Fork and for the entire West Middle Fork, especially in light of the planned development of the Fairview property.

Other potential projects include several reaches of the West Fork of Pringle Creek as it stretches on the west side of Commercial from the Pringle Creek Nature Preserve to Woodmansee Park and the Carson Natural Area, and then upstream through residential backyards to the creek's headwaters above Cannery Park. East of Commercial, opportunities exist to evaluate the series of dams and weirs in residential subdivisions where some neighbors have already enhanced back gardens along the creek, but others can use help. The reach at Leslie Middle School offers potential for enhancement in conjunction with a potential detention basin. Challenges include poor ballfield drainage, parking lot drainage treatment and previous mitigation projects at the school.

Several reaches of Clark Creek, such as that from Ewald SE to Halifax Square, would benefit from enhancements. Dams and weirs south of Madrona and west of Hillview could be removed. East of Commercial, areas benefiting from projects include reaches from Willow Court through Clark Creek Park, between Winter and Summer Streets, and around Gilmore Field and along the east side ballfields at South Salem High School.

Clark Creek has two existing stormwater detention facilities: Gilmore Field and Clark Creek Park. Potential locations of two additional detention facilities in the Pringle Creek watershed are Leslie Middle School on the West Fork and Webb Lake on the East Fork. Several detention facilities in Salem are proposed in current public parks/school grounds or in locations of future parks. Past practice has been less than successful because the ballfields and playfields have been too wet to use for their primary intended purpose: play. In addition, Clark Creek Park provides park amenities in an already well-developed area where no additional park facilities are possible because no land is available. This is a public policy issue that will be revisited many times and the solution will have to balance multiple uses in limited space.

Glenn-Gibson Watershed

According to the DSIP, the proposed drainage system improvement projects in the Glenn-Gibson watershed provide little opportunity for stream enhancement. Only two projects involving stream conveyance are proposed for the watershed. Both proposed projects lie along Glenn Creek Road just west of the creek's intersection with Orchard Heights Road (**Map 5-23**).

Six regional detention facilities, two along Glenn Creek, and four in the Gibson Creek basin, are proposed in the DSIP. The two on Glenn Creek would be located at Orchard Heights Park and just upstream from Glen Eden Court. Two detention facilities on Gibson Creek would be near Grice Hill Road; the third one would be at Gladow Pond just upstream of Orchard Heights Road, and the fourth at the Holiday Tree Farm. Which ones will be constructed has not yet been decided.

Upper Claggett Creek Watershed

Most of Upper Claggett Creek has been piped, so many of the proposed projects involving streams are in the lower portion of this sub-basin (**Map 5-24**). Ten stream conveyance projects are proposed in the DSIP for the Upper Claggett Creek Basin. The projects are located in four main areas: Claggett Gravel Pits (near Portland Road), Lancaster Drive, Hawthorne Avenue, and along Ibex Street and Ward Drive.

Upper Claggett Creek contains two City-owned regional stormwater detention facilities: Eastgate Basin Park and an area near the intersection of 37th Place and D Street. Oregon Department of Transportation (ODOT) has an additional detention facility in area between NE Fisher and I-5, just south of the Highway 99 interchange. ODOT's detention facility serves the I-5 drainage. An additional regional detention facility is proposed at the proposed Northgate Park site.

Mill Creek Watershed (Including Battle Creek)

The DSIP has identified four potential stream capacity projects in the Mill Creek watershed within Salem's urban growth boundary. Three of the four proposed projects are located between the Salem Airport and the I-5/Highway 22 exit. All four projects involve channelization of roadside ditches in order to increase their capacity for stormwater. None of the projects involve alterations to Mill Creek itself (**Map 5-25**).

Because much of the Mill Creek watershed lies outside of Salem's urban growth boundary, the DSIP did not evaluate Mill Creek using a hydrological model upstream from the UGB. Previous studies have shown that flood damage reduction in the Mill Creek system can't be achieved through conveyance improvements within the city of Salem. The U. S. Army Corps of Engineers (COE) has been studying potential regional solutions for flood reduction in Mill Creek, in order to identify major flood mitigation projects, some of which may be located in the upper reaches of the Mill Creek watershed. While potential regional detention opportunities exist upstream from Turner, the COE's final report concluded that none met their regional minimum cost-benefit ratio.

Battle Creek, a tributary to Mill Creek, has 13 proposed stream conveyance projects, according to the DSIP. Almost all the projects lie along Battle Creek and its tributaries (Waln Creek, Jory Creek, and Powell Creek) between I-5 and Sunnyside Road, including reaches of Battle Creek and Waln Creek that flow through Battle Creek Golf Course (**Map 5-26**).

Two proposed regional detention facilities are located in the Battle Creek basin. Both would be located along Liberty Road, outside of the Urban Growth Boundary (UGB), one facility in the upper reaches of Jory Creek, the other in Battle Creek.

Future Model Enhancement

The hydraulic model used to determine the types and locations of drainage system improvements needed to alleviate flooding in each watershed was adequate for master plan development. However, verification and design of the individual improvement projects will require a more detailed model. A refinement of the hydraulic model is considered an "Early Action Item" in the Stormwater Master Plan. Field data will need to be collected on a variety of factors, including rainfall and runoff amounts and culvert and channel dimensions. Once the data has been collected and incorporated, the model can be used to refine the operation of hydraulic structures, define surcharge levels for culverts and manholes, and perform a more detailed analysis.

Implementation of DSIP

The DSIP outlines specific flood improvement projects. Approximately $203.5 million will be needed for flood improvement projects within Salem's UGB (not including Keizer). Funding for DSIP projects will mainly come from utility ratepayers. The projects will be implemented over time to avoid abrupt rate increases. Some "Early Action Items" (see Stormwater Master Plan) are already in progress. Remaining DSIP projects will be prioritized once funding for stormwater management projects and associated regulatory program requirements (i.e., TMDLs and Endangered Species Act) become clearer.

Another $3 million has been allocated for a system inventory, monitoring program and hydraulic model enhancement. The system inventory and monitoring program are necessary in order to develop more detailed hydraulic models that can be used to design individual flood improvement projects.

The DSIP also has two proposals for Water Quality Facilities (i.e., projects that improve water quality) and Stream Restoration/Habitat Improvement. Projects in these two categories will be prioritized as part of the City of Salem's annual rate funded "Pay As You Go" funding program. Four million dollars has been allocated for implementation of regional water quality facilities. Another $6.1 million has been allocated for stream/habitat improvement projects. No specific projects have been identified for either of these two categories. Requirements of the Stormwater National Pollutant Discharge Elimination System program, Endangered Species Act, and the Total Maximum Daily Load (TMDL) program are still unclear, and will not be fully known until the Willamette River TMDL is established in 2003. Project prioritization will occur once stormwater management funding and regulatory requirements are clarified.

Summary

The data and information in this chapter reveal some of the many effects of land and water use on watershed hydrology in urban and rural conditions. Pringle, Glenn-Gibson, Claggett and Mill Creek are low elevation watersheds that are highly urbanized. The headwaters of Mill Creek differ from the other watersheds by being located in the foothills of the Cascades. All four basins have distinct topographic and hydrologic features that affect historic and existing drainage patterns. The construction of the Mill Race, Shelton Ditch and Salem Ditch show how humans have modified the natural movement of water in both the Pringle and Mill Creek systems.

The Salem area's previous floods and local weather patterns guarantee occurrence of future floods. The construction of dams on the Willamette River has reduced the frequency of flooding and flood levels on the main stem of the river. Many of the Willamette's smaller tributaries are also managed. Stream channelization in the

Salem area allows large volumes of water to move quickly throughout the urban landscape. As a result, urbanization causes downstream hydrographs to demonstrate higher-than-natural flood peaks.

The information in this chapter also illustrates how native fish species are impacted by both peak and low streamflows. Peak winter flows, exacerbated by urbanization, can negatively impact adult spawning activities by washing out gravels and redds. Low summer flows can negatively affect juvenile rearing habitats by isolating fish in small pools and increasing water temperatures. Most water rights in the four watersheds have probably been allocated for irrigation use. But water rights and water use in the OWRD database have not been updated to reflect current conditions. Nor have historical water rights no longer in use been purged from the database. The handful of industrial and municipal users in the four watersheds have been allocated large water rights and are probably using a significant amount of ground and/or surface water in the watersheds. A comparison between allocation and use is needed to determine if water rights are over-allocated in any of the four basins.

The chapter also identifies the variety of land and water uses in the watersheds. The amount of impervious cover in each watershed indicates the extent of urbanization. Previous studies show how stream degradation occurs with as little as 10% imperviousness and may influence peak flows, urban pollutant loads, increased stream temperatures, and the overall health of local aquatic systems. Both Pringle and Claggett Creeks are currently considered "impacted" streams. Fifty-five percent of the developed acres in Salem are impervious surface, and 42% of the land inside the UGB is covered by impervious surface as of 2000. Most of the waterways associated with Pringle, Glenn-Gibson, Claggett and Mill Creeks are affected. Estimates of the amounts of impervious surface in the Glenn-Gibson and Mill Creek basins are currently below 10%, thus ranking the creeks as "sensitive". With continued development in the watersheds, all creeks have the potential of becoming "non-supporting" streams. Non-supporting streams have limited aquatic diversity. The life in these streams is mainly composed of pollution-tolerant insects and fish.

Water diversions, and other structures, may impose a threat to safe fish passage. Important areas in the Mill Creek watershed have been identified and warrant future discussion as to water diversion and fish passage. The City of Salem has completed an inventory of fish passage barriers; see 9-23 through 9-28.

To counteract increased peak flows and decreased summer flows, the City of Salem has incorporated wetland restoration and enhancement of both stream channels and riparian zones into their Stormwater Master Plan (City of Salem Public Works Department 2000). The City of Salem has identified wetlands that provide "significant" functions, such as flood retention, and is establishing additional protection by local ordinances. An erosion control ordinance approved by the Salem City became effective as of September 1, 2001. An ordinance protecting trees within a 50-foot buffer along perennial streams, and protecting trees and native vegetation within 50 feet of fish-bearing streams took effect in June 2000.

Recommendations

All Basins

1. Work with the Oregon Water Resources Department (OWRD) to determine the consumption by basin and learn if water rights are over-allocated based on streamflow. Modeling to estimate this data will require substantial funding.

2. Encourage OWRD to update its database on water rights and water users to reflect current conditions. This will help to determine if water is being over-allocated.

3. A water right must be used at least once every five years; otherwise the right is subject to cancellation. There is no system in place to monitor or regulate the amount of water withdrawn. Work with the OWRD to identify unused water rights and implement administrative proceedings to determine the validity of the water rights and alternative distribution options.

4. In partnership with Oregon Water Trust **(http://www.owt.org/),** OWRD encourages all water right holders to donate, lease or sell all or part of an unused water right back to the stream so that the water can be used for aquatic life and fisheries. The watershed councils should collaborate with these entities to identify potential "water donors."

5. Work with OWRD to determine ownership of weirs, dams or other obstructions within stream channels that may no longer be in use for water allocation purposes. Take action to eliminate these unnecessary obstructions to fish passage.

6. Establish long-term wetland protection, enhancement and mitigation strategies on a regional watershed basis. For example, as much as 1,500 acres at Lake Labish should be considered for multi-use wetland mitigation, floodwater storage, water quality treatment, recreational opportunities and wildlife habitat/refuge.

7. Focus on how to protect the sensitive areas at the edge of the UGB, with the long-term goal of creating an "emerald necklace" around Salem's UGB which connects to sensitive areas and refuges and protects prime farm and forest lands outside the UGB.

8. Reduce, prevent, or mitigate the creation of more impervious surfaces. Future land use efforts should be broadened to include alternative planning strategies

when designing streets and parking lots. To reduce the impact of increased impervious surfaces, parking lot bio-swales or "wet ponds," vegetated buffers and regional stormwater detention basins should be incorporated into development plans. Work with local governments to establish standards aimed at better integration of transportation and drainage systems, as proposed by the Pringle Creek Watershed Council to Salem's Transportation Planning Manager on the City's proposed Sidewalk Construction and Maintenance Plan (SCAMP). Additional efforts may include identifying areas that could be converted into multipurpose (bicycle, pedestrian, wildlife, natural drainage) "greenway" corridors and refuges. Possible future collaboration may include the City of Salem, local municipalities, Oregon Department of Transportation (ODOT), and other state agencies.

9. Work to create conservation easements and other legal methods to protect both private and public sensitive natural areas along all Salem's streams.

10. Build and expand community-wide education programs to enlist broad-based and long-term support for watershed protection, enhancement and restoration.

11. Partner with the City of Salem on Drainage System Improvement Projects (DSIPs) that incorporate wetland restoration and stream enhancement (i.e., reconnecting creeks to their historic floodplains) for use as flood abatement.

12. Partner with the City of Salem on determining the location and design of regional stormwater detention basins. The process should take into account the primary purpose of land and should not negatively impact it. For example, if parkland or school ball fields are used for detention, their recreational purposes should not be degraded.

13. Identify additional project sites beyond those listed in the DSIP for stream enhancement and wetland restoration opportunities.

14. Build and expand community-wide education programs to enlist broad-based and long-term support for watershed protection, enhancement and restoration.

15. Determine and map the locations of springs and seeps in the each of the four watersheds.

16. Identify all diversions that require fish screens.

17. Locate, map and determine the status of water rights and groundwater wells on both public and private property.

18. Determine ownership and responsibility for operation, maintenance and retrofit for culverts identified as undersized or inadequate.

19. Determine the impact of Salem's water/sewer/stormwater projects on Salem's streams.

20. Document time required for major public works projects and large scale private developments to recover from disturbances, and the related impacts on native and invasive species.

21. Serve as a clearinghouse/library to facilitate project implementation, watershed outreach, and policy development by local stakeholders.

22. Produce baseline ecological descriptions of the ecosystems and stream reaches needing protection, enhancement or restoration.

23. Conduct and inventory of exotic plant and animal species currently present in Salem's watersheds.

Pringle, Claggett, and Glenn and Gibson Creeks

1. Continuous monitoring will assist watershed councils, local government agencies, and OWRD in better understanding seasonal low flow problems and the stage/discharge relationship of these creeks. Currently Mill Creek is the only stream in the four watersheds that has a continuous monitoring station to check flow, water depth, and temperature. Continuous monitoring stations need to be installed at key locations in the other three watersheds.

Pringle Creek

1. Incorporate Aquifer Storage and Retrieval testing protocols and stream bank protections at Woodmansee Park.

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Chapter 6– Riparian and Wetland Habitat

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6 – Riparian and Wetland Habitat

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Riparian and Wetland Habitat

Intercouncil Watershed Assessment Committee Questions/ Issues

1) **What is the current condition?**
   - What is the condition of the riparian corridor? Wetlands?
   - What is the extent of riparian vegetation in all creek basins?
   - Does creekside development have an impact on this? Do we need to restore former areas along the creek?
   - Do we have any riparian areas or wetlands? Where are they? Do they have any protection?
   - What is the percentage of canopy?

2) **How have riparian conditions changed over time?**
   - How have riparian zones and wetlands changed over time; specifically due to filling of wetlands and flood plains and removing riparian vegetation?
   - What changes have we seen in life forms in creeks? Species? Causes?

3) **What/where are the opportunities for restoration/ enhancement and how will they be implemented?**
   - What locations have the greatest potential for mitigation?
   - What areas are available for restoration?
   - Where are key existing wetlands in all creek basins?

4) **What is the ownership along streams? And what is the zoning?**
   - Public vs. Private
   - Are homeowners maintaining riparian areas and wetlands on their properties?

5) **What programs address identified problems and protect riparian areas?**

Introduction

This chapter summarizes riparian and wetland conditions and functions for the Pringle, Glenn-Gibson, Claggett, and Mill Creek watersheds. The purpose of the assessment was to evaluate how conditions have changed over time, how a riparian/ wetland area influences the fish, wildlife and water quality in the basin, and to identify opportunities available to restore and/or enhance impacted areas and protect intact wetland and riparian habitat.

Data sources

Aerial photographs obtained from the City of Salem, Marion County and the Marion County Soil and Water Conservation District were used as base maps to estimate shade. The criteria used to assess streamside shading were based on a shade index presented in OWAM (Watershed Professionals Network 1999).

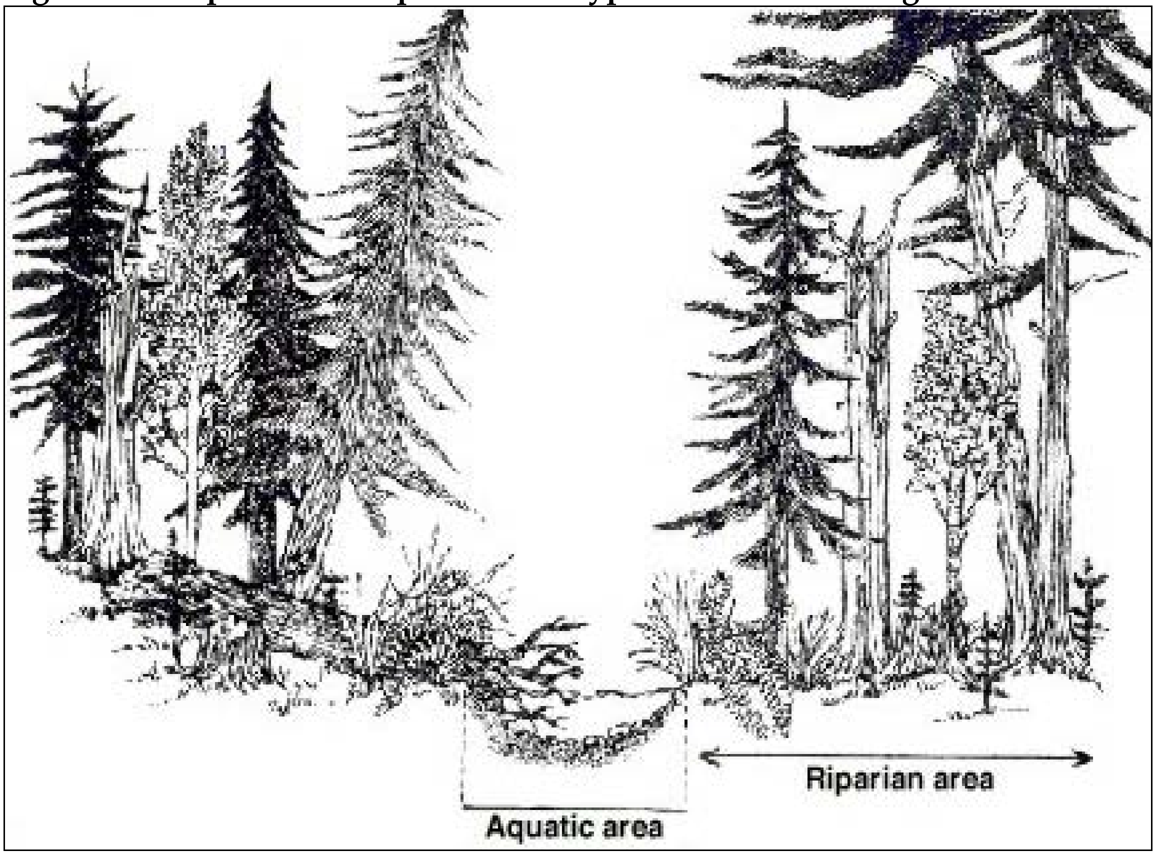
Other riparian measurements, such as riparian width and species composition, were not measured due to time constraints. Because three of the four watersheds studied in the assessment are urban, stand age was not measured. Stand age is typically measured for its potential to generate large woody debris. Flashy urban streams tend to move unattached woody debris downstream.

Riparian inventories conducted in Stayton (Fishman Environmental Services 1998) and Turner (Mid-Willamette Valley Council of Governments 2000) provided detailed information on riparian habitat conditions and functions. Information on Pringle Creek riparian habitat was provided by the City of Salem. Historical information on riparian vegetation was provided by Marion County Public Works (2000) and the Oregon Natural Heritage Program database (2000). Information on wetlands was obtained from National Wetland Inventory maps and from local wetland inventories of Salem-Keizer (Schott and Lorenz 1999), Turner (MWVCOG 2000) and Stayton (Fishman Environmental Services 2000).

What is a Riparian Area?

A riparian area, also referred to as "riparian zone", is a strip of land next to a body of water where vegetation and soils are influenced directly by the water. Its vegetation and microclimate are strongly influenced by annual and intermittent flow, a high water table, and wet (hydric) soils. Riparian zones contribute large wood, smaller organic material, shade, and insects to the stream and riparian area (Godwin 2000). A healthy riparian zone filters and purifies the water passing through it, reduces sediment loads, enhances soil stability, and contributes to ground water recharge and flow. Riparian vegetation differs around Oregon. **Figure 6-1** demonstrates a typical western Oregon riparian area dominated by conifers, deciduous (hardwood) trees, and some shrubs, native grasses (not lawns), sedges, and rushes.

Figure 6-1. Riparian and aquatic zones typical of western Oregon.



Source: Godwin (2000).

In the Willamette Valley today, hardwood trees dominate the riparian canopy. Depending on soil type and moisture availability, riparian areas in Marion County were historically dominated by Oregon ash, black cottonwood and willows in wetter areas, and bigleaf maple, Douglas fir, Ponderosa pine, and white oak in drier areas. Western red cedar, hemlock and grand fir could also be found in smaller quantities. The understory of these riparian areas contained smaller trees and shrubs such as red alder, vine maple, ninebark, hardhack, salmonberry, and native blackberries. A description of ecological communities in Marion County's valley region before Euro-American settlement can be found in the Natural Heritage Park Selection and Acquisition Plan (Marion County Public Works 2000).

The same woody species found historically in riparian areas of the mid-Willamette Valley can still be found today. However, invasive species such as Himalayan blackberry, Scotch broom, and reed canarygrass have become dominant understory species. In urban areas, English ivy, loosestrife, and other non-native plants used for landscaping have invaded riparian areas. These invasives are aggressive "pioneer" species that take advantage of soils recently disturbed by logging, grubbing, scraping, farming or development. They out-compete native species and can transform a diverse plant community into a monoculture, a community consisting of one plant species. Monocultures provide little or no habitat for many terrestrial animal species that live in or frequent riparian areas for food, water and shelter.

Ecological Benefits of Riparian Areas

Riparian areas provide many functions that influence both aquatic and terrestrial systems. Specifically, they act as a buffer zone between upland land uses and water resources, protect and enhance water quality, prevent erosion and moderate flood flows.

Water Quality

Healthy riparian areas produce multiple water quality benefits. Natural riparian vegetation settles out sediment, reduces streamside erosion, and lessens non-point source pollution from parking lots, golf courses, and lawns.

As a watershed urbanizes, impervious surface increases, and local water quality declines. Riparian areas and drainage patterns are changed by building construction, vegetation removal, bridge installation and expansion of local roads. Impervious surfaces increase the rate of stream flow, intensifying erosion and decreasing riparian areas' filtering capacity (ODSL 1998).

Increases in sediment load from poorly vegetated areas decreases local water quality. Higher sediment load also results from increased paving, and from floods. Heavy metals and organic nutrients, such as phosphates and nitrates, bind to soil particles and are carried to streams. Contaminated sediments modify stream chemistry, impact food chains and alter riparian habitat. Algal blooms in waterways may be triggered by excessive nutrient loading. When blooms decay, they consume dissolved oxygen required by other aquatic life (ODSL 1998).

Slope, riparian width and vegetative density contribute to sediment-trapping potential. Densely vegetated riparian areas with minimal slope, which allow sheet flow of runoff, are the most effective in reducing sediment entering waterways. Channelized streams carry sediment rather than allow it to settle out.

Potential riparian erosion varies with soil type, vegetative mix and density, slope and human modification. Erosion is reduced by actively growing plant root systems, complex forest cover and undisturbed soil.

Flood Management

Riparian areas, adjacent wetlands and local floodplains decrease flood volumes and rates of flow. Well-vegetated riparian areas may also store floodwaters, thereby reducing associated flood damage downstream. Forest vegetation is particularly effective in slowing and dissipating floodwaters (ODSL 1998).

The capacity of a riparian area to contain floods increases when depressions or swales are present. Excess floodwaters are slowed in these areas, soak into the ground, and release at a later date (ODSL 1998). The natural capacity of a watershed to manage flood events is reduced when channelization occurs, impervious surfaces increase and wetlands are filled in.

Thermal Regulation

Water temperature variations outside of normal ranges may impact the stream's ability to support native aquatic life. Streamside shade, especially forest cover, is important in maintaining steady temperatures in riparian areas.

Stream temperatures are important for native cold-water species such as salmonids. Summer water temperatures are the most critical for survival. (Please refer to the Fish and Water Quality chapters for more detailed information). High water temperatures disturb stream ecology by increasing plant growth and decreasing the water's capacity to retain oxygen (ODSL 1998).

Stream orientation is an important factor in correlating riparian vegetation to streamside shade. In the Willamette Valley, vegetation on the south edge of an east/west-oriented stream has the best opportunity to provide shade during the critical summer months, since in Oregon the sun is always south of vertical. Riparian vegetation overhanging the north side of an east/west stream provides limited shade. Overhanging vegetation on either bank of the stream creates cooler microclimates which benefit cold-water species such as salmon and their prey (ODSL 1998).

Larger plants and trees provide more shade when mature. Placement on southern slopes enhances shade potential. Grasses and shrubs provide limited shade on small streams (ODSL 1998).

Wildlife Habitat

Both aquatic and terrestrial wildlife species benefit from healthy riparian areas. The best wildlife habitat has a wide variety of plant species, regular water flow and minimal human disturbance. Riparian corridors serve as important migration routes for species traveling between aquatic and upland environments. Corridors facilitate mingling of individuals, thus helping preserve genetic diversity (ODSL 1998). Riparian disruptions, such as lights, bridges and roads, discourage movement, as do artificial lawns along streams. Wildlife may be harmed while crossing human places, or by the pesticides and fertilizers used to maintain lawns.

Many native Oregon species, including amphibians and reptiles, use riparian or wetland areas during their lives. Wildlife is dependent on a range of plants for food sources, cover from predators and habitat for raising young. A complex vertical canopy contains more niches for birds and mammals than a low canopy, and is less likely to be invaded by humans or domesticated animals (ODSL 1998).

Large woody debris (LWD) in riparian zones create additional aquatic and terrestrial habitat for many species of insects, birds, fish, mammals and reptiles. LWD and associated shade create microhabitats in riparian areas. Large woody debris may be deposited from adjacent riparian vegetation, fall into streams as a result of erosion or floods, or be placed during restoration activities (ODSL 1998).

In stream channels LWD modifies flows and enhances complexity. Complex stream channels provide refuges for fish during high water events, hiding areas from predators, and rearing areas (Watershed Professionals Network 1999).

Adequacy of Riparian Vegetation for Shade

Shade provided by riparian vegetation affects stream temperature by reducing the inputs of solar radiation to the water surface (Watershed Professionals Network 1999). A shade index provided by OWAM (Watershed Professionals Network 1999) (**Table 6-1**) and aerial photographs were used to roughly estimate stream shading in local streams**.** Three sources of aerial photographs were used to develop the streamside shading maps. Marion County aerial photos taken in 1998 were used in the riparian shade assessment for rural portions of the Mill Creek watershed. In addition, a series of Marion County aerial photos taken in 1992-1993 were used for areas outside of the Salem-Keizer UGB. Inside the UGB, aerial photos taken from 1994-1999 were analyzed using the OWAM criteria mentioned above. When shade cover was not discernable from aerial photographs, site visits were made for field verification. Stream segments were categorized at a minimum length of 500 feet. Shade levels were assessed along approximately 250 miles of stream located in all four watersheds. Approximately 86 miles of stream remained unclassified for the assessment, primarily due to low-resolution photos or time constraints. Each side of a stream was evaluated separately for shade.

Open water features such as ponds or lakes were classified as having low shade cover even if trees occured along the banks. These water bodies, most of which are shallow in depth, typically act as heat sinks since most of the water is exposed to the sun regardless of the presence of riparian vegetation. Exceptions to open bodies of water that may not act as heat sinks include gravel pits and Clear Lake, both which are deep.

Table 6-1. Indicators of Stream Shading Used in the Riparian Conditions Assessment

Indicator	Shade	Category
Stream surface not visible, slightly visible, or visible in patches	>70%	High
Stream surface visible but banks are not visible	40-70%	Medium
Stream surface visible; banks visible or visible at times	<40%	Low

Source: Watershed Professionals Network (1999)

Watershed Summaries

Table 6-2 shows total miles of open/closed stream miles and the percent of stream miles, within each watershed, categorized as having high, medium or low shade cover. Stream miles that were not categorized due to time constraints or low resolution photographs are also given.

Table 6-2. Percent of Stream Miles Categorized into Low, Medium and High Shade Cover and the Total Number of Open Stream Miles in Each Watershed

	High (%)	Medium (%)	Low (%)	Unclassified (%)	Stream miles classified	Total open stream miles
Pringle	28	16	52	4	27	28
Glenn-Gibson	55	10	25	10	28	31
Claggett	25	13	43	19	21	26
Mill	28	11	16	45	174	316

Note: Please refer to **Map 6-1** through **Map 6-5** for a visual representation of the shade categories.

Pringle Creek

Approximately 27 stream miles were classified in the Pringle Creek watershed. There are 164.16 miles of piped waterways. Only 4% of Pringle Creek was not classified into a shade category (**Table 6-2**). Over 50% of Pringle Creek and its tributaries have low, or less than 40%, shade cover.

Map 6-1 shows that the location of stream reaches with low shade cover are located on the main stem of Pringle Creek, East Fork Pringle Creek and in the upper extent of all tributaries. In the southeastern portion of the watershed, almost the entire length of Tanglewood Brook and a substantial section along the West Middle Fork of Pringle Creek have little shade cover. Other poorly shaded stream areas are found intermittently throughout the watershed. In general, stream sections classified as low shade are located in areas designated for industrial, commercial and residential uses.

An agricultural area just outside Salem's southeastern urban growth boundary also has low shade.

Stream reaches with high shade cover are scattered throughout the Pringle Creek system in downtown Salem and adjacent to Bush's Pasture Park and Deepwood. Sections along the West Fork of Pringle Creek, West Middle Fork of Pringle Creek and the upper reaches of the Middle Fork of Pringle Creek all appear to have some high shade cover. Land uses in these areas are primarily residential and public.

Glenn-Gibson Creeks

Approximately 28 stream miles were classified using the OWAM shade index, with 10% of the waterways reported as unclassified in the Glenn-Gibson system (**Table 6-2**). The 10% not classified includes Turnage Brook. A total of 40.42 miles of stream is piped.

Overall, the Glenn-Gibson streams and tributaries appear to have relatively good shade cover. Approximately 55% of the creeks in the watershed were categorized as having greater than 70% shade. Creeks in the Glenn-Gibson watershed have the highest percentage of creek miles with high shade cover relative to all other local streams studied.

An estimated 25% of Glenn-Gibson stream surfaces and banks have low shade cover. These low shade areas are located near the headwaters of Gibson Creek, the North Gibson Swale, and the upper extent of Farmer's Brook, Eagle Crest, Winslow Creek, Dahlia Swale, and Archer Brook (**Map 6-2**). Low shaded areas were also identified on Glenn Creek at and near the Salemtowne pond and in the southern portion of the watershed near Ptarmigan Street. Small sections of Gibson Creek exhibit medium to low shaded reaches. Single family residential, public, and some industrial areas border these waterways.

Most stream reaches with medium shade cover are within the City of Salem's urban growth boundary (UGB). Areas with high shade cover are found both inside and outside the UGB. Because relatively small stretches of creek classified as having low or medium shade cover are scattered throughout the basin (**Map 6-2**), several relatively small stream enhancements could lead to continuous shade cover for the entire length of a stream.

Claggett Creek

In the Claggett Creek system, about 21 stream miles were classified into the following shade categories: 25% high, 13% medium, and 43% low shade cover (**Table 6-2**). Approximately 19% of the waterways remained unclassified and 76.37 miles of stream are enclosed in pipes. Most of the unclassified waterway is a small tributary to Labish Ditch in the north part of the watershed. A quick review of this area shows that this tributary apparently has low shade cover along most of its length.

Map 6-3 illustrates that the shade indexes vary throughout the Claggett Creek watershed. Claggett Creek has low shade cover in the upper reaches of the watershed where land use is mostly commercial and residential. As the stream flows from east Salem into Keizer, reaches of the stream alternate between high and low shade cover. A large section of creek with low shade cover stretches from approximately Lawless Avenue to Chemawa Loop. Claggett Creek receives more shade as it flows north of Staats Lake and into Clear Lake. While Clear Lake does have trees along its banks, we categorized the lake as having low shade cover because its surface waters are totally exposed. As the stream flows from Clear Lake, it alternates between low and high shade cover. It is interesting to note that the creek in this area has a wide meander channel that is dominated by grasses, though the banks of the channel do contain mature trees. Frequent flooding and an actively moving channel may impede the growth of trees. This part of the stream is visible from a bridge on Windsor Island Road.

Some areas with high shade cover are found in the upper portion of the basin, adjacent to agricultural, single-family residential and public land. From **Map 6-3**, it appears that two areas designated as public land support highly shaded sections of stream. One area is located west of Hyacinth Street near the Salem Parkway and the other is located on the Chemawa Indian School site, south of Hazelgreen Road. The area between Portland Road and Interstate 5 supports a continuous section of stream classified as high shade.

Labish Ditch and its tributaries are predominately classified as having low shade cover. Labish Ditch is used for drainage and the land surrounding the ditch is typically farmed to the top of the bank.

Mill Creek

Approximately 174 stream miles (55% of the waterways) of the Mill Creek watershed were categorized into shade categories. Approximately 45% of Mill Creek and its tributaries remain unclassified (**Table 6-2**). About 28% of Mill Creek and its tributaries were classified as having high shade cover with another 11% as having medium and 16% as having low shade cover. There are 141.72 miles of stream enclosed in pipes.

Many of the smaller Mill Creek tributaries were not mapped due to time constraints, which contributed to the 45% of unclassified waterways. Most of these tributaries lie within the southern portion of the watershed where they have been ditched and are now primarily used for irrigation and drainage (**Map 6-4**). A cursory review of the area shows that most of the creek miles have low shade cover.

Overall, the main stem of Mill Creek has high shade cover along its entire length (**Map 6-4** and **Map 6-5**). Exceptions to this include a stretch of the creek north of Stayton along Highway 22, the reach between Mill Creek's confluence with Beaver Creek west of the City of Turner, and another reach that stretches from the Salem UGB to approximately Kuebler Road. The large stretch of creek with low and medium shade cover near Kuebler Blvd. is state-owned property. Another smaller stretch of Mill

Creek with low shade cover can be seen near the Oregon State Penitentiary along State Street in Salem.

With the exception of its headwaters, the majority of Beaver Creek appears to offer little shade cover (**Map 6-4**). This creek has been channelized and is used for drainage.

Many reaches of Battle Creek and its associated tributaries have high shade cover. Areas of low shade cover include the confluence of Battle, Waln and other tributaries just west of Commercial Street (**Map 6-5**), the lower reach of Waln Creek (**Map 6-5**), and the lower reach of Battle Creek before it flows into Mill Creek at the City of Turner (**Map 6-4**).

Other Riparian Studies

Pringle Creek

In the spring of 2000, a local riparian area survey assessed riparian functions (water quality, flood management, thermal regulation, wildlife habitat) along a 550-foot long reach of Pringle Creek between Mission and Winter Streets (City of Salem 2000). The survey was conducted by City of Salem staff and a member of the Pringle Creek Watershed Council. The survey stated:

> ….this reach is 18 to 24 feet wide with a stream bank oversteepened at a 1:1 slope and steeper, exceeds 25% impervious surface, exceeds 75% development and human disturbance, has numerous stormwater outfalls and substantial evidence of mass wasting along the bank, is constricted by man-made features such as bank armoring with riprap and concrete slabs, has less than 10% of its water resource edge bordered by a vegetated riparian area at least 30 feet wide and less than 25% of that edge has woody vegetation overhanging the water edge. Wildlife habitat and plant health are poor. Water quality, flood management, and thermal regulation (functions) are medium (City of Salem 2000).

The survey also noted invasive species and the overall health of native trees and shrubs. English ivy and Himalayan blackberries were running "rampant" on the site, with ivy overtaking the native trees and blackberries out-competing the native shrubs (City of Salem 2000).

There were a substantial number of dead and dying trees along the stretch of Pringle Creek between Mission and Winter Streets. Soil conditions may be responsible for the poor health of the native trees and shrubs. A good portion of the stream banks consisted of concrete/rock/rubble. The soil was characterized as having low fertility, a lack of tilth and very little organic matter (City of Salem 2000).

Although a riparian characterization and functional assessment has not been completed for other creeks in the Salem-Keizer UGB, the description of this reach of Pringle Creek is probably typical of many urban streams in the Salem-Keizer area.

Mill Creek

City of Turner

In spring 2000, the *Local Wetlands and Riparian Area Inventory* was completed for the City of Turner (MWVCOG 2000). The study area covered about 14.8 miles of riparian area located within the City of Turner's urban growth boundary. The project area included the Perrin Lateral Canal and Mill Creek.

The report found that most of the riparian area in Turner has been disturbed by building, landscaping, farming, or roadways. In undisturbed areas, typical riparian vegetation was forest over a shrub layer with sparse groundcover. Riparian forest canopies were dominated by Oregon ash, red alder, Pacific willow, black cottonwood, and Oregon white oak. Shrubs included Pacific ninebark, cascara, red-osier dogwood, snowberry, clustered rose and Nootka rose. Himalayan blackberry was common on disturbed sites.

Riparian area functions (water quality, flood management, thermal regulation and wildlife habitat) were evaluated and summarized in the report. Overall, water quality and flood management functions were reported as functioning at medium to high levels. Depending on the reach of stream, thermal regulation and wildlife habitat varied from high to low.

City of Stayton

In 1998, the *City of Stayton Local Wetlands and Riparian Inventory* was conducted for the City of Stayton (Fishman Environmental Services 1998). Four streams/ditches were included in the riparian corridor study: North Santiam River, Mill Creek, Salem Ditch, and the Stayton Water Ditch. Both ditches were created in the 1800s for industrial purposes. Riparian habitat has developed along both ditches over the last century and the canals have become more "naturalized."

Within the Stayton UGB, only Mill Creek and the Salem Ditch are located within the Mill Creek watershed. Mill Creek was divided into three reaches, each reach assessed separately for four functions (water quality, flood management, thermal regulation and wildlife habitat). Salem Ditch was divided into four reaches. The characterizations of these reaches follows. The codes refer to specific stretches of the ditches.

Upper Mill Creek: Stream banks are vertical mud banks about 10 feet deep. This part of the creek was most likely ditched historically for agricultural purposes. The stream is about 75% shaded east of 1st Ave. and approximately 25% shaded west of 1st Ave.

Canopy is dominated by Pacific ninebark, willow and Oregon ash. This stretch of the creek rated high for water quality and medium for flood management, thermal regulation, and wildlife habitat.

Middle Mill Creek: This stretch of the creek is well shaded. The riparian corridor is broad to the northeast, grading into a Douglas fir/big leaf maple upland forest. Reed canarygrass dominates the understory. Large woody debris is common. The stream bottom has rock to cobble substrate. This reach of Mill Creek rated high for the functions of water quality, thermal regulation, and wildlife habitat. It ranked medium for flood management.

Lower Mill Creek: This reach of Mill Creek has been channelized through the golf course. The understory has been mowed, often to the top of bank, and tree cover is limited. This reach rated medium for water quality, flood management, and thermal regulation. It ranked low for functioning wildlife habitat.

Salem Water Ditch (RSD-1): From the west end of Wilderness Park to 4th Avenue, this reach supports a well-developed riparian community. Big leaf maple, red alder and Douglas fir dominate the canopy and provide approximately 95% cover to the stream. Dominant understory species include red elderberry, snowberry, Himalayan blackberry, and sword fern. The riparian corridor is typically flat and more than 75 feet wide. Riparian functions ranked high for water quality, thermal regulation, and wildlife habitat. Flood management ranked medium.

Salem Water Ditch (RSD-2): The most urban reach of the Salem Water Ditch is located between 1st and 4th Avenue. Canopy vegetation is generally lacking and the channel is more often shaded by buildings located adjacent to the top of the banks. Vegetation is often mowed and disturbed and impervious surfaces dominate the riparian corridor. The channel is concrete lined. All riparian functions ranked low in this reach of the Salem Ditch.

Salem Water Ditch (RSD-3): Between 1st Avenue and Wilco Road, the riparian corridor is forested with a narrow band of trees and is approximately 60 feet wide. Vegetation is dominated by big leaf maple, red alder and Douglas Fir; Oregon white oak and cherry are also present. The understory includes Himalayan blackberry, snowberry, Oregon grape, English ivy, sword fern, soft rush, reed canarygrass and other grasses. Riparian functions ranked high for water quality, thermal regulation, wildlife habitat and fish habitat. Flood management ranked low.

Salem Water Ditch (RSD-3): From Wilco Road to the northwest corner of the UGB, trees are scattered and limited to a narrow band where present. This reach ranked low in flood management, thermal regulation and wildlife habitat functions. Water quality functions ranked medium.

Canopy Cover Study

The City of Salem participated in a regional study that analyzed the forest canopy from Eugene, Oregon to Longview, Washington. Classified as a "Regional Ecosystem Analysis," Salem received regional, as well as localized, data documenting tree canopy changes over the past three decades, and air quality and stormwater benefits associated with the City's existing forest canopy cover. This information was generated from satellite images, remote sensing techniques, Geographical Information Systems (GIS) technology, and field surveys. The City expanded the ecosystem analysis to show canopy cover changes along each riparian corridor in Salem within the city's 12 watersheds. The tree canopy analysis is now available to the public.

The City of Salem's Parks Operations Division has produced "Sensitive Area Management Handbook," to be used by Parks staff to help them limit impacts of park use and necessary park management practices on sensitive environmental areas within and adjacent to City parks. The handbook is the result of an ongoing study of sensitive areas in City parks. The study came about in response to Endangered Species Act listings, Clean Water Act regulation of wetlands, and an increasing awareness of the need to use techniques such as Integrative Pest Management (City of Salem Parks Operations Division 2002).

Effects of Urbanization on Riparian Areas

The cumulative effects of land-use practices including agricultural and urbanization have contributed significantly to the decline of local aquatic life forms throughout the Pacific Northwest. Over the past century salmon have disappeared from about 40% of their historical range and many of the remaining populations (especially in urbanizing areas) are severely depressed (Nehlsen et al. 1991).

The effects of watershed urbanization on streams are well documented and include extensive changes in basin hydrologic regime, channel morphology, and water quality (see May et al. 2000). Over time, these alterations have changed the instream habitat structure required by local salmonid populations. Several studies performed on Pacific Northwest urban streams reveal how development pressure has a negative impact on riparian forests. Fragmentation of the riparian corridor and an increase in impervious cover are often associated with urbanization. Urban development is also accompanied by such practices as land clearing, soil compaction, riparian corridor encroachment, and modifications to the surface water drainage network. A major finding in the report *Effects of Urbanization on Small Streams in the Puget Sound Ecoregion* is that wide, continuous, and mature-forested riparian corridors appear to be effective in mitigating at least some of the cumulative effects of adjacent basin development (May et al. 2000).

The riparian inventory conducted on a small reach of Pringle Creek is a local example of the effects of urbanization on streams.

Riparian Protection

The impact of development activities on riparian corridors can vary widely and must be addressed at the state and local levels. Until recently, regional development regulations did not address riparian buffer requirements. Sensitive area ordinances, now in effect in most local municipalities in the Pacific Northwest, typically require riparian buffers 100 to 150 feet in width (May et al. 2000). A recent report concluded that the actual size of a riparian buffer needed to protect the ecological integrity of the stream system is difficult to establish (Schueler 2000). In general, the more fragmented and asymmetrical the buffer, the wider it needs to be to perform the desired functions (Barton et al. 1985).

The state of Oregon has a set of 19 statewide planning goals. These statewide goals are achieved through local comprehensive planning. The local comprehensive plans guide a community's land use, conservation of natural resources, economic development, and public services. The purpose of Goal 5 is "to conserve open space and protect natural and scenic resources," including riparian areas. The process of achieving Goal 5 includes completing an inventory of all riparian areas, analyzing their functions, determining their "significance," and adopting local ordinances to protect significant areas. To date, Turner and Stayton are the only cities in the four watersheds that have conducted a riparian inventory and functional assessment (MWVCOG 2000; Fishman Environmental Services 1998).

Although no riparian inventory has been completed, the City of Salem does provide some protection for riparian areas. As of June 20, 2000, the City of Salem's Tree Ordinance pertains to all trees, including trees and vegetation in riparian corridors. The ordinance:

1. Prohibits removing trees within 50 feet of non fish-bearing streams.

2. Prohibits removing trees and intact riparian corridor vegetation within 50 feet of fish-bearing streams and within 75 feet of the Willamette River.

In the ordinance, "trees" are defined as 8 inches or greater diameter as measured four feet from the base. "Intact riparian corridor vegetation" is defined as a diverse, multi-layered collection of native trees and vigorous, dense understory of native plants. Finally, the width of the riparian corridor boundary is measured 50 feet horizontally from the top of the bank on each side of a stream with the exception of the Willamette River, which measures 75 feet horizontally from the top of the bank on each side. Exceptions to the tree ordinance can be granted by the City of Salem (City of Salem 2001).

Potential Sites for Riparian Restoration and Enhancement

The City of Salem's Tree Ordinance may help protect what little remaining riparian habitat is present along Salem's streams, but to improve their degraded condition, restoration and enhancement of riparian areas will be necessary. Riparian restoration and enhancement activities should focus on improving water quality, flood management, thermal regulation, and wildlife habitat associated with streams. Maintaining healthy riparian functions improves habitat for aquatic species, wildlife, and humans.

Riparian areas adjust in species, width, and complexity as streams change over time. A well-established riparian area with vegetation of various species, sizes, and ages adapts to change better than a simplified, narrow riparian area (Godwin 2000). Although there are no absolute or single solutions for riparian restoration, one common resource goal should be to integrate the needs of both aquatic wildlife and local vegetation. In general, riparian enhancement in western Oregon often focuses on the long-term goal of establishing diverse patches of tree species, sizes, and age classes (Godwin 2000). For instance, large conifers that fall into a stream last much longer than hardwoods. They provide the long-term building blocks for fish habitat. By holding organic material they provide food for stream insects, which subsequently becomes food for fish.

In urban areas, the recruitment of large wood into streams is problematic due to limited space and the increased risk of flooding. However, this does not diminish the need to manage urban riparian habitat for diverse plant communities. Terrestrial and aquatic animal communities depend on the vegetation cover and plant diversity of riparian areas to provide adequate food, water and shelter, especially in urban environments, where streamsides provide the only natural areas within a "concrete jungle" of roads and impervious surfaces.

For the most part, identification of site-specific restoration projects is beyond the scope of this document. A few early-action items will be apparent from the analysis and will be identified in the Recommendations section. Identifying sites for restoration and enhancement should be a goal of the "action plan." General areas in need of riparian restoration can be initially determined by referring to the low shade (red) areas indicated on **Maps 6-1** through **6-5**. Initial target areas for restoration or enhancement should include public land and areas zoned as vacant residential, vacant industrial, and vacant commercial. Riparian areas found in Urban Renewal areas may provide another source of potential projects. Riparian areas in these areas have usually been highly impacted by urbanization and are in desperate need of restoration or enhancement. The process of urban renewal gives the community an opportunity to improve the condition of the neighborhood economically and aesthetically, including incorporating open space. Urban Renewal areas also offer funds to help achieve their goals. These funds could potentially be tapped for riparian restoration projects.

As a result of on-the-ground (field-checked) riparian inventories, potential sites for riparian restoration and enhancement are given below:

Pringle Creek – An inventory and assessment of a small stretch of Pringle Creek between Mission and Winter Streets in Salem resulted in the following suggestions for riparian enhancement:

> This section of Pringle Creek which is bounded by Salem Cardiology Associates, the Salem Hospital, and their attendant parking lots was identified as a critical reach because of its urban connection with a fish-bearing stream in downtown Salem. The left bank offers the opportunity to plant substantial trees and shrubs for shading the creek. Removing invasive plant species and planting additional native trees, shrubs and groundcover can improve riparian functions. Trees and other tall, woody vegetation should be emphasized on the south side of the creek (City of Salem 2000).

City of Turner – The assessment results for the Local Wetlands and Riparian Area Inventory for the City of Turner (MWVCOG 2000), indicated how different riparian functions in Turner could be improved. Increasing the percentage of tall woody vegetation in the riparian area and flood-prone areas would improve all riparian functions. Water quality, thermal regulation and wildlife habitat could improve by increasing the percentage of trees and shrubs along the top of the bank to provide overhanging vegetation along watercourses. Removing riprap, berms, and channelization from watercourses in undeveloped areas could improve the flood management function. Increasing tall woody vegetation (by providing more layers and structural diversity), increasing large woody debris in the riparian area, preserving existing wetlands, and minimizing human disturbances could all potentially improve wildlife habitat. Encouraging building locations and road alignments outside of the riparian area, establishing native vegetation corridors in developed and undeveloped areas, and minimizing road crossings would all help.

City of Stayton –The *Local Wetlands and Riparian Inventory for the City of Stayton* offers recommendations based on inventory results. Overall, sites without adjacent trees would have higher values if vegetation were enhanced with a variety of native trees and shrubs. Also, protecting riparian corridors from ornamental landscaping, mowing, and other impacts would improve their value (Fishman Environmental Services 1998).

What are wetlands?

More commonly known as marshes, swamps, and bogs, wetlands are a transitional zone between terrestrial and aquatic ecosystems where the water table is usually at or near the surface or the land is covered by shallow water. In wetlands saturation with water is the dominant factor determining soil development and the types of plants and animal communities living in the soil and on its surface (Cowardin et al. 1979). According to Cowardin et al. (1979), wetlands must have one or more of the following three attributes: 1) at least periodically, the land supports predominantly hydrophytes (wetland plants); 2) the substrate is predominantly undrained hydric soil; 3) the substrate is non-soil (e.g., rock) and is saturated with water or covered by shallow water at some time during the growing season of each year.

Both the Oregon Division of State Lands (ODSL) and the U.S. Army Corps of Engineers (ACOE) regulate the filling of wetlands. According to Oregon's Removal-Fill Law (ORS 196.800) and Section 404 of the Clean Water Act, " wetlands are those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil." To identify wetlands out in the field, ODSL and ACOE use three criteria: hydrology, soils and vegetation. In general, an area is identified as a wetland if it can be proven to have surface water or saturated soil during some period of the growing season, contains hydric soils, and has a predominance of hydrophytes.

The Ecological Benefits of Wetlands

The many functions that wetlands provide are critical to watershed health. The main functions of wetlands include the following (ODSL 1999a):

Flood Storage and Water Supply--Many floodplain and stream-associated wetlands absorb and store stormwater flows, which reduces flood velocities and stream bank erosion. Preserving these wetlands reduces flood damage and the need for expensive flood control devices such as levees. When the storms are over, many wetlands augment summer stream flows when the water is needed, by slowly releasing the stored water back to the stream system.

Food Chain Support--Because of their high productivity, wetlands provide essential food chain support. The green pond scum that coats cattail stems and the ankles of wetland visitors provides food for an abundance of tiny organisms that, in turn, feed fish, wildlife, and humans.

Wildlife and Fish Habitat--Wetlands provide essential water, food, cover, and reproductive areas for many wildlife species. For example, nearly two-thirds of the commercially important fish and shellfish species are dependent upon estuarine wetland habitats for food, spawning, and/or nursery areas. Similarly, millions of waterfowl, shorebirds, and other birds depend on wetlands. In semi-arid eastern Oregon, riparian (stream-associated) wetlands and springs are crucial to the survival of many birds, amphibians and mammals. In the Willamette Valley, wetlands provide important feeding and resting areas for migrating shorebirds and waterfowl. A series of wetlands strung together as bird sanctuaries in the Valley serves as a major stopover for migratory birds on the Pacific flyway. In addition, they provide important wintering habitat for Canada geese and other waterfowl.

Habitat for Rare and Endangered Species--Nationally, nearly 35% of all rare and endangered animal species depend on wetlands, even though wetlands comprise only about 5% of the land area.

Water Quality Improvement--Wetlands are highly effective at removing nitrogen, phosphorous, some chemicals, heavy metals, and other pollutants from water. For this reason, artificial wetlands are often constructed for cleaning stormwater runoff and for tertiary treatment (polishing) of wastewater. Wetlands bordering streams and rivers and those that intercept runoff from fields and roads provide this valuable service free of charge.

Aesthetics, Recreation and Education--Depending on their type and location, wetlands provide opportunities for fishing, hunting, plant identification, and wildlife observation. They are also visually pleasing, interesting elements in the landscape, often providing some of the last open space in urbanized areas. Wetlands are wonderful outdoor classrooms and laboratories.

Types of Wetlands in Local Watersheds

Wetlands and deepwater habitats are typically classified using the Cowardin system of classification (Cowardin et al. 1979). The structure of the classification is hierarchical, progressing from systems and subsystems, at the most general levels, to classes, subclasses, and dominance types. There are five wetland systems that are further broken down into specific wetland types. Those systems are marine, estuarine, palustrine, riverine, and lacustrine (lakes):

Palustrine —These are freshwater wetlands commonly referred to as marshes, bogs, and swamps. Included are wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and some non-vegetated wetlands that do not meet the criteria for Lacustrine (lake) wetlands.

Riverine – These are river, creek and stream habitats contained within a channel, where water is usually, but not always flowing. Riverine systems are usually unvegetated but may include nonpersistent emergent vegetation; palustrine (persistent vegetation) wetlands are often adjacent to riverine systems or contained within them as islands.

Lacustrine—This system includes permanently flooded lakes and reservoirs, intermittent lakes (e.g., playa lakes), and tidal lakes with ocean-derived salinities. Typically, there are extensive areas of deep water and there is considerable wave action.

According to the National Wetland Inventory (NWI) and several local wetland inventories (LWI), two wetland systems are found in local watersheds, palustrine and riverine. The palustrine system can be further classified into eight classes: Rock Bottom, Moss-Lichen Wetland, Aquatic Bed, Unconsolidated Shore, Unconsolidated Bottom, Emergent Wetland (includes wet meadow), Scrub-Shrub wetland, and Forested Wetland. Wetlands that fall into the last four Classes are the most abundant in the four watersheds. Descriptions of the four classes follow.

Unconsolidated Bottom—Includes all wetlands and deepwater habitats with at least 25% cover of particles smaller than stones (less than 6-7cm) and a vegetative cover less than 30%.

Emergent Wetlands—These wetlands have rooted herbaceous vegetation standing above the water or ground surface. Includes wetlands such as cattail marshes and wet meadows.

Scrub-Shrub Wetlands—Wetlands dominated by shrubs and tree saplings that are less than 20 feet high.

Forested Wetlands—Wetlands dominated by trees that are greater than 20 feet high.

The riverine system can be furthered classified into four subsystems, which include: Tidal, Lower Perennial, Upper Perennial, and Intermittent. According to the NWI and the LWI, examples of the last three subsystems are present in local watersheds. Descriptions of the three subsystems follows.

Lower Perennial—The gradient is low and water velocity is slow. There is no tidal influence, and some water flows throughout the year. The substrate consists mainly of sand and mud.

Upper Perennial—The gradient is high and velocity of the water fast. There is no tidal influence and some water flows throughout the year. The substrate consists of rock, cobbles, or gravel with occasional patches of sand.

Intermittent—The channel contains flowing water for only part of the year. When the water is not flowing, it may remain in isolated pools or surface water may be present.

Because lacustrine systems, although present, are not abundant in the four watersheds, no description of subsystems or classes is given here.

Wetland modifications influence the character of such habitats, special modifying terms have been developed to explain these types of wetlands. There are six types of modified wetlands: excavated, impounded, diked, partly drained, artificial, and farmed. According to the NWI, all six of these modified wetland types can be found in the four watersheds.

Two modified wetland types are of special interest in the local area: farmed wetlands and excavated wetlands. Farmed wetlands are good potential sites of wetland restoration or enhancement projects. As for excavated wetlands, most of the Palustrine Unconsolidated Bottom Wetlands (PUB) wetlands in the Salem-Keizer UGB and in the Mill Creek watershed are the result of excavation for sand and gravel. PUB wetlands are the most abundant wetland type in the Salem-Keizer urban growth boundary (**Table 6-3**). Descriptions of the two most common modified wetland types follows.

Farmed Wetlands --Wetlands in which the soil surface has been mechanically or physically altered for production of crops, but hydrophytes will become established if farming is discontinued.

Excavated—Habitat lies within a basin or channel excavated by man.

Location of Wetlands

Two separate inventories were used to determine the location of wetlands in the four watersheds.

National Wetland Inventory (NWI)—This inventory was developed by the U.S. Fish and Wildlife Service and covers the entire country. While the NWI is extremely useful for many resource management and planning purposes, its small scale, accuracy limitations, and absence of property boundaries make it unsuitable for parcel-based decision making.

Local Wetlands Inventories (LWI)—To augment the NWI in areas where more detailed inventory information is needed, the Oregon Division of State Lands developed guidelines and rules for the Local Wetland Inventory. A LWI aims to map all wetlands 0.5 acres or larger at an accuracy of approximately 25 feet on a parcel-based map. Local wetland inventories are typically completed by municipalities when updating local comprehensive plans. For this reason, the extent of a local wetland inventory is usually within a city's urban growth boundary.

Salem-Keizer Local Wetland Inventory

According to the Salem-Keizer LWI (Schott and Lorenz 1999), there are a total of 1,482 acres of wetland within the urban growth boundary of Salem and Keizer. **Table 6-3** shows the distribution of wetlands types within the entire study area and indicates that the most extensive type of wetlands are natural ponds and inundated gravel pits (PUB), followed by emergent wetlands (PEM) and forested wetlands (PFO).

Table 6-3. Distribution of Wetland Area By Cowardin Classification Within Salem-Keizer UGB

Cowardin Class	Area (acres)
Ponds and Gravel Pits (PUB)	743
Wet Meadow Wetlands (PEM)	296
Forested Wetlands (PFO)	264
Farmed Wetlands (FW)	65
Scrub-Shrub Wetlands (PSS)	59
Total	**1427[1]**

[1]This total does not include 34 acres of wetland mitigation and 21 acres of riverine wetland included in Table 2. Riverine wetlands identified in the LWI were not classified using the Cowardin Classification, thus they are not included in the above table.
Data Source: Schott and Lorenz (1999)

According to the Salem-Keizer LWI, only 21 acres of riverine habitat are present within the urban growth boundary. All of those acres are located in the West Willamette Slough along the Willamette River. Streams and creeks are also identified in the LWI. The Salem-Keizer LWI did not attempt to identify all stream reaches (i.e. intermittent creeks, drainages or swales).

Table 6-4 shows the distribution of wetland types by watershed within the urban growth boundary. Schott and Lorenz (1999) provide a general description of the wetland types and their distribution in each of the four watersheds in the following text.

Table 6-4. Summary of Wetland Types (Cowardin Classes) By Watershed

Subwatershed	Wet Meadow (PEM)	Scrub-Shrub (PSS)	Forest (PFO)	Unconsolidated Bottom (PUB)	Farmed Wetland (FW)	Mitigation Wetland	Total
Battlecreek (BC)	4.73 acres 7 units	0.51 acres 2 units	1.34 acres 3 units	10.56 acres 16 units	0 acres 0 units	0 acres 0 units	17.14 acres 28 units
Croison Creek (CC)	0.97 acres 1 unit	0 acres 0 units	5.42 acres 1 unit	3.04 acres 4 units	0 acres 0 units	0 acres 0 units	9.43 acres 6 units
Claggett Creek Lower (CL)	89.29 acres 16 units	7.3 acres 5 units	18.32 acres 6 units	62.89 acres 6 units	0 acres 0 units	0 acres 0 units	177.8 acres 30 units
Claggett Creek Upper (CU)	34.59 acres 14 units	2.22 acres 1 unit	1.64 acres 2 units	15.22 acres 1 unit	0.39 acres 1 unit	0 acres 0 units	54.06 acres 19 units
East Bank (EB)	7.19 acres 13 units	2.02 acres 2 units	19.62 acres 6 units	65.21 acres 16 units	8.83 acres 1 unit	0 acres 0 units	102.87 acres 38 units
Glenn-Gibson Creeks (GG)	0.08 acres 1 unit	1.49 acres 3 units	1.59 acres 1 unit	4.77 acres 4 units	0 acres 0 units	0 acres 0 units	7.93 acres 9 units
Mill Creek (MC)	37.62 acres 24 units	7.99 acres 7 units	24.64 acres 10 units	281.55 acres 15 units	13.87 acres 5 units	0 acres 0 units	365.67 acres 61 units
Pringle Creek (PC)	11.67 acres 15 units	5.14 acres 3 units	12.2 acres 7 units	66.18 acres 13 units	0.62 acres 1 unit	28.13 acres 5 units	123.94 acres 44 units
Pettijohn-Laurel Creek (PJ)	0 acres 0 units	0 acres 0 units	0 acres 0 units	0.68 acres 2 units	0 acres 0 units	0 acres 0 units	0.68 acres 2 units
Little Pudding River (PU)	31.62 acres 35 units	2.49 acres 3 units	24.61 acres 16 units	2.08 acres 5 units	2.59 acres 5 units	5.47 acres 4 units	68.86 acres 68 units
Willamette Slough East (WS)	77.23 acres 14 units	22.85 acres 5 units	139.32 acres 15 units	228.62 acres 32 units	38.09 acres 10 units	0 acres 0 units	506.11 acres 76 units
Willamette Slough West (WW)[1]	0.93 acres 1 unit	7.46 acres 3 units	15.3 acres 3 units	2.30 acres 1 unit	0.47 acres 1 unit	0 acres 0 units	48.72 acres[1] 17 units
Total	**296 acres**	**59 acres**	**264 acres**	**743 acres**	**65 acres**	**34 acres**	**1482 acres**

1. Total wetland acreage and units for the Willamette Slough West includes 8, R2 wetland units subtotaling 21.48 acres

Source: Schott and Lorenz (1999)

Watershed Summaries of Wetland Locations

Because all four watersheds lie either entirely or partly within the Salem-Keizer urban growth boundary, the Salem-Keizer LWI was used to determine the types of wetlands present and their locations in these watersheds. Because the upper portion of the Glenn-Gibson watershed and the lower portion of the Claggett Creek watershed lie outside the UGB, the NWI was used to identify and locate wetlands outside the UGB. The Mill Creek watershed crosses several jurisdictional boundaries. The identification and location of wetlands in this watershed was determined using the NWI and the local wetland inventories of Salem-Keizer (Schott and Lorenz 1999), Turner (MWVCOG 2000), and Stayton (Fishman Environmental Services 1998).

Pringle Creek

Pringle Creek, a perennial creek, drains the area north of Kuebler Blvd., west of the Salem airport, and east of the hills at Belcrest Memorial Park and Cemetery. In the lower reaches, Pringle Creek flows through Bush's Pasture Park, the south downtown area and into the Willamette Slough near Boise Cascade's downtown plant. The several branches of Pringle Creek are best described as stormwater drainages in an urbanized environment. There are isolated wetlands at the south end of the Salem airport and in the Fairview Industrial Park area. Ponded areas created by past gravel mining are located north and south of McGilchrist Street. There are a total of 123.94 acres of inventoried wetlands in this sub-basin (**Table 6-4**). **Map 6-6** shows the location of wetlands in the Pringle Creek Watershed.

Glenn-Gibson Creeks

Glenn and Gibson Creeks originate in the hills of West Salem. The upper reaches of Glenn Creek currently flow through undeveloped property. There may be opportunities for stormwater detention in this upper reach. Small constructed ponds are located within the drainages at several locations. The largest native wetland complex is located south of Brush College Road in the northern portion of West Salem. A ponded area on the northern boundary of the West Salem study area, east of Wallace Rd., appears to have been constructed to hold water for irrigating agricultural fields. There are 7.93 acres of inventoried wetlands in the Glenn-Gibson watershed (**Table 6-4**). **Map 6-7** shows the location of wetlands in the Glenn-Gibson watershed. The wetlands highlighted in blue are taken from the Salem-Keizer Local Wetland Inventory. The wetlands highlighted in green or with a green border are from the National Wetland Inventory.

Lower Claggett Creek

Most of the wetland area in this watershed is along the riparian floodplain of Claggett Creek. The floodplain is in an undeveloped greenway. Both indigenous wetland plants such as sedges, rushes, and Oregon ash, as well as the introduced reed canarygrass grow in the wetlands. There appear to be opportunities for enhancement and mitigation along the lower portion of Claggett Creek. This area appears to be in relatively good ecological condition with high ratings for wildlife habitat, hydrologic control, and aesthetics.

Staats Lake and ponds on McNary Golf course are constructed features, created for aggregate mining or landscaping. Inventoried wetlands in this sub-basin total 177.80 acres (**Table 6-4). Map 6-8** shows the location of wetlands within the UGB in the Claggett Creek watershed. The wetlands highlighted in blue are taken from the Salem-Keizer Local Wetland Inventory. The wetlands highlighted in green or with a green border are from the National Wetland Inventory.

Labish Ditch enters Claggett Creek from the east. It is channelized with portions flowing through culverts. This ditch drains an area known as Lake Labish, a historic swamp that had once been the main channel of the Willamette River. This area, approximately 2000 acres in size, is now drained and intensively farmed. The soils of Lake Labish are peat or muck, decayed organic matter typically found in swamps. The Labish Ditch drains Lake Labish in two different directions. The west portion of the historic lake bed drains west into the Claggett Creek watershed while the majority of the area drains east into the Pudding River.

Upper Claggett Creek

Existing wetlands in the Upper Claggett watershed tend to be either small or isolated due to extensive development. Historic swales with hydric soils have been filled. Drainages tend to follow old swales with portions now in underground pipes. There are isolated depressions in fields used for parking lots at the north and south ends of the State Fairgrounds that meet jurisdictional wetland criteria. There is a relatively large emergent wetland and gravel pit complex at the lower end of the basin, just north of the Salem Industrial Park. The wetland appears to have been disturbed in the past and has enhancement potential. At the end of 2002, the City was poised to acquire 37 acres for a large urban park adjacent to the Northgate Extension Project. The additional 29 acres will be developed as light industrial and office space. The entire 66 acres is within the Northgate Urban Renewal Area. As part of the agreement, the City will file a conservation easement to cover Claggett Creek, its riparian area and nearby wetlands. There are a total of 54.06 acres of inventoried wetlands in the Upper Claggett Creek sub-basin (**Table 6-4**). **Map 6-8** shows the location of wetlands within the UGB in the Claggett Creek watershed. The wetlands highlighted in blue are taken from the Salem-Keizer Local Wetland Inventory. The wetlands highlighted in green or with a green border are from the National Wetland Inventory.

Mill Creek

The Mill Creek basin is approximately 110 square miles in area and originates in the foothills of the Cascades north of Stayton. Mill Creek is a perennial creek. The creek's water supply is supplemented from the North Santiam River during Oregon's growing season (March 1-October 1). Historically, before North Santiam water was supplied to Mill Creek, it is believed the creek had periods of very low to no flows in late summer. Major tributaries of Mill Creek include Beaver Creek and Battle Creek.

According to the NWI, large natural wetlands still remain intact in several areas throughout the watershed. **Map 6-9** shows the location of wetlands throughout the Mill Creek watershed. Wetlands are abundant near the confluences of creeks. Palustrine wetlands are located along Beaver Creek just before it flows into Mill Creek at Turner. Where Shaw Creek enters Beaver Creek, a large emergent and forested wetland dominated by Oregon ash and reed canarygrass, can be seen just north of Highway 22 across from the Aumsville wastewater treatment lagoons. Emergent and forested wetlands can also be found along the flat terrain of Beaver Creek, east of Turner, and along Simpson Creek north and west of Aumsville.

Mill Creek enters the southeast portion of the study area on State Penitentiary farm property. There are no riparian wetlands along this reach. Several isolated farmed wetlands are located on the southeast portion of the farm property. Between Kuebler Blvd. and Highway 22, including Cascades Gateway Park, there are several ponds created by gravel mining. Some of the best examples, in terms of diversity of native plant species, of wet prairie and forested wetlands are found in wetlands near the banks of Mill Creek between Highway 22 and the Southern Pacific Railroad. Several small and isolated emergent wetlands are located on the penitentiary property north of the railroad.

West of the State Penitentiary property Mill Creek divides into three branches including the constructed Mill Race and Shelton Ditch. These channels, passing through Salem's downtown areas have been channelized with riprap banks in many locations or in the case of the Mill Race, flow through a concrete-lined sluice. Currently, there are no native wetlands in the downtown Salem area. However, there are historical accounts of wetlands in this area, as noted in the Historical Conditions and Hydrology chapters. Inventoried wetlands in the Mill Creek sub-basin total 365.67 acres (**Table 6-4**). **Map 6-10** shows the locations of wetlands in the portion of the Mill Creek watershed that lies within the Salem-Keizer urban growth boundary. The wetlands highlighted in blue are taken from the Salem-Keizer Local Wetland Inventory. The wetlands highlighted in green or with a green border are from the National Wetland Inventory.

Wetlands Quality Assessment

Local wetland inventories gather information about the location, type and size of wetland resources. Information about the quality of wetland resources is determined by applying the Oregon Freshwater Assessment Methodology (OFWAM) (Roth et al.

1996) to the inventory information. Wetland quality assessments, combined with the inventory data, complete the information required to determine resource "significance." Local jurisdictions can then proceed with long-range planning to conserve significant natural resources, required by Oregon Land Use Planning Goal 5 (MWVCOG 2000). Once a wetland is determined to be "significant," the local jurisdiction can take steps to protect it by using a combination of methods such as land acquisition, conservation easements, local ordinances and education.

OFWAM gathers information about the watershed and the individual wetlands from background reports, maps, and fieldwork. The methodology indicates which functions are performed by wetlands in the planning area. OFWAM evaluates four ecological functions (wildlife habitat, fish habitat, hydrologic control, and water quality); three social functions (education use, recreational use, and aesthetic appeal), and two wetland conditions (sensitivity to impact and enhancement potential). If a wetland ranks "high" in any of the four ecological functions, it is considered a "locally significant wetland." However, a wetland can be deemed significant based on a combination of factors.

In 2002 the City of Salem complied a list of wetlands that meet the State's criteria for "locally significant wetlands." Currently, the City of Salem is in the process of completing the analysis for a list of significant wetlands as part of the City's effort to comply with the state planning goals. Development of the local significant wetlands list is a directive of Goal 5. The process for developing this list is outlined in the City's new wetlands ordinance Chapter 126. Once the list is developed, those wetlands within riparian corridors will have limited protection through SRC Chapter 68, Preservation of Trees and Vegetation. Further protection, such as for those wetlands outside riparian corridors, will be evaluated as the City's efforts progress. The cities of Turner and Stayton have already determined significant wetlands within their urban growth boundaries.

Potential Sites for Wetland Enhancement

Because wetlands provide many functions that are critical to watershed health, enhancement and restoration of wetlands should be a critical component in any watershed plan. In this section, information obtained from the Salem LWI, Stayton LWI and Turner LWI, was used to compile a list of degraded wetland sites whose functions (i.e. water quality improvement, fish habitat, wildlife habitat and hydrologic control) could be enhanced through efforts of the watershed councils or other interested parties.

The local wetland inventories reviewed in this assessment used the Oregon Freshwater Assessment Methodology (OFWAM) to determine a wetland's potential for enhancement. In some cases, the methodology outlined by OFWAM did not accurately rate a wetland's potential for enhancement. In these cases, notes made by the authors of the wetland inventories were used to more accurately rate enhancement potential. In other words, the ratings shown below are the result of OFWAM and best professional judgments. Information regarding the enhancement potential of wetlands outside of urban growth boundaries, but within the watershed boundaries, does not exist for the four watersheds.

Some wetlands listed are not rated for enhancement potential. Ratings were not available for wetlands in which information was lacking in local wetland inventories. Wetlands were also not rated if the wetlands were active gravel mines, permitted to be filled for development, mapped as mitigation sites, or current uses were not conducive to enhancement (e.g., wetlands on State Fairgrounds that are mowed and used for parking).

Some wetlands were rated "low" for enhancement potential because they were already of high quality. The authors of this document noted a couple of wetlands that perhaps should be preserved because of special characteristics identified in either the local wetland inventories or via personal communication with watershed council members.

Many times the terms "wetland restoration" and "wetland enhancement" are used interchangeably. "Wetland creation" is also term used frequently when talking about wetland mitigation. The Oregon Division of State Lands (ODSL) provides detailed definitions of these three terms (ODSL 1999b):

Wetland restoration— the re-establishing of wetland vegetation and hydrology to a site that was historically wetland but has been dried out by diking, draining, or filling.

Wetland enhancement -- improving an existing but badly degraded wetland by correcting the conditions that cause it to be degraded.

Wetland creation— constructing a wetland in an area that never supported wetlands historically.

Because local wetland inventories only identify existing wetlands, potential sites for wetland enhancement are emphasized in the following tables adapted from local wetland inventories.

Watershed Summaries for Wetland Enhancement

Wetlands are identified by a letter code in the following tables. The letter codes identify wetlands on local wetland inventory maps. Because of space limitations, local wetland inventory maps displaying wetland codes for all identified wetlands were not printed. Wetland maps provided show the extent of current wetlands and identify only the wetlands with high enhancement potential. For more detailed information, the reader must refer to the actual local wetland inventories: Salem LWI, Stayton LWI and Turner LWI. These documents are available for public review at the Oregon Division of State Lands.

Pringle Creek

Table 6-5 lists and identifies wetlands with high enhancement potential in the Pringle Creek watershed. Four wetlands have high enhancement potential according to the Salem LWI (Schott and Lorenz 1999). Three of the wetlands are actually abandoned gravel pits: Walling Sand and Gravel Pits (PC-E), Webb Lake (PC-F), and Berger Lake (PC-O). The fourth wetland is a cattail marsh (PC-DD) located west of 36th Avenue near the intersection of 36th and Kashmir Way. A forested wetland (PC-X) near the headwaters of the East Fork of Pringle Creek is the largest natural wetland still in existence in the watershed and may be a candidate for preservation. The wetland is dominated by Oregon ash and soft rush.

Table 6-5. Enhancement Potential of Wetlands in the Pringle Creek Watershed[1]

Wetland Identifier	Area (acres)	Enhancement Potential
PC-A	0.14	LOW
PC-AA	0.36	-
PC-BB	0.61	-
PC-DD	3.32	HIGH
PC-E	11.52	HIGH
PC-F	43.69	HIGH
PC-G	4.85	-
PC-I	0.62	-
PC-J	7.16	MODERATE
PC-K	1.68	MODERATE
PC-L	0.23	-
PC-M	0.58	MODERATE
PC-O	5.96	HIGH
PC-P	0.79	MODERATE
PC-S	0.39	-
PC-T	28.16	-
PC-U	0.46	-
PC-V	0.79	MODERATE
PC-W	0.12	-
PC-X	10.99	LOW-PRESERVE
PC-Y	1.52	LOW
Watershed Total	**123.94**	

[1] Source: Schott and Lorenz (1999).

Glenn-Gibson Creek

Table 6-6 lists and identifies wetlands with high enhancement potential in the Glenn-Gibson Creeks watershed. Two wetlands have high enhancement potential according to the Salem LWI. The first wetland (GG-E) is found along a tributary to Glenn Creek just east of the intersection of Linwood Street and Goldcrest Avenue. The tributary contains a palustine scrub-shrub wetland. The second wetland (GG-M) is the pond at Salemtowne. The pond was created by placing a weir across Gibson Creek. Woody vegetation is lacking around the pond. The lack of shade causes water temperatures to soar in summer months creating a thermal barrier to migrating salmonids in the Glenn-Gibson watershed (see Water Quality Chapter).

A palustrine forested wetland on Glenn Creek may be a candidate for protection. The Salem LWI notes the wetland, GG-G, has good riparian vegetation cover. This wetland is also the largest natural wetland within the portion of the Glenn-Gibson watershed that lies within Salem's UGB.

The Glenn-Gibson Watershed Council also represents the Turnage Brook watershed. Turnage Brook is mapped as a small intermittent stream in the Salem LWI and by the NWI. The stream drains directly into the Willamette River. Although not identified in the Salem LWI, a wetland is adjacent to Turnage Brook between Lower La Vista Court NW and Eola Drive. The site is protected by a wetland conservation easement and has been designated as a "Wetland Conservation Area".

Table 6-6. Enhancement Potential of Wetlands in the Glenn-Gibson Watershed Within Salem's City Limits[1]

Wetland Identifier	Area (acres)	Enhancement Potential
GG-A	3.55	LOW
GG-E	0.89	HIGH
GG-G	1.59	LOW-PRESERVE
GG-M	1.34	HIGH
GG-N	0.22	LOW
GG-O	0.34	-
Watershed Total	**7.93**	

[1] Source: Schott and Lorenz (1999).. The study area for the Salem-Keizer LWI was limited to the city limits in Polk County.

Outside city limits in West Salem, wetlands in the Glenn-Gibson watershed are mainly limited to ponds that have been created by impounding Glenn or Gibson Creeks and their tributaries. Enhancement potential for these created wetlands is unknown. The ponds probably provide stormwater detention. However, the weirs or dams associated with the ponds can be fish barriers (see Fish and Fish Habitat Chapter).

According to the NWI, one natural palustrine emergent wetland does occur along a small tributary of Glenn Creek just East of Mogul Street and north of Hoodoo Court.

Claggett Creek

Table 6-7 lists and identifies wetlands with high enhancement potential in the Claggett Creek watershed. Six wetlands have high enhancement potential according to the Salem LWI (Schott and Lorenz 1999). Four of the wetlands are contiguous and form a corridor along Claggett Creek from just north of Promenade Way to the Salem Parkway (CL-F, CL-G, CL-H, CL-I). Evidence of diking and channelization can be seen throughout this stretch of the creek. Amount of vegetative cover along the creek varies from mowed grass to a well-established canopy of Oregon ash trees. Reed canarygrass can be found dominating the plant community in some areas. The fifth wetland, CL-M, is located at the Chemawa Indian School, west of Portland Road and just south of Chemawa Road. This wetland is part of the old Lake Labish. It is currently dominated by a very dense stand of reed canarygrass. The final wetland, CU-J, is located at McKay Park between Hollywood Drive and Phipps Lane. This degraded palustrine emergent wetland lies along the upper reaches of Claggett Creek. It is currently dominated by reed canary grass and soft rush.

Table 6-7. Enhancement Potential of Wetlands in the Claggett Creek Watershed Within Salem-Keizer's Urban Growth Boundary[1]

Wetland Identifier[2]	Area (acres)	Enhancement Potential
CL-A	1.35	MODERATE
CL-C	56.17	LOW
CL-D	0.2	MODERATE
CL-F	11.64	HIGH
CL-G	26.59	HIGH
CL-H	5.96	HIGH
CL-I	31.32	HIGH
CL-J	6.41	LOW
CL-K	2.15	LOW
CL-L	2.92	MODERATE
CL-M	30.92	HIGH
CL-N	2.17	LOW
CU-B	31.33	MODERATE
CU-C	15.22	LOW
CU-D	1.22	-
CU-E	0.5	LOW
CU-F	0.93	LOW
CU-G	0.57	-
CU-H	0.46	-
CU-I	1.14	LOW
CU-J	0.61	HIGH
CU-K	0.76	-
CU-L	0.81	LOW
CU-M	0.51	MODERATE
Watershed Total	**231.86**	

[1] Source: Schott and Lorenz (1999). [2] CL=Lower Claggett Creek; CU=Upper Claggett Creek

Outside of the Salem-Keizer UGB, the NWI shows extensive wetlands in the north part of the watershed surrounding Clear Lake and the lower portion of Claggett Creek before it drains into a backwater slough of the Willamette River. Many of the wetlands classified as palustrine forested or palustrine emergent appear to be old meander scars or oxbows of the Willamette River. Small isolated wetlands, including gravel pits, are also found in this area.

Mill Creek

City of Salem

Table 6-8 lists and identifies wetlands with high enhancement potential within the Mill Creek watershed. This list contains wetlands located within the Salem UGB only. Four wetlands have high enhancement potential according to the Salem LWI. The first wetland (MC-Q) is an old gravel pit, Wirth Lake, adjacent to Mill Creek in Cascades Gateway Park. The west side of the lake is the best location for future wetland enhancement or creation. The second and third wetlands, MC-V and MC-X, are farmed wetlands located on prison property just east of Kuebler Boulevard. If the state stops farming this land, these wetlands could be enhanced. Wetland MC-L is a possible candidate for preservation. Located just south of the State of Oregon motor pool and east of Airport Road, this wetland is considered one of the best examples of wet meadow in the Salem-Keizer UGB.

According to the Salem LWI, only one wetland in the Battle Creek sub-watershed has high enhancement potential. Wetland BC-B is a constructed pond that was not field verified by the authors of the Salem LWI. It is believed that the pond may have potential fish habitat. The wetland is located on the northeast corner of Holder Lane and Liberty Street.

Table 6-8. Enhancement Potential of Wetlands in the Mill Creek Watershed Within Salem's Urban Growth Boundary[1]

Wetland Identifier[2]	Area (acres)	Enhancement Potential
MC-AA	2.56	LOW
MC-C	0.51	LOW
MC-D	0.82	LOW
MC-E	2.57	LOW
MC-EE	0.77	MODERATE
MC-F	4.48	LOW
MC-G	7.4	MODERATE
MC-H	1.34	MODERATE
MC-I	0.42	-
MC-J	7.1	-
MC-K	5.38	-
MC-L	7.1	LOW-PRESERVE
MC-M	2.61	-
MC-N	22.24	-
MC-O	44.53	-
MC-P	0.27	MODERATE
MC-Q	20.4	HIGH
MC-R	0.33	-
MC-U	2.1	MODERATE
MC-V	10.73	HIGH
MC-W	216.8	-
MC-X	5.21	HIGH
BC-B	0.87	HIGH
BC-F	2.62	MODERATE
BC-G	0.64	MODERATE
BC-H	4.12	LOW
BC-I	2.83	LOW
BC-J	0.65	LOW
BC-K	3.83	LOW
BC-M	0.99	LOW
BC-N	0.59	LOW
Watershed Total	**382.81**	

[1] Source: Schott and Lorenz (1999).

[2] MC=Mill Creek; BC=Battle Creek

City of Turner

Approximately 137 acres of wetlands were located in the City of Turner. The local wetland inventory for the city identifies three wetlands with high enhancement potential (**Table 6-9**) (MWVCOG 2000). The first wetland, MCN-C, is located on the Mill Creek floodplain in northwest Turner. It is an old gravel pit and it is the future site of Lake Turner. Most of the mine will be reclaimed as 82 acres of open water. According to the wetland mitigation plan and mining reclamation plan developed prior to the mining operation, approximately 17.7 acres of wetlands will be enhanced, restored and created at the site. Wetland MCN-D is located on the east side of the future Lake Turner. This wetland is classified as a palustrine emergent and scrub-shrub wetland. An intermittent stream that has been ditched flows through the wetland. This wetland is also part of the mitigation plan for the gravel pit, the future site of Lake Turner. The final wetland, MCC-D, is a constructed pond located in the east central part of Turner. This wetland is fed by a spring and swale located north of the pond. Vegetation surrounding the pond is highly impacted by grazing.

Table 6-9. Enhancement Potential of Wetlands and the Identification of Locally Significant Wetlands in the Mill Creek Watershed Within City of Turner's Urban Growth Boundary[1]

Wetland Identifier[2]	Area (acres)	Enhancement Potential	Significance[3]
MCN-B	1.76	-	S
MCN-C	85.7	HIGH	S
MCN-D	3.91	HIGH	NS
MCN-E	0.2	-	S
MCC-B	0.93	-	S
MCC-C	14.66	-	NS
MCC-D	0.9	HIGH	NS
MCS-B	0.2	MODERATE	S
MCS-C	2.51	-	S
MCS-D	4.04	MODERATE	S
MCS-F	1.34	MODERATE	NS
PL-B	1.09	-	S
PL-C	0.54	-	S
PL-D	1.74	MODERATE	NS
PL-E	2.45	-	S
PL-F	15.68	-	S
Watershed Total	137		

[1] Source: MWVCOG (2000).
[2] Abbreviations represent the following sub-watersheds: MCN=Mill Creek North; MCC=Mill Creek Central; MCS=Mill Creek South; PL=Perrin Lateral Channel.
[3] Identifies which wetlands are considered Locally Significant Wetlands when using the methodology presented in the Oregon Freshwater Assessment Methodology (OFWAM).

Many of the wetlands identified within the City of Turner UGB did not have high enhancement potential because they were already operating at a high ecological level. In other words, the wetlands did not need enhancement to improve their ecological functions.

With the exclusion of the future Lake Turner, Wetland PL-F is the largest wetland located in the City of Turner. The wetland is centered along an intermittent drainage that was the former location of the Perrin Lateral Channel, which is now located east of this drainage. Using OFWAM, this wetland is rated high, having diverse wildlife habitat and intact water quality and hydrological functions. The land is currently designated for industrial use in the Turner Comprehensive Plan.

City of Stayton

Within the City of Stayton's UGB, approximately 115 acres of wetlands were identified in the Mill Creek watershed. An additional six acres are found along the Salem Ditch, a channel that diverts water from the North Santiam River into Mill Creek. According to the Stayton LWI (Fishman Environmental Services 1998), seven wetland units have high enhancement potential in the Mill Creek watershed, including the area surrounding the Salem Ditch (**Table 6-10**). Wetland W1 consists of a reach of Mill Creek that has been ditched (M1) and a large 10 acre wetland mitigation site (M2) owned by the Oregon Department of Transportation just south of Highway 22 on the east side of the Cascade Highway. The ditched creek is the portion of this wetland unit that could be enhanced. Wetland M3 is a large emergent wetland lying within the floodplain of Mill Creek on the west side of the Cascade Highway. Mill Creek has been channelized in this location and the vegetation has been impacted by agricultural practices. The third wetland unit, W8, is composed of two golf course ponds (M9) whose vegetation cover is limited to an emergent fringe. Wetland unit W9, or wetland MT1, is a large wetland in the Mill Creek floodplain located east of the Cascade Highway and south of Mill Creek. This wetland is currently being filled for development. Wetland mitigation is occurring on-site according to the Removal-Fill Permit (FP-11456) filed at ODSL. Wetland unit W10, or wetland MT-4, is a channelized tributary of Mill Creek that flows across the Santiam Golf Course in northwest Stayton. Vegetation along the creek is typically mowed.

Two wetlands have high enhancement potential along the Salem Ditch. Wetland SD1 is a small emergent wetland north of Locust Street on the east bank of the Salem Ditch. It provides water quality functions but has degraded fish habitat and hydrologic control. The second wetland, SD3, is a constructed pond located south of Shaff Road on the east side of the Salem Ditch. The open water attracts waterfowl, but wetland vegetation is lacking.

Table 6-10. Enhancement Potential of Wetlands and the Identification of Locally Significant Wetlands in the Mill Creek Watershed Within City of Stayton's Urban Growth Boundary[1]

Wetland Unit[3]	Wetland Identifier[2]	Area (acres)	Enhancement Potential	Significance
W1	M1, M2	11.5	HIGH	S
W2	M3	34.65	HIGH	S
W3	M4, MT2, MT3	20.15	-	S
W4	M5	6.4	LOW	S
W5	M6	9.8	MODERATE	S
W6	M7	4	LOW	NS
W7	M8, MT5	7.4	MODERATE	S
W8	M9	1	HIGH	NS
W9	MT1	19.2	HIGH	S
W10	MT4	1.3	HIGH	S
W19	SD1	0.6	HIGH	S
W20	SD2	2.9	LOW	NS
W21	SD3	2.2	HIGH	NS
Watershed Total		**121.1**		

1 Source: Fishman Environmental Services (1998).
2 Abbreviations represent the following sub-watersheds: M=Mill Creek; MT=Mill Creek tributary; SD= Salem Ditch.
3 Some wetlands were grouped together into "wetland units" in order to conduct the Oregon Freshwater Assessment Methodology assessment. The wetlands were grouped together due to their proximity, connectivity and/or for their similarities in type (e.g. farmed wetlands) or in function (e.g. provide diverse wildlife habitat).

Outside Urban Growth Boundaries

Many large wetlands still exist within the Mill Creek watershed in the rural landscape. Five large wetland complexes are worth noting. All five wetlands are classified as palustrine, each wetland containing a mix of emergent, scrub-shrub and forested wetland types. The first complex stretches for two miles along Battle Creek immediately before the creek's confluence with McKinney Creek south of the City of Turner. The second wetland complex is located on the north side of Beaver Creek, west of 75th Place SE and south of Olney Street. Shaw Creek, a tributary of Beaver Creek, contains extensive wetlands that can be seen north of Highway 22, across the highway from the Aumsville Ponds. The fourth wetland complex occurs along Simpson Creek. This creek flows south into Beaver Creek approximately 1.25 miles east of the Aumsville Ponds. According to the NWI maps, the wetland complex stretches along the creek for over a mile. The fifth and final wetland is found north of the City of Stayton. This large palustrine emergent wetland is located south of Highway 22 and immediately west of the Cascade Highway. Because all these wetlands are located in the Mill Creek watershed in mostly fertile soil, many of the wetlands are probably impacted by farming or grazing, in addition to other impacts associated with Highway 22 and the extensive road network in the lower portion of the watershed. Enhancement potential is unknown.

Potential Sites for Wetland Restoration

Wetland Restoration is the re-establishing of wetland vegetation and hydrology to a site that was historically a wetland but has been dried out by diking, draining, or filling. The number of potential wetland restoration sites will be limited by current land uses. Restoration may be impossible in areas that have current infrastructure or irreversible changes to hydrology sources. For example, wet meadows were more common in the Salem-Keizer area before development and before stream channels became incised due to an increase in stormwater runoff. Restoration of wet meadows where incised stream channels lower the neighboring water table will require both the restoration of vegetation and a change in the management of stormwater runoff.

The following maps and information provide a beginning to a process that will lead to a list of potential wetland restoration sites. An inventory, not unlike a local wetland inventory, will be needed to determine the availability and feasibility of restoring wetlands in areas that historically contained wetlands.

Watershed Summaries

Pringle

Pringle Creek is a perennial creek that drains the south Salem hills and a large flat area that extends from Kuebler Boulevard northwest through Fairview Industrial Park and the Salem Airport, crossing downtown Salem, and flowing into the Willamette Slough under Boise Cascade. Most of the hydric soils in the Pringle Creek watershed are mapped in the flat area that makes up the eastern portion of the watershed (**Map 6-6**).

Areas containing extensive hydric soils in the Pringle Creek watershed include the following:

1. A large belt of hydric soil is associated with Clark Creek. The belt extends from Gilmore Field, through the South Salem High School property and ends at Bush's Pasture Park. Land use in this area is mostly residential and public.
2. A large complex of hydric soils extends south of Mission Street and parallels the west side of Turner Road. Land use in this area is mostly industrial or commercial. The Salem Airport is zoned public. The Fairview Industrial Park sits on top of a large historic wetland. Wetland mitigation is occurring in this area to compensate for the loss of wetlands due to the development of the park. The mitigation has been met with limited success.

3. South and east of the Kuebler Boulevard and I-5 exit, land use is mainly industrial and residential. This area of the watershed is currently under development and vacant land is still in abundance.

Glenn-Gibson

The Glenn-Gibson watershed terrain is steep, particularly in the upper reaches, with flatter slopes near the basin outlet. Creeks flow down steeper gradients than on the valley floor and stream channels tend to be narrow and generally lack broad floodplain or riparian areas (Schott and Lorenz 1999). Hydric soils are limited to the lower reaches of Glenn and Gibson Creeks (**Map 6-7**).

The majority of hydric soils are mapped in three main areas in the Glenn-Gibson watershed:

1. The Turnage Brook sub-basin contains a belt of hydric soils along the base of the hills to the north. Land use is mainly residential and some commercial.
2. The confluence of Glenn and Gibson Creeks contains extensive hydric soils. About half of the historic wetland area lies just outside Salem's city limits at the base of an old river terrace. Glenn Creek flows across the Willamette River floodplain at the base of the terrace. The NWI maps indicate the presence of palustrine emergent and forested wetlands at this location. The rest of the hydric soil is mapped in a residential area just south of Gibson Creek.
3. The third large historic wetland was located along Glenn Creek as it flows north across agricultural land and into the Willamette River. This site is actually within the Willamette River floodplain. The NWI shows the presence of palustrine forested and scrub-shrub wetlands at this location.

Claggett

Claggett Creek drains most of east Salem from State Street north, including land along Lancaster Drive. The creek then flows north through the City of Keizer, into Clear Lake, and finally drains into a slough of the Willamette River. Mapped hydric soil complexes are abundant in the relatively flat terrain of the Claggett Creek watershed (**Map 6-8**).

Large hydric soil complexes are located in four main areas:

1. Long linear stretches of hydric soil are mapped in the upper portion of the watershed in east Salem. The location of hydric soils found in the watershed is typical of historic swales that once covered the flat valley floor of the Willamette River. Most of these swales have been filled, culverted and piped underground for development. There are limited opportunities for restoration in this area of the watershed.

2. An extensive belt of hydric soils is mapped in north Salem. The area includes the State Fairgrounds. Land use for most of the remaining area is industrial and residential with some commercial along Silverton Road.
3. Salem Industrial Drive lies in the middle of a historic wetland that stretches from Cherry Avenue to the Salem Parkway. The area is primarily used for industrial purposes, however, this area is under development, includes the Northgate Urban Renewal project, and vacant land is still present.
4. The largest historic wetland in the Claggett Creek watershed is Lake Labish. Once an extensive wetland, this area has been drained with a series of ditches. The west side of Lake Labish drains into Claggett Creek via the Labish Ditch. The area is now used intensively for row crops. Marion County Public Works is looking closely at the restoration potential of Lake Labish as part of its "Natural Heritage Park Selection and Acquisition Plan" (Marion County Public Works 2000). According to the plan, the peat soils of Lake Labish once supported a rare shrubland ecosystem. Restoration of the lake would improve water quality and could reduce flooding problems in the area. Because there are large land holdings within the area, restoration of large areas may be possible. Marion County has already begun negotiation with some the landowners to examine restoration potential.
5. Marion County Public Works (2000) also identified Mission Bottoms as a potential restoration site. The confluence of Claggett Creek and the Willamette River lies within the proposed project area. Restoration would include restoring riparian and wetland habitat along the Willamette River and restoring isolated oxbows on the Willamette River floodplain.

Mill

In the Mill Creek watershed, most of the hydric soil complexes are found on alluvial fan materials deposited by the North Santiam River and on older courses of the Willamette River. Previous channels of Mill Creek, "meander scrolls,'' can be observed in some parts of the bottomlands, but grading and filling have removed most of the undulating topography typically observed in floodplains (MWVCOG 2000).

Four areas with extensive hydric soils are found in the Mill Creek watershed (**Maps 6-9** and **6-10**):

1. A large belt of hydric soil extends south and east from State Penitentiary property on State Street to another piece of State Penitentiary property just east of Kuebler Blvd. Land use is dominated by industrial and public uses. Large gravel pits can be found in areas adjacent to Mill Creek. Historic wetlands on currently farmed land, owned by the State Penitentiary, may be restorable if farming ceased.

2. Extensive hydric soils are mapped at the confluence of Battle Creek, Waln Creek and Powell Creek. This confluence is located on the Battle Creek Golf Course between Sunnyside Road and Commercial Street.
3. McKinney Creek drains the south part of the Mill Creek watershed. Extensive hydric soil complexes are mapped along the entire length of McKinney and some of its tributaries. The branching pattern of hydric soils found east of McKinney Creek is typical of historic swales that once covered the flat valley floor of the Willamette River. McKinney Creek and its tributaries have mostly been channelized and are used extensively for irrigation purposes. Land south and southeast of Turner was identified by Marion County Public Works (2000) as having potential for wet prairie restoration.
4. Just north and east of Highway 22 and east of Aumsville, Beaver Creek and its tributaries once supported a large wetland complex in a small flat valley. Since settlement, Beaver Creek has been channelized and the wetlands converted to cropland. Marion County Public Works (2000) identified Beaver Creek and a tributary, Simpson Creek, as a potential site for wetland restoration. The Grenz Wetland Mitigation Bank is located in the Beaver Creek watershed and may provide the opportunity for Marion County to acquire a restored, shrubland ecosystem.
5. Historically, the area south and southwest of Aumsville was wet prairie. Much of the land is now unmanaged pasture. Marion County suggests that further examination is needed to determine the potential for wet prairie restoration southwest of Aumsville and in areas adjacent to the county-owned Aumsville Wetlands (Marion County Public Works 2000). Using the Aumsville Wetlands as a core area, a large wetland complex could be restored in this part of the watershed.

Summary

Riparian areas and wetlands provide many beneficial functions including fish and wildlife habitat, thermal regulation, flood storage, water quality and food chain support. Unfortunately, as a society we have neither understood nor valued these resources for the functions they provide us. Due to development, many riparian areas have been reduced to a thin strip of trees or have been fragmented extensively. Wetlands have been drained to accommodate agricultural practices and have been filled to make room for development. As wetlands and riparian areas disappear, water quality declines, flood levels increase, stream flows becomes flashy, and fish disappear from local streams.

Historically, riparian areas were once broad, and in some instances stretched several miles back from the streambanks. Wetlands covered large portions of our watersheds. Recent inventories of riparian and wetland resources indicate that the remaining wetlands and riparian areas are in critical need of protection, and in many cases are degraded and will require enhancement in order to recover lost functions.

Wetlands and riparian areas should be tools to manage urban landscapes. Land use policies should incorporate wetlands and riparian areas into the urbanizing landscape as mitigation for the impacts of increased impervious surfaces and to the changes in hydrology associated with urbanization. Taking advantage of the functions of riparian and wetland habitat will decrease the likelihood of having to pay for water quality improvements and flood damage at a later date. Protection measures such as ordinances, easements, land acquisition, and education for streamside property owners need to be established now to shield existing riparian and wetland habitat from further harm. Restoration and enhancement of riparian and wetland habitat should be incorporated into comprehensive plans, stormwater management plans, neighborhood plans, capital improvement plans, greenway development, Urban Renewal areas and soil erosion plans for farms.

Recommendations

All Basins

1. Gather data on riparian width and species composition of riparian areas not yet inventoried. Document baseline information.

2. Document stream reaches where the dominant understory species consist of invasive vegetation, and restore areas with plants native to the Willamette Valley and the local area.

3. Field verify streamside areas along the riparian corridor designated as low shade (red) on **Map 6-1** through **Map 6-5**, and determine feasibility of riparian enhancement.

4. Using available tools such as GIS (ArcView), map all unclassified stream sections and categorize into the high, medium, or low shade indexes. This will require more GIS time, field checking, and for some areas, better quality air photos.

5. The goal of all riparian projects should be to improve one or more of the four basic riparian functions: water quality, flood management, thermal regulation, and wildlife habitat. Use functional assessments to prioritize projects. A common resource goal should be to integrate the needs of both aquatic wildlife and local vegetation.

6. Develop a list of potential wetland restoration sites using the LWI, soils maps, historical and other appropriate data to determine availability and feasibility of restoring wetlands in areas that historically contained wetlands.

7. To assess site-specific restoration and enhancement potential, use an inventory and functional assessment as was done for Pringle Creek and Mill Creek in the local wetland/riparian inventories of Turner and Stayton. Use the assessment as one of many tools to determine which areas can feasibly be restored and/or enhanced.

8. Encourage the City of Salem and landowners and developers to accept the findings and recommendations provided in the newly completed Tree Canopy Analysis. The study's information should be used to strengthen the City's tree ordinance, complete a wetlands protection program and be incorporated into comprehensive plans as well as City plans for stormwater management, capital and infrastructure improvements, and neighborhoods. It also should be used in greenway development and in Urban Renewal areas.

9. In rural areas, actively manage the riparian zone to ensure LWD where feasible. In both urban and rural areas, riparian enhancement should include the long-term goal of establishing diverse patches of tree species, sizes, and age classes. This will improve habitat for both aquatic and terrestrial species.

10. Manage riparian areas at both the streamside level and at the larger landscape level. Protect what we have, and restore and enhance what has been degraded or lost.

11. Comply with the City of Salem's tree ordinance and provide input to improve the long term-ordinance, especially in protection of intermittent streams, adequate setbacks for development, and the protection of riparian habitat regardless of quality or whether or not native vegetation is intact.

12. Pursue wetland restoration opportunities in Lake Labish. Restoration of this drained and farmed wetland could provide substantial water quality and flood control benefits to both Claggett Creek and Pudding River watersheds. Restoration of this historic lakebed is also a priority of Marion County (Marion County Public Works 2000).

13. Identify wetlands outside urban growth boundaries. Contact appropriate landowners/agencies and initiate discussion about wetland protection measures, such as conservation easements and wetland enhancement/restoration projects.

14. Encourage Marion and Polk counties and all the municipalities in the watersheds to inventory and assess wetland and riparian resources. Encourage these agencies to provide protection for existing wetlands and riparian areas by developing ordinances that limit their development. Conservation easements and land acquisition could also be used to protect wetlands.

15. Provide streamside and watershed resident education to prevent further degradation of the riparian and wetland areas.

16. Meet Statewide Planning Goal Five and Six requirements.

17. Support the required removal debris from streambanks and wetlands, decommissioning unused or abandoned stormwater drains, and bank stabilization prior to any new or further development.

18. Identify and propose solutions for conflicting public policies such as conveyance and fire suppression versus water quality and healthy riparian areas. There are examples in the City of Salem Sensitive Lands Management Handbook.

19. Identify site-specific early action items by watershed as known.

20. Support continuing student research projects and compile results in an area clearinghouse.

21. Support establishing riparian zones. Limit development and require setbacks to protect them.

22. Support location of buildings and infrastructure away from streams, wetlands and riparian areas. Minimize road crossings.

23. Require at least a superficial Environmental Impact Statement (EIS) prior to any site disturbance in areas known or suspected to be special areas.

24. Support establishment of wetland conservation districts, such as the West Eugene Wetlands Program.

Claggett Creek

1. Determine which wetlands with high or moderate enhancement potential are located on public land, vacant land or in an Urban Renewal area. Identify landowners and initiate contact with them to discuss wetland enhancement projects. Determine feasibility of enhancement project by doing a site assessment.

Pringle Creek

1. Actively recruit private landowners to enter their property into the Wetland Reserve Program (WRP). Encourage landowners to contact Marion Soil and Water Conservation District and the Natural Resource Conservation Service and enroll the land in the Wetland Reserve Program (WRP). This federal program provides cost-share money to enhance and restore wetlands. Work with Marion Soil and Water Conservation District and the Natural Resource Conservation Service in accomplishing this goal.

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Chapter 7– Sediment Sources

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7 – Sediment Sources

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Introduction

Sediment in streams comes from the erosion of upland areas, lateral movement of stream channels (i.e., meandering), and downcutting of streambeds. Soil erosion is the removal of surface material by wind and/or water. Erosion is a natural process that happens in all watersheds. In nature, sediment movement is often episodic, with most erosion and downstream soil movement occurring during intense runoff events. Fish and other aquatic organisms adapt to deal with sediment amounts that enter streams under normal ranges of disturbance (Watershed Professional Network 1999).

In addition to natural rates of erosion, human-induced erosion can occur. Accelerated soil erosion on cropland, forest roads and construction sites is a potential source of sediment pollution to surface waters. Sediments can fill natural depressions and drainages, road ditches, and pool in creeks, destroying fish and wildlife habitat (Ecosystems Northwest 1999).

Separating human-induced erosion from natural erosion can be difficult because of the highly variable nature of natural erosion patterns. Furthermore, human-caused erosion may also be variable in timing and pattern. It is nearly impossible to specify when a human-induced change in sediment is too much for a local population of fish and other aquatic organisms to handle. But in general, the greater a stream deviates from its natural sediment levels the greater the chance that the fish and other aquatic organisms are going to be affected (Watershed Professionals Network 1999).

This chapter will identify the primary sediment sources in Pringle, Glenn-Gibson, Claggett and Mill Creek watersheds. The role of human-induced erosion in the study area is included in the discussion.

Data Sources

Data for this chapter was collected from the following sources: Marion Soil and Water Conservation District (Marion SWCD), City of Salem, Marion County, and the Oregon Department of Geology and Mineral Industries (DOGAMI).

Two Aspects of Erosion

Loss of material from eroded soil and the production of sediments are two major aspects of erosion (Knox et al. 2000). In most cases, both aspects are detrimental. Loss of material tends to reduce the productivity, stability, or utility of the eroded soil, and sediments resulting from water erosion tend to damage soils, water quality, and waterways downslope.

The amount of soil redistributed downslope from an area experiencing erosion is known as "sediment yield." Sediment yield is an important concept when discussing the connection between erosion and aquatic habitat degradation. In most instances, soil loss at an upland site will not directly impact aquatic habitat downslope. It is the amount of soil from the eroded site that actually reaches a stream or other waterbody (i.e., the sediment yield) that may impact aquatic habitat.

Sedimentation, the settling out of the soil particles that are transported by water, occurs when the velocity of water in which soil particles are suspended is slowed to a sufficient degree and for a sufficient period of time to allow the particles to settle out of suspension.

Importance of Sediments to Salmonids

The amount and type of sediments available in a stream is an important factor in determining adequate spawning habitat for salmonids. Although excessive sediments of any size (i.e., gravel, sand, silt) can negatively impact the survival and growth of salmonids, a certain amount of sediment, such as gravel, is necessary for spawning and for the survival and growth of juvenile salmonids. Coarse sediments also provide habitat for many of the aquatic insects that are a food source for salmonids.

Fine particles deposited on a streambed may blanket spawning gravels and reduce survival of fish eggs incubating in the gravel. Fine sediment may cover exposed rock surfaces preferred by aquatic insects, reducing the food supply to fish. Suspended sediments cause turbidity (clouding of the water), which limits visibility and prevents fish from feeding. Large deposits of coarse sediments can overwhelm the channel capacity, resulting in pool filling, burial of spawning gravels, and, in some cases, complete burial of the channel, resulting in subsurface stream flows (Watershed Professionals Network 1999).

Erosion Factors

Wind, ice, water and gravity all dislodge and relocate soil in the erosion process. Water is the primary means by which soil erosion leads to non-point source pollution. Water-based soil erosion processes are described below (Marion Soil and Water Conservation District 1982):

1. Raindrop erosion results from direct impact of raindrops upon soil particles. The impact dislodges soil particles, which can then be transported by the flow of surface runoff.
2. Sheet erosion is the removal of a layer of exposed soil by raindrop splash and runoff. The removal is by the movement of broad sheets of water over the land and is not confined to small depressions.
3. Rill and gully erosion occurs when runoff flows concentrate in rivulets, cutting several inches deep into the soil surface. These grooves are called rills. Gullies may develop in unrepaired rills or in other areas where a concentrated flow of water moves over the soil.
4. Stream and channel erosion can occur if the volume and velocity of runoff taxes the capacity of stream or channel banks and bottom.

Soil characteristics, vegetative cover, topography and climate interrelate to determine an area's erosion potential.

Soil Characteristics

Erodibility defines how susceptible a soil type is to erosion. Several specific factors determine actual soil erodibility (Marion Soil and Water Conservation District 1982):

1. Average particle size
2. Percentage of clay particles
3. Percentage of organic content
4. Soil structure

5. Soil permeability

Soils with a high percentage of sand and very fine silt are the most erodible. These materials are not tightly bound to other soil particles and are easily dislodged. As the amount of clay or organic matter increases, the soil's erodibility decreases. Clay serves to bond particles together and organic matter contributes to soil structure, thereby improving stability and permeability. Organic matter also increases soil capacity to absorb water, and thus reduce runoff (Marion Soil and Water Conservation District 1982).

The least erodible soils include well-drained gravel and gravel-sand mixtures with a minimum of silt. Long or steep slopes contribute to soil erodibility even for soils with low erodibility potential. In contrast, soils with high erodibility may erode very little in areas with gentle slopes or management practices that protect soils (Marion Soil and Water Conservation District 1982).

Vegetation

Vegetative cover is another factor in determining erosion potential. Its presence influences erosion in the following ways (Marion Soil and Water Conservation District 1982):

1. Shields the soil surface from the impact of falling rain
2. Slows the velocity of runoff by obstruction
3. Maintains the soil's capacity to absorb water
4. Holds soil particles in place

Promotion of land management practices that protect or restore existing vegetative cover and minimize exposed soil will significantly lessen soil erosion and related sedimentation. Preserving vegetation is particularly important in areas with high erosion potential, such as steep slopes, drainage ways and riparian areas (Marion Soil and Water Conservation District 1982).

Topography

A watershed's size and shape determine the quantity and rate of runoff, which influences the area's erosion potential. The greater the area's slope and runoff volume, the higher the potential for erosion (Marion Soil and Water Conservation District 1982).

The slope orientation contributes to erosion potential. A south-facing slope with minimal vegetation and unproductive soil may have difficulty re-establishing vegetation. To minimize potential erosion, bare slopes must be protected and replanted as soon as practical (Marion Soil and Water Conservation District 1982).

Climate

Erosion is also influenced by climatic factors, including the frequency, duration and intensity of precipitation. As runoff increases, its ability to transport soil directly also increases. Climate-related erosion potential varies seasonally according to temperature and rainfall (Marion Soil and Water Conservation District 1982).

Sediment Sources

There are many potential sources of sediments, but land use will determine which sources are important in a watershed. Pringle, Glenn-Gibson and Claggett Creek watersheds are highly urbanized or urbanizing watersheds. Land use in the Mill Creek watershed is predominately agricultural but the watershed is also experiencing a rapid rate of development as the cities of Salem, Turner, Aumsville, Sublimity and Stayton continue to grow. Important sediment sources in a landscape dominated by agricultural and urban land uses include the following:

1. Agricultural runoff (i.e., crop land and pasture)
2. Urban runoff
3. Eroding streambanks
4. Landslide hazard areas (i.e., hillsides that are unstable and vulnerable to landslides)

Agricultural Runoff

In rural areas, soil functions primarily as an ecological and hydrological resource that supports the growth of plants and controls the fate of precipitation (Knox et al. 2000). It provides water, nutrients, and mechanical support for natural or managed stands of vegetation, for animal populations, and for vegetation management practices.

Production of food, feed, and fiber is the primary motivation for vegetation management on farms (Knox et al. 2000). Soil loss from a crop field means a loss of nutrients, water retention, and a growing medium for plants. Healthy soil ensures the continual productivity of a farm operation. For this reason, soil retention on farm fields is of great importance.

Evaluating soil erosion from cropland is complicated, since it is related to many factors, such as the types of crops planted, soil type, farming practices, topography, and the timing of erosion-causing events (i.e., high intensity rainfalls, summer thunderstorms, quick snowmelt). In order for much soil movement to occur, these erosion-causing events must coincide with the cropland being vulnerable to erosion. When a field is covered by vegetation with thick roots, a high-intensity rainfall will not create much erosion. Yet, when that same field is freshly plowed, a high-intensity rainfall may cause extensive erosion (Watershed Professionals Network 1999).

Farming practices that incorporate erosion control measures are extremely important in areas with a high potential for surface erosion. **Map 7-1** and **Map 7-2** show the location of "highly erodible lands" (HEL) in the four watersheds. HEL is determined by using information regarding the soil characteristics of different soil types and the local topography. To encourage the use of erosion control practices on HEL, the federal government requires all farmers enrolled in farm subsidy programs to have a farm conservation plan if they have HEL on their land. The farm conservation plan will outline erosion control measures that the farmer must follow in order to reduce erosion from his or her property.

Reducing erosion from cropland helps protect streams not only from excessive sediment, but also from elevated nutrient and pesticide loads. Nutrients, such as phosphorus, and chlorinated pesticides attach themselves to fine soil particles and can be transported to streams during erosion events. Some soils associated with HEL contain high amounts of silt and clay, fine particles that readily attach themselves to nutrients, pesticides, toxic substances, and trace elements.

The amount and location of HEL in each watershed varies. In the Mill Creek watershed most of the HEL is located in the headwaters, tributaries of Beaver Creek, hills north of the City of Turner, west side of McKinney Creek and scattered throughout the entire Battle Creek basin (**Map 7-1**). In the Pringle Creek watershed, HEL is located in the mid-portion of the watershed between south Commercial Street and the East Fork of Pringle Creek. HEL predominates throughout the Glenn-Gibson watershed except for the lower portion of watershed along Wallace Road. Finally, the small amount of HEL in the Claggett Creek watershed is mostly associated with steep slopes immediately adjacent to waterways (**Map 7-2**). According to the historical vegetation maps presented in the Overview of Watersheds chapter, most of the HEL was once upland closed forest or savanna.

There are approximately 2,546 farms in Marion County. Approximately 306,000 acres of land is farmed in the county (See maps in the Overview of Watersheds chapter). According to the Economic Information Office of Oregon State University Extension Service, the agricultural commodity sales of Marion County totaled over $463 million dollars in 1998. Over 200 crops are grown in Marion County. The top ten agricultural commodities are shown in **Table 7-1**.

Table 7-1. Agricultural Commodity Sales ($) Marion County, 1998

Commodity	Sales (in millions of dollars)
Nursery	91
Grass seed	71
Vegetables	51
Dairy	45
Berries	35
Greenhouses	31
Christmas trees	30
Horticulture	25
Eggs	20
Hops	16

Source: OSU Extension Service

Erosion control continues to improve on farms with the help of the Natural Resource Conservation Service (NRCS), the local soil and water conservation districts, and cooperating landowners. The agencies work with a landowner to develop a farm management plan customized to fit the needs of the farmer while improving soil retention on crop fields and pastures. Minimum tillage, crop residue management, cover crops, contour farming, cross-slope farming, filter strips and riparian buffers are some of the techniques used by farmers to prevent erosion and to reduce the amount of sediment entering local streams.

Efforts to reduce the amounts of pollution from agricultural and rural lands continue with the development and implementation of Agricultural Water Quality Management Area Plans (AgWQM). The AgWQM Area Plans and Rules were created pursuant to Senate Bill 1010 (AgWQM Act), passed by the 1993 Oregon Legislature.

A commitment to healthy streams and improved habitat for threatened and endangered aquatic species, known as the Oregon Plan for Salmon and Watersheds, was developed by the state of Oregon in 1997. The AgWQM Act has been incorporated into the Oregon Plan as the agricultural community's response to water quality issues.

The Oregon Department of Agriculture, in consultation with other state agencies, determines priority watersheds for development of AgWQM Area Plans. Through its locally based planners, ODA assembles a Local Advisory Committee consisting of stakeholders residing in the watershed. The committee is responsible for developing a draft action plan to address water quality issues arising from agricultural activities and soil erosion on rural lands.

AgWQM Area Plans describe water quality issues, goals and objectives for the watershed. It also details strategies for improving water quality, such as education, funding for conservation projects, and one-on-one technical assistance for landowners. AgWQM Area Rules describe conditions that must be met on all agricultural lands, allowing landowners to decide how to meet the conditions. The intent of both Plans and Rules is to give landowners flexibility in meeting water quality standards and encourage water quality improvements through voluntary conservation as much as possible. Enforcement is used as a last resort when repeated attempts to develop a voluntary solution have failed.

The AgWQM Plan for the Mollala-Pudding-French Prairie-North Santiam Sub-basins (Mollala-Pudding-French Prairie-North Santiam Sub-basins Local Advisory Committee 2001) includes the rural lands found in the Mill Creek, Claggett Creek and Pringle Creek watersheds. An AgWQM Plan being developed for the Middle Willamette AgWQM Area in Polk and Benton Counties includes the Glenn-Gibson watershed.

Urban Runoff

In urban locations, sediment derived from erosion has a major environmental impact. In these developed areas, the primary source of sediments is from active construction sites. According to recent studies, construction sites transport sediment at 20 to 2,000 times greater the rate of other land uses (Schueler 2000a).

Approaches to soil management differ significantly between urban and rural areas. This has implications for sediment and erosion. At rural sites soil is treated as an economic, ecological and hydrological resource that is essential for crop growth. In urban locations soil is excavated and relocated to facilitate residential and commercial uses. Thus, erosion prevention and sediment control methods vary between urban and rural settings (Knox et al. 2000).

At urban construction sites, most of the erosion occurs during the brief period of actual construction. Less erosion takes place before construction begins, and it tapers off afterwards. One reason that construction sites have so much erosion is that in most cases construction start-ups include removal of the vegetation. Heavy equipment tends to compact soil surface layers. These bare soils are at risk for erosion, as are exposed agricultural lands before crops are planted (Knox et al. 2000).

Soil loss in rural areas has serious ramifications for agriculture, including lesser water retention and fewer nutrients for growing crops. In contrast, soil loss at urban construction sites is relatively small and can be replaced without major expense. Urban erosion is important because it is the source of potentially damaging sediments in local waterways. In urban locations, sediment yield often has more impact than loss of soil at the construction site (Knox et al. 2000).

In response to the listing of several salmonid species under the federal Endangered Species Act and growing concern over water quality in the Willamette Valley, many cities are beginning to adopt stricter erosion prevention and sediment control ordinances. The City of Salem has recently adopted a new Erosion Prevention and Sediment Control Program, found in Chapter 75 of the Salem Revised Code. The ordinance was effective as of September 2001. The principal focus of the ordinance is to prevent erosion from all "ground-disturbing activities" such as new home and building construction, fill and removal activities, and other types of construction in which soil is exposed or moved. The intent of the new program is to minimize the amount of sediment and other pollutants reaching our waterways, wetlands, and the public storm drainage system and thus protect the environment during the life of the ground-disturbing activity. Permits and City of Salem compliance inspections are required with the new ordinance. The program also establishes "performance standards" which apply to all parcels and all land within the city, regardless of whether that property is involved in a construction or development activity (City of Salem 2001a).

Other Sources of Sediments in an Urban Setting

In addition to construction sites, other sources of sediment in urban areas include wind- deposited soil or atmospheric deposition (often from sources far removed from the local watershed), degrading pavement, and erosion from yards and other areas not covered by impervious surfaces. Stormwater sediments may include leaves, twigs, grass clippings, and pet waste.

Different types of land within an urban setting produce different amounts of sediment (Watershed Professionals Network 1999). Residential neighborhoods produce the least amount of sediment per square mile. Commercial areas produce moderate loads of sediment, and heavy industrial areas produce even higher amounts.

The importance of these sediments to water quality is evident not only in the amount of sediment that could potentially reach local streams, but also in the amount and kind of pollutants associated with the sediments. According to a study conducted in Alameda County, California (Mineart and Singh 2000), sediments found trapped in storm drain inlets were highly enriched in trace metals and petroleum hydrocarbons; residential areas had the highest concentration of petroleum hydrocarbons and commercial and industrial areas had the highest metal concentrations (i.e., copper, lead and zinc).

Street cleaning, frequent catch basin cleaning and the use of detention ponds are tools typically used in an urban environment to reduce the amount of sediments entering the stormwater system and waterways. The effectiveness of these tools can vary.

Street Cleaning

Regular street cleaning can make quite a difference in how much sediment ends up in the stormwater. Normal mechanical sweeping does a moderately good job of reducing sediment in curbs and parking lots. Vacuum-assisted cleaning following mechanical sweeping removes an even larger portion of surface sediments, especially those sediments that are lightweight or small and do not readily settle out in detention ponds (Watershed Professionals Network 1999).

The City of Salem regularly cleans it streets using regenerative air sweepers (City of Salem 2000). Salem sweeps its central business district and Capitol Mall area once a week, increasing the frequency of cleaning to two times a week during summer months. The frequency of residential sweeping is determined by debris accumulation rates identified in four categories: *Light, Medium, Heavy, and Very Heavy*. The *Very Heavy* debris accumulation zone contains five routes and is swept eight times per year. Eleven routes are ranked as *Heavy* accumulation zones and are swept six times per year. The *Medium* debris accumulation zone contains 13 routes and is swept four times per year. The 12 routes in the *Light* zone are swept twice a year. All accumulated debris is disposed of in the City's DEQ-approved landfill site located at the south end of the McNary Field Airport, near the shared watershed boundary of Pringle and Mill creek watersheds.

The City notes both quantity and quality of material collected by the street sweepers. According to the City of Salem (2000), the City swept 12,900 curb miles, collected 2,480 cubic yards of sweeping debris, and removed 4,500 cubic yards of leaves during the 2000-2001 fiscal year. The City plans to expand the street sweeping program. The annual budget of the program increased in fiscal year 2001-2002. Plans to increase the budget and add a fourth sweeping machine is targeted for the 2004-2005 budget. The City of Salem also uses volunteers through its Adopt-A-Street program to help keep streets clean. The program has been very successful. In fiscal year 2000-2001, 1050 volunteers collected 13,480 pounds of trash from our city streets.

Catch Basin Cleaning

Storm drains help convey urban runoff from streets to receiving waters. Depending on the design of the stormwater system, the system has some capacity to capture and temporarily store sediments and debris. Storage components include drop inlets, sump pits or catch basins (Mineart and Singh 2000).

Many public works departments across the U.S. annually remove the sediments that accumulate in storm drain inlets using vactor trucks or manual methods. In Salem, catch basins are cleaned on a proactive basis, supplemented on an "as needed" basis based on complaints, storm conditions, and observations made by city crews (Downs pers. comm.). The "Catch Basin Rangers" clean all of the catch basin grates on a regular basis during the leaf season (normally October thru January). The goal of keeping the grates clear during the leaf season is to avoid local ponding/flooding conditions. From January to March, the catch basin themselves are cleaned of debris and sediment.

While catch basins are cleaned regularly, trash does still reach our streams. For this reason, the City of Salem supports the volunteer-based annual City-wide stream cleanup program. This program is now supplemented by the Public Works seasonal "stream team" which utilizes a team of twelve seasonal employees to walk the urban streams and remove trash and debris, including "log jams" and other similar blockages that impair the streams' flow and carrying capacities (City of Salem 2000). In 2000, over 47,000 pounds of trash and 33 cubic yards of recyclable material were recovered from

Salem's creeks, including 12,100 pounds from Clark and Pringle Creeks, 1,560 pounds from Glenn Creek, 16,120 pounds from Claggett Creek and 12,560 pounds from Mill Creek (including Shelton Ditch and Waln Creek).

The City of Salem has also initiated a storm drain stenciling program. Storm drain stencils remind citizens not to dump any wastes into their local storm drains. The total number of storm drains stenciled to date is unknown. From 1997 to 1999 approximately 1,020 storm drains had been stenciled (City of Salem 2000). Storm drain markers have recently been incorporated into the program. In 2001, curbside markers were applied to 350 storm drains in the Glenn-Gibson watershed. The markers are like stickers that are applied to a curb using an adhesive.

Finally, roadside maintenance practices have been improved to reduce the amount of sediment entering storm drains (City of Salem 2000). Roadway pavements are repaired as rapidly as resources and weather allow, thus decreasing the amount of degraded pavement entering storm drains. Where possible, potholes are now fixed with hot asphalt instead of "cold mix" asphalt. This helps reduce the amount of asphaltic debris migrating into drainage ditches and catch basins. Regenerative air street sweepers are regularly used to clean debris from roadways after repairs are made.

Where possible, graded shoulder widths are reduced to a minimum in order to promote vegetation growth near roads (City of Salem 2000). The vegetation helps stabilize slopes and retain aggregate in the shoulder area, filter road surface runoff, and still allow stormwater to properly drain from road surfaces. The type of rock used for shoulders has also been changed. Shoulder rock now being utilized is "fully fractured," which locks into place and has greatly reduced the amount of erosive aggregates into the creeks, ditches and catch basins.

Detention Ponds

The final tool used to reduce the amount of sediments entering stormwater systems and waterways is the construction of stormwater detention ponds. Stormwater ponds are one of the most effective techniques for providing channel protection and pollutant removal for urban streams (Schueler 2000b).

The City of Salem has 550+ on-site detention facilities (City of Salem 2000). These facilities were inventoried and field evaluated for their effectiveness in controlling stormwater quantity and quality during the summer of 1997. Each facility's location and identification number is now included in the City's GIS system for the stormwater infrastructure system. The detention facility field inventory and evaluation is being repeated during the spring/summer of 2001, with the resulting data and photos being incorporated into the City GIS system for quick reference and updating.

To improve the functions of stormwater detention ponds, the City of Salem has initiated a maintenance program that includes scheduled City inspections, public information regarding owner operation and maintenance responsibilities, and compliance assurance procedures to encourage proper maintenance and operation (City of Salem 2000). The City is also pursuing the use of regional detention facilities. Consultants have been hired to evaluate the identified potential regional detention sites (see Hydrology chapter).

Marion County Best Management Practices

Marion County recently developed BMPs for routine road maintenance, parks and facilities maintenance, ferry operation, engineering design, and other activities. These BMPs include actions to reduce soil erosion. The intention of the BMPs is to guide specific Public Works activities in the County's on-going efforts to aid salmon recovery. The *Marion County Department of Public Works Best Management Practices* was adopted by the Marion County Board of Commissioners on July 11th, 2001 (Marion County Public Works Department 2001).

The BMPs and supporting documentation (Maps, Environmental Baseline Assessment, ODOT comparison matrix, etc.) to seek a programmatic limitation under Limit 10 of the Endangered Species Act's 4 (d) rules was submitted to the National Marine Fisheries Service in September of 2001 (Marion County Public Works Department 2001).

Channel Erosion

The appearance of a channel reflects site-specific, relatively short-term processes, such as flow energy, and broader resistive forces such as geology and climate. The complex interactions among these factors ensure that stream channels are seldom in a steady state. Channel erosion is an example of these dynamics. It is a natural process resulting from the flow energy being greater than the resistive forces. Channel erosion and meandering help create gravel deposits, deep pools, and areas of low water velocity that are critical to fish habitat. However, considerable damage can be done to a stream and the fish habitat it provides by drastically changing the relationship between flow energy and resistive forces (Watershed Professionals Network 1999).

Stream bank or channel erosion removes portions of the land surface above and adjacent to the bank. When high flows saturate soils and undercut the toes of banks, unprotected stream banks slough or collapse in large slabs, delivering sediments directly into the stream (Ecosystems Northwest 1999). Severe channel erosion destroys the productive capacity of the soil, vegetation, fences, roadways, and buildings on the undercut land.

Channel erosion is frequent in urban settings (Knox et al. 2000). Streets, buildings, and other impermeable surfaces reduce infiltration of precipitation to zero, transmit runoff efficiently in the short term, and concentrate water flow. Extensive areas of impervious surface in urban settings increase the total runoff and greatly augment peak stream flows, thus increasing stream power. One study estimated that channel erosion rates were three to six times higher in a moderately urbanized watershed (14% impervious cover) than a comparable rural one, with less than 2% impervious cover (Neller 1988; Caraco 2000). Public and private landowners attempt to counteract the higher rates of erosion in urban areas by increasing the resistive forces of the stream banks. This is done by replacing the earthen banks with riprap (i.e., large chunks of concrete, rocks or other hard material) or retaining walls.

Channel erosion is exacerbated in urban areas even where attempts are made to preserve the natural character of the streams. In many parks and natural areas, recreation near or in streams results in a loss of streamside vegetation, compacted soils, and disturbance to the streambed. The number of humans and dogs climbing into creeks in urban areas is causing Salem's Parks Operations to consider designing appropriate "access points" on sensitive lands, such as at Woodmansee Park in South Salem.

Human-induced channel erosion also occurs in rural areas. Streamsides are vulnerable to intensive grazing. Livestock are attracted to the lush vegetation of riparian areas in late summer and fall when other foraging areas have become dry and less productive. When intense grazing occurs during this period, streamsides are left with sparse foliage and root mass during potential high-flow periods in winter and spring.

Eliminating riparian buffers and cropping to the top of bank can also increase rates of stream bank erosion. Annual crops do not provide the aboveground stem density or the belowground root mass necessary to keep soil in place. High flows in winter and spring can easily erode stream banks denuded of perennial vegetation and wash away fertile soil. Examples of this may be found along Mill Creek above Stayton.

Management practices that can help slow high rates of channel erosion include the establishment and maintenance of a riparian buffer, and limiting development and certain activities within the buffers. Flow energy can be decreased by incorporating stormwater detention ponds, restoring wetlands in floodplains, using bioengineering techniques for bank stabilization, and reducing the amount of impervious surface in a watershed.

No survey has been conducted on the location and extent of channel anchoring in local streams in the study area. No survey is available on the location and extent of stream banks that may be experiencing moderate to high rates of erosion.

Landslide Hazard Areas

Many hillsides, especially in Western Oregon, are unstable and vulnerable to landslides, debris flows, and mudflows. These can result from ground saturation, runoff, improper or poorly designed drainage systems or earthquakes. Landsliding is a natural process that tends to reduce the height and slope of mountains and ridges and is part of the normal ongoing process of smoothing topographical high points. Slides occur in natural materials and in placed fill materials. The process is simple: a mass of earth slides when the forces from the weight of the slide mass exceeds the strength of the material holding it in place. Determining specifically when and where sliding will occur is difficult. Landslides and mudflows occur especially when prolonged heavy rainfall saturates the soil and rocks, and when human activities steepen the slopes, remove the toes of slopes, add weight or water to the slopes (City of Salem 2001b), or remove vegetation.

Map 7-3 shows the landslide hazard areas in the four watersheds within the Salem-Keizer UGB. The hazard areas delineated are actually the combination of three data layers: slopes greater than 25%, slopes that may be unstable during earthquakes, and areas that are susceptible to water-induced landslides. The latter two layers of data were developed by the Department of Geology and Mineral Industries (DOGAMI). Land was "scored" on its susceptibility to landslides based on the three parameters given above. Unfortunately, DOGAMI only had information regarding earthquake-susceptible slopes and water-induced landslides for West Salem and the southwest portion of Salem, so the remaining land within the Salem-Keizer UGB was only scored using the 25% slope criteria. This lack of information explains why many areas in the UGB scored no higher than "3" on their susceptibility to landslides. If information on the other two data layers was available, some of the areas scoring "3" or lower may actually score higher.

DOGAMI has developed earthquake-induced landslide hazard maps, and a report explaining how the maps were made, for small communities throughout Oregon, including Aumsville, Sublimity, and Stayton in the Mill Creek watershed (Madin and Wang 2000).

Landslides are a natural phenomenon, but the risk of human-induced landslides needs to be reduced in order to minimize human and physical losses. To reduce the risk of landslide hazard, local governments will need to use a variety of tools. These may include land use planning, building codes, zoning regulations, public education, open space preservation, and other activities. The City of Salem has a Landslide Hazard Ordinance.

Marion County has also passed a landslide ordinance, effective in 2002. The ordinance applies only to landslide hazard and excessive slope areas in the county that have been identified and mapped (Marion County Community Development Department 2001). In the four watersheds, steep slopes susceptible to landslides outside of the Salem-Keizer UGB are located in the Battle Creek basin and the upper portion of the Mill Creek watershed above Stayton.

Summary

Erosion is a natural process. Human-induced erosion accelerates natural background rates of erosion and can increase the sediment yield in streams, thus degrading aquatic habitat. Separating human-induced erosion from natural erosion is difficult because of the highly variable nature of natural erosion patterns. In addition, human-induced erosion also tends to be variable in timing and pattern (Watershed Professionals Network 1999).

The main sediment sources in the four watersheds include: agricultural runoff, urban runoff, channel erosion, and slopes susceptible to landslides. While the amount of sediment contributed from each of the sediment sources is unknown, steps are being taken to reduce erosion rates in both agricultural and urban settings. The implementation of Agricultural Water Quality Management Plans and farm conservation plans will facilitate the incorporation of erosion control measures on farmland. Changes in land use planning, building codes, construction site maintenance, and zoning regulations will help reduce erosion rates in urban areas. Open space preservation, strict riparian and wetland preservation ordinances, and restoring/enhancing riparian buffers will aid in reducing channel erosion and decreasing sediment loads in streams.

Recommendations

All Basins

1. Estimate surface erosion rates from cropland, pasture land, and fallow (unmanaged) land using a model based on the Universal Soil Loss Equation. This equation will require the collection of data on rainfall intensity, erodibility of soils, steepness and length of slopes, crop type, and type of farming practice (i.e., conservation tillage vs. no conservation tillage), and vegetation type in areas not farmed. Use the model to develop a map that shows the location of erosion "hot spots" in the rural portions of the watersheds.

2. Estimate surface erosion rates and sediment load estimates in urban areas using a land use-based model. Refer to the Long Tom Watershed Assessment (Thieman 2000) for more details on this kind of model.

3. Collect information on turbidity and flow in streams and use data to calibrate both the agricultural and urban model for erosion rates and sediment yields. The City of Salem has collected information on turbidity and total suspended solids (TSS) on a monthly basis for the four watersheds. This information was not analyzed in this assessment due to time constraints. The data collected can be used to determine background rates of turbidity and TSS.

4. Conduct a survey on the location and extent of channel armoring (i.e., riprap, retaining walls, gabions, etc.) in our creeks. Determine channel erosion "hot spots" and when feasible use bioengineering techniques, including restoring wetlands and riparian buffers, to alleviate erosion rates.

5. Support the City of Salem's new Erosion Prevention and Sediment Control Program. Encourage county and other city governments to adopt ordinances that prevent erosion and control the amount of sediment entering our streams. Ordinances should include compliance inspections at construction sites to ensure erosion control measures are being followed. Ordinances should be updated and modified as new information on surface erosion rates, sediment loads, BMPs, and bioengineering techniques becomes available.

6. Limit development in riparian areas, wetlands and floodplains, which slows the rate of surface runoff, and reduces the sediment entering streams. These areas also reduce the rate of urban streamflow and decrease channel erosion. The protection of these natural areas decreases the need for expensive stormwater facilities.

7. Where natural watershed features can no longer manage urban stormwater runoff, support the construction of detention ponds that use native vegetation to provide improved water quality and wildlife habitat.

8. Provide education to maintenance crews, groundskeepers and construction crews on Best Management Practices (BMPs) for soil erosion. Support programs such as Salem's Parks Operations Sensitive Lands Management Program. Also help large landholders such as Willamette University and the State of Oregon, to use BMPs for soil erosion because their maintenance and construction activities have a significant impact on water quality.

9. Encourage local public works departments to continue incorporating street maintenance procedures that reduce erosion.

10. Provide volunteers for Adopt-A-Street, stream cleanups and storm drain stenciling programs.

11. Increase the efficiency of existing stormwater detention facilities by supporting the City of Salem's maintenance program for them. Provide public education to people who have stormwater detention ponds on their property and emphasize the importance of maintaining them for the health of local streams and the protection of property downstream.

12. Analyze data to determine what relationship exists between soils/sediments and pesticide/fertilizer residues. Specifically,

    a. Determine which types of soils have the greatest propensity for binding with chemical pesticides and fertilizers.

    b. Determine the potential cumulative effect of soils laced with pesticides coming into contact with urban runoff particulates and the substances concentrated in catch basins. For example, what is the carrying capacity ot binding capability of HEL soils when placed in contact with industrial/parking lot runoff?

    c. Determine if there are greater risks with pesticide or chemical-laced soils in the areas identified as being HEL.

    d. Determine whether additional protections are merited in Salem's erosion control program and landslide hazard ordinances for areas with HEL.

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Chapter 8 – Water Quality

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Introduction

The following chapter provides an initial evaluation of water quality information using simplified methods. The purpose of this level of assessment is to flag obvious areas of water quality impairment in the watersheds.

The term "water quality" includes the water column and the physical channel required to sustain aquatic life (Watersheds Professional Network 1999). Water quality is defined by a multitude of different parameters. Physical and chemical measures of water quality include temperature, dissolved oxygen, turbidity, total suspended solids, nutrients, and toxins such as heavy metals, pesticides and other chemicals. Biological parameters include the type and abundance of bacteria, algae, macroinvertebrates (i.e., aquatic insects), and fish.

Parameters commonly measured in a stream monitoring program are described in **Table 8-1**. A brief description on how some of these parameters affect salmonids is given in the following text.

Data Sources

Data for this chapter was compiled from the following sources: City of Salem, Oregon Department of Environmental Quality (DEQ), Oregon Water Resources Department (OWRD), U.S. Geological Survey (USGS), Oregon Department of Geology and Mineral Industries (DOGAMI), Glenn-Gibson Watershed Council, and McKay High School.

Water Quality Parameters

Temperature

High water temperatures can impair feeding, growth, and reproduction of aquatic organisms and even cause death. High stream temperatures can decrease the capability of water to hold dissolved oxygen that is crucial to the survival of aquatic organisms. Fish species vary in their tolerance to water temperatures. Even a small change in temperature can drastically affect fish life cycles. Salmonids, including salmon and trout, are especially vulnerable to temperature changes or extremes before they hatch and during their early stages of life. Spawning activities, metamorphosis, and migration can be triggered at the wrong time of year by a slight change in temperature. This, in turn, can decrease or destroy a species' chance for survival. Temperature increases may also enable warm-water fish species (e.g. bass and bluegill) to gain a competitive advantage or may facilitate predation of juvenile salmon and trout.

Removal of streamside vegetation, heated industrial discharges, return flow from irrigated fields, summer stormwater runoff from highly urbanized areas, water impoundments and low stream flows may elevate stream temperature.

Oregon Department of Environmental Quality's (DEQ) temperature standard for cold-water fish is 64 degrees Fahrenheit (17.8 Celsius) over a 7-day moving average unless there is cold-water fish spawning or bull trout habitat. These special habitat areas have standards of 55 (15.3 Celsius) and 50 (13.9 Celsius) degrees Fahrenheit respectively. In the lower Columbia and Willamette rivers, the temperature standard is 68 degrees (18.9 Celsius).

Dissolved Oxygen

Fish absorb oxygen from the water through their gills. They are sensitive to the amount (partial pressure) of oxygen in the water, just like humans are sensitive to the amount of oxygen in the air they breathe (Long Tom Watershed Council 2000). Low amounts of oxygen in the water may cause stress or even death to some aquatic organisms.

The quantity of dissolved oxygen in a stream is a function of atmospheric pressure, water turbulence (i.e., a babbling brook vs. still water), water temperature, and amount of biological activity (Portland Multnomah Progress Board 2000). Dissolved oxygen is negatively correlated with high temperatures: as water temperature rises, the carrying capacity of the water decreases and it is unable to hold as much oxygen. The same relationship occurs between dissolved oxygen and the amount of biological activity. Waterbodies with large amounts of algae produce lots of oxygen.

Table 8-1. Limiting Water Quality Parameters and Their Effect on Salmonids

Water Quality Constituent	Definition	Importance to Salmon	General Threshold	Criteria for Protecting Fish[1]
Temperature	See text	Affects metabolism, growth, embryo development, fry emergence, smoltification	Depends on species and life stage; e.g., tolerances for Coho range from 40^0F for spawning to 60^0F for adult migration; also see preferred and lethal temperature table.	64^0F (17.8^0C) 7 day moving average of daily maximum (DEQ standard)
Dissolved Oxygen	See text	Oxygen supports high energy demands associated with upstream swimming.	DO levels of 8-9 mg/L or more are needed to ensure that normal physiological functions of salmon are not impaired; low dissolved oxygen is correlated with high water temperature.	DEQ standard is 8.0 mg/l 30-day mean minimum for cold-water fish; 6.5 mg/l 30-day mean minimum for cool-water fish; 5.5 mg/l 30-day mean minimum for warm-water fish
Total Suspended Solids (TSS)	Fine particles that are suspended in water; includes silts, clays, & microscopic algae. See "Sedimentation" section in text.	Smothering of spawning gravels; pool filling; respiratory abrasion; reduced growth, reduced feeding rates, impair homing instincts.	No thresholds, although salmon typically prefer water with low turbidity and suspended sediment content. Some suspended sediment may actually be beneficial because it attaches to harmful chemicals (thus reducing the toxin's bioavailability to salmon).	None.
Turbidity	Measures the clarity of water by assessing the amount of light that scatters when a beam of light is passed through a water sample. See "Sedimentation" section in text.	Smothering of spawning gravels; pool filling; respiratory abrasion.	No thresholds, although salmon typically prefer water with low turbidity and suspended sediment content.	<50 NTU maximum above background levels (OWAM guideline); Ground disturbing activities should not increase the natural, background stream turbidity by more than 10% (DEQ standard).
Total Dissolved Solids (TDS)	Non-particulate material dissolved in water.			Total instream dissolved solids should not exceed 100 mg/L (DEQ standard).

Water Quality Constituent	Definition	Importance to Salmon	General Threshold	Criteria for Protecting Fish[1]
pH	A logarithmic scale that measures the acid or base concentration of the water. See text for further explanation.	Can be lethal to fish and other aquatic organisms if pH is too high (high base concentration) or too low (high acid concentration). pH and high temperatures together can increase the toxicity of certain chemicals such as ammonia and metals.	Fish prefer water that is close to pH neutral.	pH 6.5-8.5 (DEQ standard)
Nitrogen (N, NO3, NO2, NH3)	Important plant nutrient; in water usually occurs as nitrate (NO3) or ammonia (NH3). See "Nutrients" section in text.	Nitrogen is needed for plant growth. Algae and other aquatic plants are a source of food for aquatic insects. Salmonids, in turn, rely on an abundance and diversity of aquatic insects for growth and survival.	High nutrient levels in surface water promotes rapid growth of algae (a.k.a. algal blooms). As these algal blooms die and decompose, bacteria consume the algae and respire, using a significant portion of the dissolved oxygen in the water. The amount of oxygen remaining in the water may not be sufficient for the continual survival of salmonids.	< or = 0.30 mg/l (OWAM guideline)
Phosphorus (P, PO4)	Important plant nutrient; in water usually occurs as PO4. See "Nutrients" section in text.	Same as above.	Same as above.	< or = 0.05 mg/l (OWAM guideline)
Biological Oxygen Demand (BOD)	Reflects the amount of carbon in the water; high carbon concentration=high BOD. See "Nutrients" section in text.			None
Chemical Oxygen Demand (COD)	Reflects the amount of chemicals in the water that can be oxidized (a process that removes available oxygen from the water).			None
Toxic Substances				
Heavy Metals	Includes elements such as arsenic, cadmium, chromium, copper, lead, mercury and zinc. See "Toxic Substances" section in text.	Depending on the metal, even small amounts in surface water can be toxic to fish.		Each metal has a different standard; often depends on water hardness.

Water Quality Constituent	Definition	Importance to Salmon	General Threshold	Criteria for Protecting Fish[1]
Organic Compounds	Compounds containing carbon; some can be highly toxic. See "Toxic Substances" section in text.	Taking oil as an example of a carbon-based compound, oil can affect the gills of fish and interfere with respiration, coat and destroy fish food sources, coat the bottom of streams and interfere with spawning areas.		Each compound has a different standard.
Pesticides	See "Toxic Substances" section in text.	Depending on the pesticide and its concentration in the water, pesticides can cause behavioral changes in aquatic organisms, developmental deformities, and/or death. Some pesticides can bio-accumulate, becoming more concentrated as contaminated prey is consumed by organisms higher in the food chain.		Each pesticide has a different standard; many do not have established standards.
Biological Parameters				
Bacteria	Bacteria group used as an indicator of human or animal feces. See text for further explanation.	High counts of fecal coliform bacteria sometimes correlates with high levels of nutrients. (See Nitrogen and Phosphorus)		Standard for water-contact recreation for *E.coli* (DEQ standard states not to exceed): • 406 cells/100ml: single sample • 126 cells/100ml: log mean of at least 5 samples over 30 days Old standard for fecal coliform: • 200 cells/100ml: log mean of at least 5 samples over 30 days with no more than 10% of the samples in the 30 day period exceeding 400 cells/100ml
Macro-invertebrates	Aquatic insects and larvae commonly used to assess stream health. See text for further explanation.	Serve as a food base for salmonids and other aquatic organisms.		None

[1] DEQ water quality standards for Willamette Basin in ORS 349-041-0442; OWAM guidelines taken from Watershed Professionals Network (1999)

Table Adapted from:

1. Portland Multnomah Progress Board (2000)
2. Thieman (2000)

Factors such as high Biological Oxygen Demand (BOD), nutrient loads from point and non-point sources, urban stormwater runoff, dredging, combined sewer over flows, and sanitary sewer over flows can lower the amount of dissolved oxygen in a stream by encouraging excessive algal growth.

In waters supporting salmonids, the necessary DO levels range from 11 mg/l in spawning and rearing waters to 6 mg/l in non-spawning waters (the absolute minimum DO level needed to avoid acute mortality) (Oregon Plan Monitoring Team 1999). Dissolved oxygen levels of 8-9mg/l or more are needed to ensure that normal physiological functions of salmonids are not impaired. DEQ has set a standard of 8.0mg/l 30-day mean minimum for cold-water fish.

Sediments

Excess soil erosion can cause serious problems for a stream or waterway. Sediment suspended in a stream can smother spawning gravels (i.e., bury salmon eggs), fill pools, clog the gills of fish, bury food sources such as insect eggs and larvae, impair the vision of sight-feeding fish for locating their prey, as well as block needed light to underwater plants. Sediments also carry with them heavy metals, nutrients and pesticides that can negatively impact the quality of the aquatic environment.

A healthy stream will have naturally suspended sediment because the stream acts as a large conveyor belt carrying sediment, silt, and organic matter while carving out valleys and shaping the landscape. Although erosion is a natural process, an unnatural acceleration of erosion levels can be caused by land-disturbing activities of people. In urban areas, flushes of sediment into a stream are episodic and exacerbated by high flow and storm events. One major source of excess sediment is construction sites where erosion barriers are improperly maintained or not in place. Agriculture is another major source of excess sedimentation. This results from poor farming practices such as farming on highly erodible land or hillsides or over-planting. Surface mines, logging operations, filling floodplains for development, stream channelization, and excess water runoff from paved urban areas all contribute to erosion. When these sources of excess erosion are not abated or prevented, a stream can be seriously degraded (Izaak Walton League 1999).

In the Willamette River Basin, urban sites contribute the greatest amount of suspended sediment to the Willamette River on a *per-acre* basis. Agriculture, however, contributes more sediment to the Willamette River than any other activity in the basin (Institute for the Northwest 1999).

Particles in water may stay suspended indefinitely, or eventually settle out. Turbidity and total suspended solids (TSS) are two ways to measure these particles. DEQ does not have a standard for suspended solids. As for turbidity, DEQ states that no ground-disturbing activities should increase the natural, “background” levels of turbidity in a stream by more than 10%.

pH Levels

This indicator measures the hydrogen ion activity in water and its relative acidity on a scale of 1 to 14. A pH of 1 is most acidic, pH of 7 is neutral, and pH of 14 is least acidic or most basic. Normal rainfall is actually slightly acidic, with a pH ranging from 5 to 6 in the Pacific Northwest. In Salem, rainfall is slightly more acidic than the normal range for the Pacific Northwest; median value of local rainfall is 4.6 (City of Salem 1982). The pH of rainwater increases as it hits the ground and penetrates the soil surface or other substances. In fact, the average pH measured in Salem's streams is around 7.0 (Miller pers. comm.). The pH of water can be affected by human activities (e.g. industry, automobile exhaust, etc.), the soil and rock types in the watershed and even the amount of photosynthetic activity by algae in the water.

One reason for low pH values and high acidity is acid rain. In addition, acids can be released suddenly during the spring thaw when snowmelts occur, freeing acids concentrated in the ice during the winter months. Acids formed are from oxides of sulfur and nitrogen released into the atmosphere from combustion of fossil fuels—such as coal and oil—and from power plants, factories, and automobiles. Effluents from steel mills, plating mills, paper mills, tanneries, textile mills, and chemical plants also contribute to low pH in streams. Low pH and high water temperatures together can increase the toxicity of certain chemicals such as ammonia and metals (Izaak Walton League 1999) as well as directly affect fish.

DEQ specifies the expected pH range as 6.5 to 8.5 for basins west of the Cascades.

Nutrients

The most common nutrients contributed by human activities include nitrogen and phosphorus. These elements are important plant nutrients and can be limiting factors for plant growth. Excess levels of either of these nutrients can lead to large algal blooms, which in turn lead to lower dissolved oxygen levels.

Excess organic matter, such as algal blooms, causes many problems in streams including blocked surface light to submersed aquatic plants, odor and surface scum, competition for natural fish food sources, interference with spawning areas, disappearance of native fish populations, clogged irrigation systems and limited opportunities for recreational water use. In addition, an increase in the level of organic matter in a stream can cause a rise in the Biological Oxygen Demand (BOD). BOD is a measurement of the oxygen required to carry out the stream's natural processes, such as decomposition. A limited supply of oxygen exists in the water. Therefore, oxygen supplies will decrease as increased amounts of organic matter decompose. Native fish populations are thus deprived of necessary oxygen levels (Izaak Walton League 1999).

Natural sources of nutrients include decaying plants and animals and fecal matter from wildlife. Humans and their activities can increase the level of nutrients in a stream. Human sources of nutrients include: discharge from wastewater treatment plants; leaking septic systems; fecal matter from livestock; effluent from fruit and vegetable canneries and other industries (in Salem, effluent from canneries discharges to the sanitary sewer system, not the stormwater system); grass clippings or leaves dumped into gutters or streams; fertilizers from farms, lawns and gardens; pet waste; and detergents, especially from washing vehicles in driveways and parking lots.

The level of phosphorus and nitrogen in water is typically measured as "Total Phosphorus" and "Total Kjeldahl Nitrogen." DEQ offers no set standard for either of these nutrients in regards to fish or aquatic life. Recommendations from the Oregon Watershed Assessment Manual (OWAM) suggest that phosphorus levels remain equal to or lower than 0.05mg/l and nitrates at or below 0.30mg/l (Watershed Professionals Network 1999).

Toxic Substances

An element is said to be toxic if it injures the growth or metabolism of an organism above a certain concentration. Toxic substances can poison aquatic life, destroy aquatic food supply, and deform fish larvae. If the discharge is acute (of high intensity but lasting for a short duration), it may not last long enough to produce long-term effects on aquatic life. If the discharge is chronic (of long intensity over an extended period of time), its effects may take longer to become apparent but will be easier to measure. Some toxic substances can "bioaccumulate," which means they can increase in concentration and become more dangerous as they move up the food chain beginning with microorganisms and continuing up to humans (Izaak Walton League 1999).

Toxic pollutants commonly found in urban runoff include trace metals such as lead, copper, zinc, and organic compounds including oils, grease, phthalates, and chlorinated hydrocarbons (Richter 2000). Storm water picks up toxic substances such as oil, heavy metals and pesticides as it flows across parking lots, roads, and lawns. Illegal disposal of these substances along with paint, household chemicals, chlorine, and industrial material can also enter streams as they are illegally dumped into to storm drains. Sources of toxics include the breakdown of metal products, vehicle fuels and fluids, vehicular wear, industrial processes, and industrial and household chemicals.

Car washing can add a considerable amount of oil and phosphates into a local storm drain system. As soap is hosed off vehicles, it typically drains down driveways or across parking lots into the nearest catch basin where it is piped directly into the stream. Allowing soap to enter the storm drain system is a violation of city code. In Salem, commercial car washes must discharge to the sanitary sewer. Soaps and other pollutants are prohibited by City Code of be discharged into stormdrains. However, charity car washes and private individuals are exempt from this requirement by State Law. City Staff are encouraging those involved with charity car washes and the public at large to change their practices when practical to minimize discharge. The City of Salem in partnership with the Watershed Enhancement Team (WET), is providing public education encouraging people to wash their cars on lawns or other permeable areas.

Other factors affecting toxic levels in water and sediments include dredging (which can disturb buried sediments that contain toxic material), sanitary sewer overflows, irrigation return flows, pesticide applications, leaky underground storage tanks, contaminated groundwater, and point source discharges such as industrial effluent.

The amount of certain toxics released in industrial effluent is regulated by DEQ under the authority of the Environmental Protection Agency (EPA) through the National Pollutant Discharge Elimination System (NPDES) program. Although there are hundreds of toxic chemicals released into the environment through industrial effluents, legal limits exist on only a few. The EPA has classified a small fraction of these toxic substances, and many chemical compounds are only now being recognized as harmful. In addition, many chemicals become toxic only in combination with other compounds or under certain environmental conditions (e.g. high water temperatures and low pH) making measurements of their effects and the setting of acceptable concentration limits difficult (Izaak Walton League 1999).

Oil—A Common Toxic Substance in Urban Streams

Petroleum products severely affect all types of aquatic life in streams. Free-floating oil and emulsions act on the membrane surface of a fish's gills and interfere with respiration. Petroleum products destroy the fish's food sources by coating and destroying algae and other plankton. Additionally, the flesh of the fish can be tainted when contaminated algae and plankton are ingested. If the oily substance settles, it coats the waterway bottom, destroying bottom-dwelling organisms and interfering with spawning areas. Films of oil on the water's surface interfere with plant photosynthesis and respiration. Surface films also destroy algae and reduce the oxygen level in the water (Izaak Walton League 1999).

Sources of oil pollution include vehicle usage, leaky vehicles, vehicular accidents, industrial plant wastes, grease and fats from lubrication of machinery, the manufacturing process of hydrogenated glycerides, rolling mills, leaky underground storage tanks, storm water overflows, gas stations, and car oil dumped into street drains by homeowners. Rainwater will pick up a significant amount of oil as it flows across street surfaces and parking areas and into storm drain systems, ultimately discharging into our streams.

Pesticides—Urban and Rural Contaminants

A pesticide is any chemical that is used to prevent the growth or survival of unwanted plants, animals, insects, fungi or bacteria. Herbicides, fungicides and insecticides are types of pesticides. Acute spills of pesticides into surface waters can be lethal to aquatic organisms, depending on the chemical(s) that constitute the pesticide. Even small amounts of pesticides can be harmful to aquatic organisms, affecting their behavior, development, and overall strength. Many pesticides are water-soluble and will percolate down into the ground water. Other pesticides will attach themselves to sediment particles and remain in the soil until erosion washes them into streams.

Pesticides are used extensively in both rural and urban environments. The four most common pesticides found in Willamette Valley streams are atrazine, metolachlor, simazine and diuron (Anderson et al. 1997) (**Table 8-2**). Five other compounds—carbaryl, diazinon, dichlobenil, prometon, and tebuthiuron—had significantly higher concentrations at urban sample points than at agricultural sites (Anderson et al. 1997).

Table 8-2. Most Frequently Detected Herbicides in the Willamette Basin

Most frequently detected compounds found in Willamette Basin	Percent of samples compound detected	Detection limit (micrograms per liter)	Maximum found (micrograms per liter)	EPA pesticide risk assessment (rainbow trout)	Lethal Concentration (LC)(micrograms per liter)	Exposure time (hours)	General use and sample trade name
atrazine and its by products	99%	0.001	90	slightly toxic	9,900	96	Herbicide (AAtrex)
metolachlor	85%	0.002	4.5	moderately toxic	2,000	96	Herbicide (Dual)
simazine	85%	0.005	1	low toxicity	56,000	48	Herbicide (Princep)
diuron	73%	0.020	29	moderately toxic to fish; highly toxic to aquatic invertebrates	3,500	96	Herbicide

Fecal Coliform Bacteria

Escherichia coli (E. coli) is a member of a group of bacteria called fecal coliform bacteria. As the name implies, this group of bacteria is associated with fecal matter from both humans and animals. *E. coli* is a specific species of bacteria found in the fecal coliform "family" of bacteria.

While the presence of fecal coliform in surface waters in not unnatural, high concentrations of fecal coliform bacteria pose a threat to water-contact recreation, water foal and wildlife. High levels of fecal coliform in a water body may be an indicator of large inputs of nutrients. Wastewater treatment facilities, faulty septic systems, runoff from livestock operations, and runoff carrying pet waste may all contribute to high levels of fecal coliform bacteria in our streams and lakes.

Prior to 1996, a water body did not comply with state water quality standards for water-contact recreation if the log mean of at least 5 surface water samples taken in a 30-day period exceeded 200 fecal coliform per 100 ml, with no more than 10% of the samples in the 30-day period exceeding 400 colony forming units (cfu) per 100 mls. To improve the standard, the fecal indicator was changed in 1996 from the bacterial group of fecal coliforms, which includes a suite of different species of bacteria, to a specfic species within the fecal coliform family called *E. coli*. DEQ changed this standard as of January 11, 1996, to read "no single sample should exceed 406 *E. coli* organisms per 100 ml" (Oregon Administrative Rules 340.41). This standard was set for water-contact recreation and not for the survival of salmonids. The standard was set to protect human health. While high levels of *E. coli* bacteria in a stream may be a human health hazard, it does not indicate whether or not it is a hazard to aquatic species.

Macroinvertebrates

Macroinvertebrates are small organisms lacking backbones; they can be seen without the aid of a microscope. The types and number of macroinvertebrates present in a stream can be used as an indicator of stream health. Most streams, no matter how polluted, contain invertebrates. Some species cannot tolerate poor stream conditions, while others may thrive in polluted streams.

Degraded stream conditions can be determined by presence or absence of tolerant and intolerant species. Stoneflies, mayflies, and most species of caddisflies are abundant in healthy streams: those characterized by low water temperatures, high dissolved oxygen and low suspended solids. Black fly larvae, amphipods, and "left-handed" snails are abundant in streams in poor condition: those characterized by low dissolved oxygen, high temperatures, and stream bottoms with fine sediment deposits (i.e., stream bottoms with high amounts of silt particles and low amounts of sand and gravel particles).

The 303(d) List and Stream Health

Section 303(d) of the Clean Water Act requires each state to develop a list of water bodies that do not meet water quality standards, and to submit an updated list to the Environmental Protection Agency (EPA) every two years. The list of water bodies helps state residents to identify problems and develop and implement watershed recovery plans to protect beneficial uses while achieving federal and state water quality standards (DEQ 2001e).

DEQ establishes water quality standards to protect beneficial uses of the state's waters. Beneficial uses are defined by law and include such things as recreation, aquatic life, irrigation, fisheries and drinking water (**Table 8-3**). While there may be competing beneficial uses in a river or stream, federal law requires DEQ to protect the **most sensitive** of these beneficial uses. For Willamette River tributaries, aquatic life, particularly salmonid spawning and rearing, is considered one of the most sensitive beneficial uses. For this reason, the standards for water quality and in-stream conditions are geared towards assuring adequate quality for salmonids, which will assure adequate quality for other beneficial uses.

Table 8-3. Beneficial Water Uses in the Willamette Basin

Beneficial Uses	Willamette River Tributaries						Main Stem Willamette River				
	Clackamas River	Molalla River	Santiam River	McKenzie River	Tualatin River	All Other Streams & Tributaries	Mouth to Willamette Falls, Including Multnomah Channel	Willamette Falls To Newberg	Newberg to Salem	Salem to Coast Fork	Main Stem Columbia River (RM 86 to 120)
Public Domestic Water Supply[1]	X	X	X	X	X	X	X	X	X	X	X
Private Domestic Water Supply[1]	X	X	X	X	X	X	X	X	X	X	X
Industrial Water Supply	X	X	X	X	X	X	X	X	X	X	X
Irrigation	X	X	X	X	X	X	X	X	X	X	X
Livestock Watering	X	X	X	X	X	X	X	X	X	X	X
Anadromous Fish Passage	X	X	X	X	X	X	X	X	X	X	X
Salmonid Fish Rearing	X	X	X	X	X	X	X	X	X	X	X
Salmonid Fish Spawning	X	X	X	X	X	X			X	X	X
Resident Fish & Aquatic Life	X	X	X	X	X	X	X	X	X	X	X
Wildlife & Hunting	X	X	X	X	X	X	X	X	X	X	X
Fishing	X	X	X	X	X	X	X	X	X	X	X
Boating	X	X	X	X	X	X	X	X	X	X	X
Water Contact Recreation	X	X	X	X	X	X	X	X[2]	X	X	X
Aesthetic Quality	X	X	X	X	X	X	X	X	X	X	X
Hydro Power	X	X	X	X	X	X	X	X			X
Commercial Navigation & Transportation							X	X	X		X

[1] With adequate pretreatment and natural quality that meets drinking water standards.
[2] Not to conflict with commercial activities in Portland Harbor.

Source: DEQ (2001)

Pringle, Clark and Mill Creeks are listed as water quality limited streams and are included on the 1998 303(d) list (**Table 8-4**). Pringle Creek is listed for bacteria, temperature and toxics (i.e., dieldrin). Clark Creek and Mill Creek are listed for bacteria only.

Table 8-4. Water Quality--Limited Streams from 303(d) List

Stream Location	Parameter Examined	Criteria	Season of Concern	Basis for Listing	Supporting Data
Pringle Creek mouth to headwaters	Temperature	Rearing 64° F (17.8° C)	Summer	City of Salem data	Two City of Salem sites in 1997; 7-day ave. max. temperatures were 63.3/74.3° F. Did not/did exceed temperature standard of (64° F)(17.8 Celsius).
Pringle Creek mouth to headwaters	Toxics	Water - Pesticides (Dieldrin)		USGS data	USGS Data: (Site 14191970, at Bush Park): 2 of 3 values with an average of 0.0025 ug/l exceeded dieldrin standard (0.0019 ug/l - fresh water chronic criteria, 0.71 ug/l water and fish ingestion criteria) on 11/30/94 (USGS, 1995). 1996 USGS data additional 6 exceedances of 6 samples at 0.1 ug/l.
Pringle Creek mouth to headwaters	Bacteria	Water-contact recreation (*E. coli*) Fresh Water		NPS Assessment-segment 95: moderate data (DEQ,1988); City of Salem data.	Two City of Salem sites 50% (23 of 46) of samples exceed *E.coli* bacteria standard of (406). High value was 1330.
Clark Creek mouth to headwaters	Bacteria	Water-contact Recreation (*E. coli*) Fresh Water		City of Salem data	Two City of Salem sites 44% (7 of 16) samples exceed *E. coli* bacteria standard of (406). High value was 11,700.
Mill Creek mouth to headwaters	Bacteria	Water-contact Recreation (fecal coliform-96-Std).	Year round	City of Salem data; NPS Assessment - segment 64 and 65: moderate data (DEQ, 1988).	City of Salem data (10 sites):32% (249 of 781).Annual values exceeded fecal coliform standard (400) between 1990-1994.

Source: DEQ (2001i)

DEQ seeks all available information on a water body to determine if it is violating water quality standards. Data collected by individuals, organizations, government agencies and DEQ staff can be used to determine if a water body is water-quality limited, as long as the data meets specified minimum quality assurance requirements.

DEQ does not have information on all Oregon water bodies. Those with no information, or information not compatible with EPA guidelines, are not included on the 303(d) list. To date, Claggett is not listed on the 303(d) list for any water quality parameter. Data collection using EPA/DEQ guidelines will be necessary to determine if these creeks should be listed for one or more water quality parameters. Data collected by DEQ in 2002 may cause Glenn and Gibson creeks to be added to the list for the first time and Pringle to be listed for three more parameters **(Table 8-5).**

Table 8-5: Proposed DEQ 2002 303(d) Listings for the Salem Area Streams[1]

Waterbody Name	Parameter	Season	River Mile	List Date
Clark Creek	E Coli		0 to 1.9	1998
Gibson Gulch	**Dissolved Oxygen**	**October 1- May 31**	**0 to 2.8**	**2002**
Glenn Creek	**Dissolved Oxygen**	**October 1- May 31**	**0 to 7**	**2002**
Mill Creek	Fecal Coliform	Year Around	0 to 25.7	1998
Pringle Creek	E Coli		0 to 6.2	1998
Pringle Creek	Dieldrin	Year Around	0 to 6.2	1998
Pringle Creek	Temperature	Summer	0 to 6.2	1998
Pringle Creek	**Copper**	**Year Around**	**0 to 6.2**	**2002**
Pringle Creek	**Lead**	**Year Around**	**0 to 6.2**	**2002**
Pringle Creek	**Zinc**	**Year Around**	**0 to 6.2**	**2002**

[1] Additions in **bold**
Source: Oregon Department of Environmental Quality 2003.

Sources of Pollution: Point Source and Non-point Source

Pollution entering Oregon's streams can be classified into one of two categories: point source pollution and non-point source pollution. Point source pollution refers to end-of-pipe discharges or pollution that originates from a clear source. Types of facilities/activities that can generate point source pollution include sewage treatment plants, factories, food processing facilities, mines, construction sites, paper and pulp mills, leaky underground storage tanks, solid waste sites and hazardous waste sites.

Regulation of Point Source Pollution

Discharges to Ground and Surface Waters

DEQ regulates some types of point source pollution by issuing water quality permits. The agency requires a water quality permit whenever there is a discharge of pollutants to waters of the state or to the ground (DEQ 2001d). Permits are required for discharges of wastewater (sewage, processing water, etc.), wash water, and even relatively clean wastewaters, such as non-contact cooling water. These discharges may occur through a variety of disposal systems including land irrigation, seepage ponds, on-site sewage systems and dry wells, or may discharge to surface waters directly via a pipe or ditch or indirectly through a stormwater system.

There are two types of water quality permits:

1. National Pollutant Discharge Elimination System (NPDES) is a requirement of the Clean Water Act and Oregon law. DEQ has been given authority by the Environmental Protection Agency (EPA) to administer this program and issue permits. NPDES permits are required for point source discharges of pollutants to surface waters. Certain industries, municipalities and activities are also required to obtain NPDES permits for stormwater runoff.

2. Water Pollution Control Facilities (WPCF) is a state requirement for the discharge of wastewater to the ground only. WPCF permits are issued for land irrigation of wastewater, non-discharging wastewater lagoons, on-site disposal systems, and underground injection control systems (i.e., dry wells, sumps, etc.). The primary purpose of a WPCF permit is to prevent discharges to surface waters and to protect groundwater from contamination. This permit is also used to prevent nuisance conditions such as odors and mosquitoes. The intent is to prevent overloading surface soils and vegetation with contaminants such as organics, nutrients, and heavy metals.

As of February 2001, a total of 59 NPDES and WPCF permits are active in the Claggett, Pringle, and Mill Creek (including Beaver Creek) watersheds (**Table 8-6**). No water quality permits were issued in the Glenn-Gibson basin. Of the 59 permits issued, 40 of the permits are in the Mill Creek watershed, which includes the Beaver Creek basin. This is not surprising considering the Mill Creek watershed is 5 to 10 times larger than the Claggett and Pringle Creek watersheds.

Table 8-6. National Pollution Discharge Elimination System Permits by Watershed Active as of February 2001 for the Greater Salem Area Watersheds

Watershed[2]	River Mile[3]	Facility ID	Legal Name	Category[4]	Permit Type	Permit Type Description	Discharge Type[5]
Claggett Creek	0.0	106167/A	Tosco Corporation	IND	GEN15A	Petroleum Hydrocarbon Cleanups - NPDES	N
	1.5	111000/A	Salem-Keizer School District	IND	GEN12C	Construction disturbing >= 5 acres	I
	2.1	104663/A	SumcoUSA	IND	GEN12Z	Industrial Activities	D
	3.0	103549/B	Rainsweet Inc.	IND	GEN12Z	Industrial Activities	D
	3.2	111122/A	Salem-Keizer School District 24J	IND	GEN12C	Construction disturbing >= 5 acres	I
	4.0	87663/A	Americold Corporation	IND	GEN01	Cooling Water/Heat Pumps - NPDES	D
	4.0	104619/A	IFF Concentrates Inc.	IND	GEN12Z	Industrial Activities	D

Watershed[2]	River Mile[3]	Facility ID	Legal Name	Category[4]	Permit Type	Permit Type Description	Discharge Type[5]
	4.5	110906/A	Tran Co.	IND	GEN12C	Construction disturbing >= 5 acres	I
	5.0	108174/A	Graham, John	IND	GEN12Z	Industrial Activities	I
	5.0	102576/A	May Trucking Company	IND	GEN12Z	Industrial Activities	I
	7.0	107759/B	STAATS Corp.	IND	GEN10	Gravel Mining - WPCF	N
Pringle Creek	2.0	106415/A	Boise Cascade Corporation	IND	GEN12Z	Industrial Activities	I
	2.0	108033/A	NORPAC Foods, Inc.	IND	GEN12Z	Industrial Activities	D
	2.0	107948/A	Yamasa Corporation U.S.A.	IND	GEN12Z	Industrial Activities	D
	2.5	106923/A	Salem, City of	IND	GEN12Z	Industrial Activities	I
	3.0	110121/A	SAIF Corporation	IND	GEN15A	Petroleum Hydrocarbon Cleanups - NPDES	I
	4.0	109676/A	Russell's Landscape Service, Inc.	DOM	GEN54	Holding Tank - WPCF On-Site - Expired	N
	5.0	110959/A	Mountain West Investment Corporation	IND	GEN12C	Construction disturbing >= 5 acres	I
	6.0	108824/A	SumcoUSA	IND	GEN12Z	Industrial Activities	I
Mill Creek	1.5	110017/A	G & R Auto Wreckers, Inc.	IND	GEN12Z	Industrial Activities	I
Mill Creek	1.5	110017/A	G & R Auto Wreckers, Inc.	IND	GEN54	Holding Tank - WPCF On-Site - Expired	I
	1.5	103758/A	Microflect Company, Inc.	IND	GEN12Z	Industrial Activities	D
	1.5	110456/A	Oregon Department of Forestry	IND	GEN12C	Construction disturbing >= 5 acres	I
	2.0	110133/A	Carter, Laurence, & S. Diana	DOM	GEN54	Holding Tank - WPCF On-Site - Expired	N
	2.5	110704/A	Federal Express Corporation	IND	GEN12Z	Industrial Activities	D
	2.5	110566/A	Kettle Foods Inc.	IND	GEN12Z	Industrial Activities	D
	2.5	109727/A	Oregon State Penitentiary	IND	NPDES		D
	3.0	110101/A	Harris, Harlow	DOM	GEN52A	Gravel Filter <5,000 gpd - WPCF On-Site - Expired	N
	3.0	106809/A	State of Oregon Department of Administrative Services	IND	GEN01	Cooling Water/Heat Pumps - NPDES	D
	4.0	106826/A	Kyotaru Oregon, Inc.	IND	GEN12Z	Industrial Activities	I
	4.0	107320/A	United States Postal Service	IND	GEN12Z	Industrial Activities	I
	4.5	111113/A	Rogers, Eric	IND	GEN12C	Construction disturbing >= 5 acres	I

Watershed[2]	River Mile[3]	Facility ID	Legal Name	Category[4]	Permit Type	Permit Type Description	Discharge Type[5]
	5.0	102895/C	Calyx Fruit, LLC	IND	GEN14A	Seasonal Food Processing<25,000gpd - WPCF	I
	5.0	109040/A	Pottheff, John H.	IND	GEN54	Holding Tank - WPCF On-Site - Expired	N
	5.0	110922/B	Trapani, Anthony	IND	GEN12C	Construction disturbing >= 5 acres	I
	5.5	107426/B	J. C. Compton Company DBA River Bend Sand & Gravel Co.	IND	GEN12A	Sand, gravel, and non-metallic mining	D
	6.0	109144/A	Trussell, Carl V.	DOM	GEN54	Holding Tank - WPCF On-Site - Expired	N
	7.5	110960/A	RMA Development, L.L.C.	IND	GEN12C	Construction disturbing >= 5 acres	I
	7.8	110426/A	William Kostenborder	IND	GEN12C	Construction disturbing >= 5 acres	D
	8.5	106804/A	Salem Black Top and Asphalt Paving, Inc.	IND	GEN12A	Sand, gravel, and non-metallic mining	A
	9.0	110410/A	Meduri Farms, Inc.	IND	GEN14A	Seasonal Food Processing<25,000gpd - WPCF	N
	9.0	102749/A	Meduri Farms, Inc.	IND	WPCF	Terminated	N
Mill Creek	9.0	108574/A	Sass, Gerald M. Jr.	IND	GEN14A	Seasonal Food	I
	10.0	108854/A	Turner Gravel Inc	IND	GEN12A	Sand, gravel, and non-metallic mining	D
	10.0	104544/A	Willamette Valley Vineyards, Inc.	IND	GEN14A	Seasonal Food Processing<25,000gpd - WPCF	I
	10.2	12355/B	Caliber Forest Products, Inc.	IND	GEN12Z	Industrial Activities	N
	10.2	12355/B	Caliber Forest Products, Inc.	IND	GEN05	Boiler Blowdown - NPDES	N
	10.5	108181/A	Bruce Packing Company, Inc.	IND	GEN14B	Other Food Processing <25,000gpd - WPCF	I
	10.5	77770/A	Salem, City of	IND	NPDES	Franzen Reservoir	D
	18.5	84820/A	NORPAC Foods, Inc.	IND	NPDES	Food Processor	I
	18.5	84820/A	NORPAC Foods, Inc.	IND	GEN12Z	Industrial Activities	I
Beaver Creek	2.5	4475/A	Aumsville, City of	DOM	NPDES	Sanitary Sewer—Domestic wastewater treatment	D
	4.1	110141/A	Great American Development Company	IND	GEN12C	Construction disturbing >= 5 acres	I
	4.1	110281/A	Wood Waste Reclamation, Inc.	IND	GEN12Z	Industrial Activities	D
	5.0	109885/A	M & H Oregon City	IND	GEN12C	Construction	I

Watershed[2]	River Mile[3]	Facility ID	Legal Name	Category[4]	Permit Type	Permit Type Description	Discharge Type[5]
			(South End), L.L.C.			disturbing >= 5 acres	
	12.0	107298/A	United Disposal Service, Inc. DBA	IND	GEN12Z	Industrial Activities	I
	13.0	109762/A	Brundidge Construction, Inc.	IND	GEN12C	Construction disturbing >= 5 acres	I
	17.0	109630/A	Forell, Jack	IND	GEN12C	Construction disturbing >= 5 acres	I

[1] Information on active permits taken from DEQ (2001h). Permits listed were active as of 02-16-01. The list of active permits changes frequently. Please refer to the website for the most up-to-date information.
[2] No NPDES permits for Glenn and Gibson Creeks or for Battle Creek were found during this search.
[3] River Mile: Refers to the distance upstream from the mouth of the creek.
[4] Category: IND=Industrial; DOM=Domestic. Domestic permits are issued to sewage and wastewater treatment plants, as well as other systems designed to treat water that is primarily composed of human sewage.
[5] Discharge Type: D=Directly into stream; I=Indirectly into stream; A=Adjacent to stream; N-Discharge to nearest stream.

Stormwater

Although stormwater is typically considered a non-point source of pollution, DEQ regulates stormwater discharge as a point source pollutant. In 1990, the EPA adopted regulations requiring NPDES permits for stormwater discharges from certain industrial sites (DEQ 2001g). Stormwater permits are also needed for construction or land disturbing activities (i.e., clearing, grading and excavation) that disturb one or more acres of land. Large cities are also required to get a NPDES stormwater discharge permit.

The City of Salem's NPDES permit for stormwater is a negotiated permit. The City of Salem proposes Best Management Practices (BMPs) that could help reduce pollutants entering the storm drain system and creeks in its permit application. DEQ may approve the BMPs or suggest revisions to the proposed BMPs. BMPs may include education to landowners and businesses on waste management, maintenance of existing public works structures, the construction of new structures (e.g. bioswales, stormwater detention ponds) and/or stream and wetland restoration projects.

Sixty percent of all water quality permits issued in the four watersheds were for stormwater. One-third of all the stormwater permits issued were for construction activities (**Table 8-7**).

Table 8-7. Number and Types of Active NPDES Permits in Watersheds of the Salem-Keizer Area

Watershed	Stormwater	Other	Total
Claggett	8	3	11
Pringle	6	2	8
Mill	16	17	33
Beaver	6	1	7
Glenn-Gibson	0	0	0
Grand Total	**36**	**23**	**59**

Source: DEQ (2001h)

Hazardous Waste Facilities

Hazardous wastes can be liquids, solids, or sludges. They can be by-products of manufacturing processes or discarded commercial products. If hazardous wastes are not handled properly, they pose a potential hazard to people and the environment.

To ensure that companies handle waste safely and responsibly, EPA has written regulations that track hazardous wastes from the moment they are produced until their ultimate disposal. DEQ is authorized by the federal Environmental Protection Agency (EPA) to regulate hazardous waste in Oregon. The regulations set standards for the hazardous waste management facilities that treat, store, and dispose of hazardous waste (EPA 2001).

Hazardous waste management facilities receive hazardous wastes for treatment, storage, or disposal. There are no permitted hazardous waste management facilities within the four watersheds. But there are many hazardous waste generators. These businesses generate or store hazardous for short periods of time. They include businesses such as dentist offices (store and use silver for fillings), warehouses or retail stores (use and sell light bulbs which contain mercury), and stores that process film (silver). Hazardous waste generators do not need a permit to operate. But they are required to follow regulations on the storage and disposal of hazardous waste.

Solid Waste

According to Oregon Revised Statute (ORS) 459, solid waste is all "useless or discarded putrescible and non-putrescible materials, including but not limited to garbage, rubbish, refuse, ashes, paper and cardboard, sewage sludge, septic tank and cesspool pumpings or other sludge, useless or discarded commercial, industrial, demolition and construction materials, discarded or abandoned vehicles or parts thereof, discarded home and industrial appliances, manure, vegetable or animal solid and semisolid materials, dead animals and infectious waste (ORS 1999).

Solid waste facilities can pollute water resources if leachate--percolating liquid that seeps through the landfill and picks up soluble material--enters the groundwater. Conventional contaminants include total dissolved solids, chloride, sulfate and heavy metals. Leachate may also include organics, which can effect the Biological Oxygen Demand (BOD) of groundwater (Jones-Lee and Lee 1993).

Oregon Revised Statutes (ORS 459) require that a solid waste facility apply to the Department of Environmental Quality for a Solid Waste Disposal Permit prior to starting operation. There are many of kinds of facilities that need a permit, including landfills, composting facilities, incinerators, and transfer stations, among others (DEQ 2000). Only one active landfill, the Salem Airport Disposal Site, is located within the four watersheds. The site is located near the watershed boundaries of Pringle Creek and Mill Creek. The permittee is the City of Salem and the site is used for the disposal of public works construction debris, street cleaning debris and the like.

Underground Storage Tanks

Leaky underground storage tanks pose a possible threat to Oregon's air, water and land quality. Petroleum products and other hazardous wastes stored in underground tanks may enter groundwater and pollute drinking water sources. Contaminated groundwater may also filter into streams and other surface water.

In 1987, DEQ developed the Underground Storage Tank (UST) Program. The goal of the program is to maintain, restore and enhance the quality of Oregon's air, water and land by the proper installation of new tank systems; the monitoring, maintenance and upgrade of existing tank systems; and the timely cleanup of petroleum contamination from leaky underground storage tanks (DEQ 2001b).

Compliance and prevention requires the registration of USTs and specifies the technical requirements for new and existing UST systems. A regulated UST (requiring a permit) is any tank that has at least 10% of its volume underground and which is used to store petroleum or certain hazardous substances. Tanks not requiring permits include: farm and residential tanks holding 1,100 gallons or less of motor fuel used for noncommercial purposes; residential and commercial heating oil tanks; septic tanks; and tanks holding less than 110 gallons.

The UST cleanup program, otherwise known as Leaking UST or LUST, requires the reporting of petroleum releases in both regulated and nonregulated tanks, and the investigation and remediation of soil and groundwater contamination resulting from leaks and spills.

Although not requiring permits, Heating Oil Tanks (HOT) also pose a possible threat to water resources. Heating oil tanks are not regulated until a spill/release occurs. All HOT releases are required to be reported to DEQ. Clean-up and remediation of releases is done by certified HOT Service Providers. DEQ certifies the cleanup reports submitted by the HOT Service Providers.

Although DEQ provides a list of all leaky USTs and HOTs throughout the state, we could not determine the number of leaky underground storage tanks specifically within the four watersheds (DEQ 2001b). To get an estimate of the number of reported leaky USTs and HOTs in the general area, we compiled a list of all reported leaky underground storage tanks located in Salem, Keizer, Turner, Aumsville, Sublimity and

Stayton. Approximately 1,320 leaky UST's and HOT's have been reported for the general area since 1987. Many of the tanks have undergone or are currently undergoing cleanup.

Spills and Accidents

Spills resulting from carelessness or accidents can result in the release of petroleum products, hazardous material, or excessive sediments entering our storm drains and streams. The City of Salem's Environmental Services Department takes both reactive and pro-active measures to protect Salem's water quality. Reactive responses include going out to spill and accident sites to perform or oversee cleanup and remediation once something has occurred. Pro-active responses include educating people and regulating their activities in an attempt to prevent problems. The Environmental Service Department is also working on spill prevention plans and facilities under the City of Salem's wastewater pretreatment program.

From July 1, 2000, through June 26, 2001, Environmental Services responded to 618 calls that resulted in, or had the potential for, harmful discharges entering storm drains (Roley pers. comm.) (**Table 8-8**).

Table 8-8. Number of Spill Responses by Pollutant Type Conducted by the City of Salem Environmental Services from July 1, 2000, to June 26, 2001.[1]

Pollutant	# of Calls
Chemical	61
Fuel	219
Hazardous Material	28
Oil Spills	133
Other Spills	19
Storm-related Complaints[2]	158
Total	**618**

[1] Does not include spills from motor vehicle accidents or leaks from the sanitary sewer system.
[2] Category includes everything from overflowing manholes, containers filling with storm water and overflowing contents to surface, and observations of bubbles/color/foam in creek. Of the 158 calls, 57 were related to erosion episodes that created cloudy water or excessive sediments in the creek.

Contaminated Sites and Long-term Cleanup

The Environmental Cleanup Program, dedicated to cleaning up contaminated sites, is run by DEQ and is responsible for longer-term environmental cleanup projects. According to the Environmental Cleanup Program's "Active Site List", there are four cleanups occurring as June 18, 2001, within the four watersheds (DEQ 2001f). The list includes only long-term projects.

Two dry-cleaners in the Pringle Creek watershed have leaked chlorinated solvents (i.e., Perchloroethylene) into the soil and groundwater. The first dry-cleaner is located on the corner of Commercial Street and Owens Street SE, right on the watershed boundary between Pringle Creek and the Willamette River. This site is also contaminated with petroleum. The second dry-cleaner is located near the headwaters of the West Fork of Pringle Creek near the Sunnyslope Shopping Center on Hermitage Way.

The other two active cleanup sites are located in Mill Creek. The first site is the Oregon State Penitentiary. Groundwater samples collected in 1989 from two of OSP's irrigation water wells contained solvents, including trichloroethylene (TCE) and perchloroethylene (PCE). The water supply wells at OSP were removed from service in 1989 as soon as the contamination was discovered. The likely source of the contamination was leakage or improper disposal of wastewater from the laundry dry-cleaning facility. The laundry facility was upgraded in 1983 and no longer uses dry-cleaning fluids. The second site is a former mint distillery and dairy and located on Marion Road in Turner. Soil and surface water contamination from a diesel spill at that site occurred in July of 1997.

Surface Mining

Sand and gravel mining within or adjacent to river and stream channels can initiate channel degradation and erosion (Hartfield 1997). Inappropriately sited floodplain mines may capture the river during flood events, causing a relocation of the thalweg (i.e. the part of a stream channel in which the water moves the fastest). Such changes are accompanied by increased water velocity above the mined areas precipitating local channel scouring and erosion. Mining-induced erosion can threaten upstream property, reduce recreational and fish and wildlife values, and negatively impact aquatic fauna by adding sediments to the stream channel.

To mine for rock, sand or gravel in Oregon, mine operators must obtain an Aggregate Mine Permit from the Oregon Department of Geology and Mineral Industries (DOGAMI). DOGAMI regulates the extraction and reclamation of all upland and underground mining in Oregon to minimize the impacts of mining to the state's lands and waters.

Mill Creek watershed hosts seven active aggregate mine sites (**Map 8-1**). Claggett contains three active mine sites, one in the Salem Industrial area, one on Wheetland Road, the other near the mouth of Claggett Creek as it flows into the Willamette River via a slough (**Map 8-2**). The Glenn-Gibson watershed does not contain any active aggregate mine sites with the exception of two sites on the Willamette River floodplain through which Glenn Creek flows before emptying into the Willamette River. The Pringle Creek watershed contains no active mine sites. Mining at a majority of these sites is for sand and/or gravel; two sites in the Mill Creek watershed are being mined for basalt.

Non-point Source of Pollution

During the last 25 years, as pipe discharges have been regulated, it became clear that while each individual pipe discharge into a water body might meet water quality standards, the water body as a whole might still fail to meet the standards (DEQ 1998). It became evident that there are sources of pollution other than from pipes.

Non-point source pollution does not originate from a clear or discrete source. It can be described as the accumulation of pollutants resulting from common, widespread activities in both urban and rural areas. Activities that can cause non-point source pollution include overuse of fertilizers and pesticides; improper disposal of household hazardous wastes (e.g., paint, aerosol sprays, swimming pool/hot tub chemicals, oil, gasoline, radiator fluid, ammonia-based cleaners); illicit dumping of chemicals and garbage in streams or storm drains; leaky vehicles on streets, driveways and parking lots; habitat destruction and poor erosion control techniques on construction sites and agricultural fields.

Agricultural runoff carries pesticides, fertilizers and sediments as a result of erosion. In contrast, urban runoff pollutants are many and variable depending on the land uses and pollutant sources. Typically, urban pollutants are greatest from industrial and commercial areas, roads and freeways, and higher-density residential areas. Major categories of urban pollutants include sediments, nutrients, microbes (e.g., fecal coliform bacteria), and toxic metals and organics. Motor vehicles are recognized as a major source of pollutants, contributing oils, greases, hydrocarbons, and toxic metals (Richter 2000).

After years of regulating point source pollution, state and federal agencies are now taking a more comprehensive approach to water quality improvement, taking into account the accumulative impacts of both point source and non-point source pollution (DEQ 2001a). DEQ is in the process of calculating pollution load limits, known as Total Maximum Daily Loads (TMDLs), for each pollutant entering a body of water. TMDLs take into account pollution from all sources, including discharges from industry and sewage treatment facilities; runoff from farms, forests and urban areas; and natural sources, such as decaying organic matter.

DEQ plans to have federally approved TMDLs on all water bodies listed on the 1998 303(d) list by the end of the year 2007. Salem's watersheds lie within the Mid-Willamette Sub-basin. TMDLs are scheduled for completion in this basin in late 2003. A draft work plan for determining TMDLs for the Mid-Willamette Sub-basin can be viewed on the DEQ web site (DEQ 2001c).

In conjunction with TMDL approval, each water body will have a comprehensive water quality management plan that will guide water quality improvement efforts. These comprehensive plans will be developed by state government agencies with the help of local governments, industry, agriculture, soil and water conservation districts, watershed councils, nonprofit organizations and other interested parties.

Past Studies on Stormwater and Surface Water Quality

To diagnose the health of our streams, the watershed councils have compiled information from past water quality studies conducted in the Salem-Keizer area. The information that follows is presented on a study-by-study basis. Most of the data collected is the result of stormwater quality studies conducted by several agencies, and an on-going stream monitoring program conducted by the City of Salem.

Section 208 Urban Stormwater Runoff Plan: 1975-1977

The Mid Willamette Valley Council of Governments (MWVCOG) was designated as a Section 208 Areawide Waste Treatment Management Agency in November of 1974. The agency's task was to develop an area-wide waste treatment management plan for the three-county region of Marion, Polk and Yamhill counties. The project was funded by the EPA in the summer of 1975, and work was begun in the early fall of 1975. The section 208 Plan was organized into four sub-plans and a Final Summary Plan. Those sub-plans were (City of Salem and ODOT 1994):

1. Urban Stormwater Runoff Sub-plan
2. Master Sewage Plan
3. Individual Waste Disposal Sub-plan
4. Soil Erosion and Sediment Countrol Sub-plan

The Urban Stormwater Runoff Sub-plan (MWVCOG 1977), which was completed in October, 1977, had four objectives:

1. To quantify with a rational methodology the parameters, factors and relationships that contribute to urban stormwater runoff pollution.
2. Development of a simulation model for predicting urban stormwater runoff pollution in the future.
3. Development and implementation of abatement controls for urban stormwater pollution if the pollutant assessments indicate water quality degradation.
4. Prioritization of areas in the three-county region where urban stormwater pollution could be a problem.

Only the first two objectives were partially completed during the study because of the record drought in the Willamette Valley during the winter of 1976-1977. However, to address the first two objectives, six stormwater outfalls were selected within the Salem urban area for water quality and quantity sampling during four storm events. The six outfalls drained areas ranging in size from 10 acres to 390 acres. Land uses included a mixture of open space, agricultural, residential and commercial uses. Three of the outfalls were located in the more hilly south Salem area, and three in relatively flat east Salem.

The drought conditions severely crippled the monitoring component of the urban stormwater sub-plan. Since the monitoring element was the key to a site-specific assessment of Salem and the development of a simulation model, the sub-plan left many questions unanswered as to the validity and usability of the model for management decisions. Because of these limitations, results of the study are not presented in this assessment.

USGS Study on Stormwater: 1979-1981

In July of 1978, the City of Salem authorized MWVCOG to investigate and prepare an urban storm water runoff proposal for Salem. A grant application was submitted to EPA in March of 1979. The project was awarded the grant monies in July of 1979. In order to utilize early 1979 rainfall/runoff condition in advance of receiving EPA monies, Salem joined with the USGS in a cooperative agreement to assess rainfall/runoff relationships in the urban area (City of Salem 1982; City of Salem and ODOT 1994).

The goal of the EPA-funded study was to define runoff as related to urbanization. Data was collected from winter of 1979 to spring of 1981. Fourteen in-stream monitoring stations were set up in 13 sub-basins of Glenn-Gibson, Claggett, Pringle, Mill, Croisan and the Little Pudding watersheds to monitor for water quality. Parameters measured included Temperature, pH, Total Phosphorus, Dissolved Nitrates and Nitrites, Suspended Kjeldahl Nitrogen, Dissolved Ammonium, Dissolved Kjeldahl Nitrogen, Total Lead, Chemical Oxygen Demand, Suspended Organic Carbon, Dissolved Organic Carbon, Fecal Coliform, Biological Oxygen Demand, Suspended Sediment, Dissolved Solids, Specific Conductance, and Turbidity.

The USGS' findings were presented in a report (Laenen 1983). Peak flow, storm runoff, and rainfall intensity information was used to define flood-frequency relationships for specific gauged sites. Specific data and the resulting predictive model information can be found in the USGS report.

Data collected in the USGS study is presented in two chapters of this assessment. Information on stormwater hydrology (water quantity) in Salem is discussed in the hydrology chapter of this assessment. Information on the water quality of Salem's streams and stormwater, as a result of the EPA-funded project, follows.

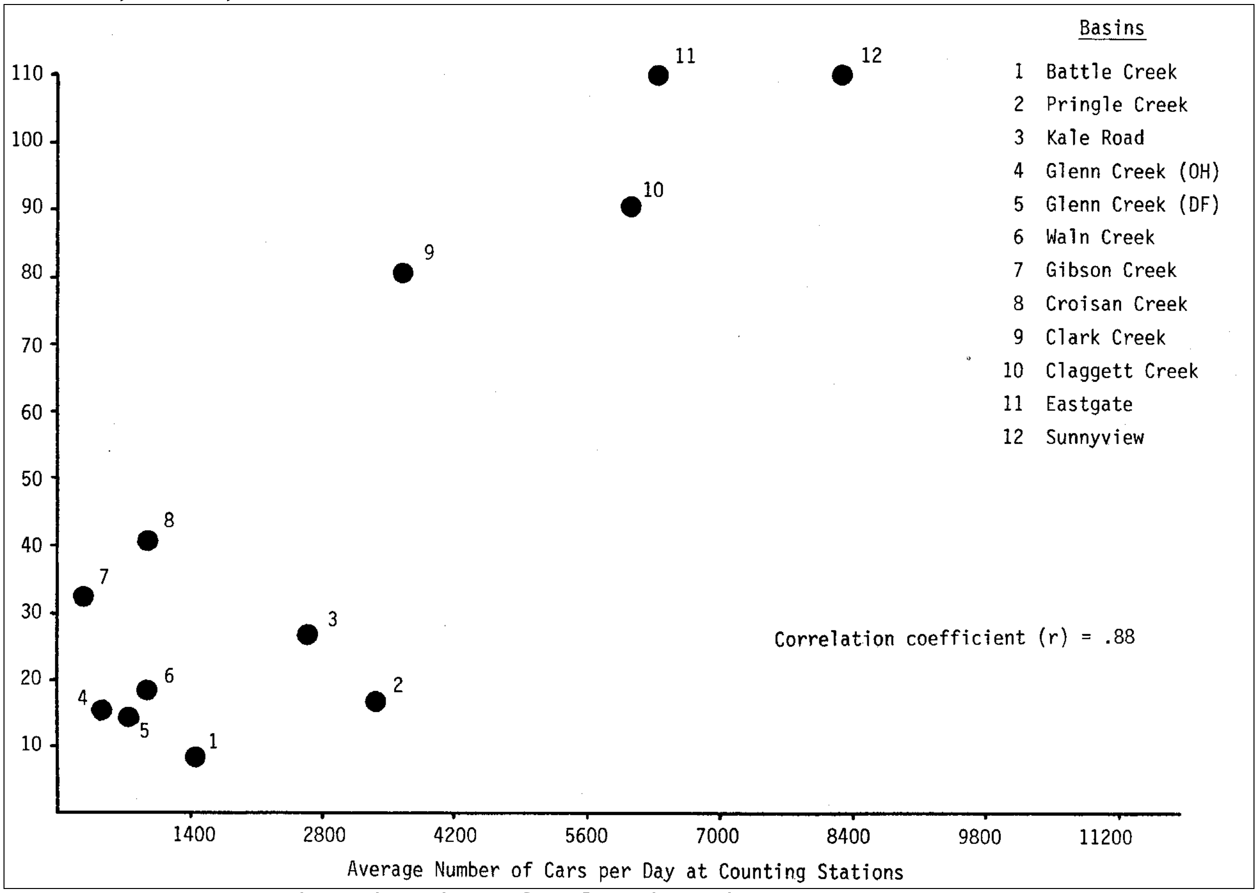
The Salem Urban Area Water Quality Plan (City of Salem 1982) presented the findings of the two-year EPA-funded Salem/MWVCOG/USGS water quality and quantity sampling program. The results of the study suggested that while isolated and intermittent trouble spots were present, Salem generally had high water quality. Based on this information, it was recommended that Salem should address surface water quality from a maintenance rather than an improvement perspective.

Ambient water quality in Salem's streams was found to be of high quality. However, three contaminants were found in high enough concentrations to merit discussion.

Lead

Instances were recorded where lead levels equaled or exceeded DEQ's standard for drinking water (50ug/l) in 12 of 13 basins, with an average concentration for all basins of 73ug/l. Of the 67 samples analyzed for lead, 35 samples (52%) exceeded 50ug/l. The highest concentration (370ug/l) was recorded at the outlet of Hawthorne Ditch at Sunnyview, along the west side of I-5. This basin drains a significant portion of I-5 and has a high proportion (42%)of commercial land use. Data analysis for this and other sites resulted in the study's conclusion that a strong relationship exists in Salem between surface runoff lead content and traffic patterns and intensity (**Figure 8-1**).

Figure 8-1. Correlation Between Traffic Counts and Median Lead Concentrations in Streams, Salem, OR.



Data source: USGS (1997); City of Salem (1982)

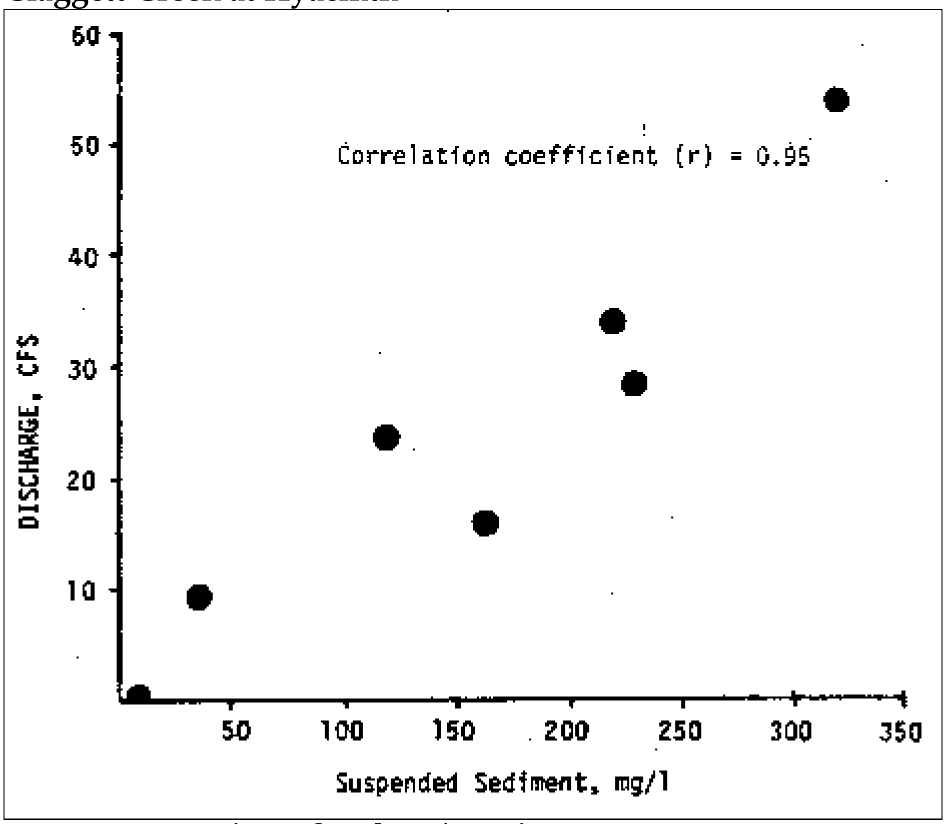
Fecal Coliform

DEQ's water quality standard for fecal coliform is based on preserving the designated beneficial use of water contact. The standard is the log mean of 200 fecal coliform per 100 ml based on a minimum of 5 samples in a 30-day period, with no more than 10% of the samples in the 30-day period exceeding 400 cfu per 100 ml. (This is the old DEQ standard. See **Table 8.1** for current standards.) Twenty-four of the 32 samples collected for fecal coliform analysis exceeded the 200 cfu/100 ml standard. The maximum concentration of 6300 was recorded at a tributary of the Little Pudding River at Kale Road; a minimum level of 38 was recorded at Claggett Creek during non-runoff base flow conditions. While Salem exhibits elevated fecal coliform levels, the levels identified in the USGS' Salem study were significantly lower than levels found in Portland (up to 27,000 cfu/100 ml) and Medford (up to 200,000cfu/100 ml).

Suspended Sediment

A major finding of the Salem Urban Area Water Quality Plan was that "elevated suspended sediment levels seem to be primarily related to increased streamflows resulting from urbanization, poor channel and bank design, and, in some cases, construction activities" (City of Salem 1982). A total of 30 samples were collected from Claggett, Glenn and Waln Creeks, and Hawthorne Ditch; maximum suspended sediment concentrations approached 800mg/l. The data revealed a strong correlation between discharge (streamflow) and sediment concentrations. A sample graph from the Claggett Creek watershed shows the correlation (**Figure 8-2**) (City of Salem 1982).

Figure 8-2. Correlation Between Rate of Discharge and Suspended Sediment in Claggett Creek at Hyacinth



Data source: City of Salem (1982)

Dry Weather Field Screening: 1992

The following information is summarized from *Salem Part I NPDES Municipal Stormwater Discharge Permit Application* (City of Salem and ODOT 1994).

The detection and elimination of illicit discharges from storm sewers to receiving waters is one of the primary goals of EPA's Phase I. stormwater regulations. As a first step in the process of achieving this goal, EPA's Phase I regulations governing municipal applications for an NPDES stormwater discharge permit require municipalities to conduct a field screening program looking for evidence of illicit discharges.

EPA requires municipalities to conduct their field screening using one of two sampling schemes: 1) field screening points, or 2) screening at major outfalls. The City of Salem chose to field screen the major outfalls.

EPA rules define a "major outfall" as "a municipal separate storm sewer outfall that discharges from a single pipe with an inside diameter of 36-inches or more, or its equivalent; or for municipal separate storm sewers that receive stormwater from lands zoned for industrial activity, an outfall that discharges from a single pipe with an inside diameter of 12 inches or more, or its equivalent." The City of Salem conducted field screening at all major outfalls, plus some additional outfalls that were later determined to be "non-major" based upon verification of their size, drainage area, and/or upland land use. Ninety major outfalls were screened.

Two grab samples were collected at each outfall that had dry-weather flow (i.e., during August and September). In most instances the two samples were collected within a 24-hour period, but with a minimum period of four hours between samples. Following EPA requirements, the water samples were tested for pH, total chlorine, total copper, total phenol and detergents. Visual observations were also made.

Forty-one of these major outfalls were flowing during the dry-weather field screening and were subsequently sampled. Results using the five parameters follows.

Detergents

Detergents were detected at concentrations greater than 0.1 mg/l at 13 of the 41 outfalls. Concentrations ranged from 0.1 to 1.15 mg/l, with the highest observed at Outfall No. 45-488-731, discharging into Shelton Ditch. Between the first and second sampling visit, five outfalls decreased in detergent concentration and eight increased.

Total Chlorine

Total chlorine was detected at concentrations greater than 0.1 mg/l at 20 of the 41 outfalls. Concentrations ranged from 0.1 to 0.6 mg/l, with the highest concentration at Outfall No. 39-474-611, discharging into the Willamette River. Between the first and second sampling visit, 11 outfalls decreased in concentration of chlorine and 8 outfalls increased. The field test kit used to measure chlorine does not register chlorine concentrations below 0.1 mg/l. Therefore, discharges without detectable chlorine concentrations as measured in the field may or may not exceed water quality criteria for effects in freshwater organisms as adopted by the State of Oregon (chronic criterion = 0.011 mg/l; acute criterion = 0.019 mg/l).

Total Copper

The field test kit does not detect concentrations of copper below 0.1 mg/l, and discharges with non-detectable copper concentrations may or may not exceed water quality criteria for receiving waters. The receiving water quality chronic criterion for copper is 0.012 mg/l for waters having a hardness of 100 mg/l.

Total Phenol

Phenol was detected at only one outfall, with the two samples recording concentrations of 1.0 and 0.3 mg/l. The samples were taken from Outfall No. 42-482-611, discharging into the Willamette River. The concentrations detected at this outfall were significantly below the receiving water quality chronic criterion for phenol of 2.6 mg/l.

pH

pH values ranged from 4.9 to 8.6, with the highest value recorded at Outfall No. 45-466-652, discharging into the East Fork of Pringle Creek. The lowest value was recorded at Outfall No. 42-482-611, discharging into the Willamette River. In-stream water quality standards for pH are 6.5 to 8.5. While outfall discharges are required to meet water quality standards, four outfalls were below the 6.5 minimum, and one outfall exceeded the 8.5 maximum.

Visual Observations

Field crews also took note of any visible signs of pollution in stormwater discharges (**Table 8-9**). They identified solid and liquid pollution, but not the sources.

Table 8-9. City of Salem Dry Weather Field Screening (1992) Significant Visual Observations and Field Sampling Results

Map No.	Outfall No.	Location	Observations
30-456	12-1 (Non-Major)		This outfall is an open channel about 30" in width. Landowners on both sides have complained that the flow in this ditch has become excessive since the new subdivision has been built on Joplin Street, which is where the ditch originates. Landowners have tried building up the sides of the ditch to control water.
39-474	611		This 18" metal outfall has pumpkin seeds and pulp being washed down through it. It also had chlorine reading of 0.6 mg/l.
42-476	619		This is a 42" concrete outfall emptying into the Willamette River. It had a "musty sewage" smell and had brownish-gray scum hanging off it. The detergent reading was 0.25 mg/l.
42-482	611		This 42" outfall into the Willamette River had a very strong smell of sewage, sulfur, and other "musty" smells. The pipe was flowing with gray slime and surface scum. The pH was 4.9 the first day, and also contained detergents and phenols. It turned the copper test black.
42-476	696 (Non-Major)		This 12" outfall into Mill Creek was barely trickling, but its concentration of detergent was off-scale. It drains a car wash.
51-486	2-1		This ditch is in the process of being dammed by beavers right near its outfall.
51-488	603 (Non-Major)		This is only a 12" outfall. It was running very slowly, but had a strong "sewer" smell. There were black oily deposits around and below the outfall. It had a 6 mg/l copper, and turned the phenol test blue.
48-464	613		This 30" outfall into Pringle Creek did not appear to be flowing (see Table 6-1), but the water surface ponding in it was covered with thick yellow "gunk" (possibly cooking grease).

Source: City of Salem and ODOT (1994)

Wet Weather Screening: 1995-2000

The following information was taken from *Salem Part I NPDES Municipal Stormwater Discharge Permit Application* (City of Salem and ODOT 1994) and from *Part 2 NPDES Municipal Storm Water Permit Application* (City of Salem and ODOT 1996).

Required as part of the City of Salem's NPDES stormwater permit part 2 application, wet weather sampling of outfalls and/or screening points (i.e., manholes) was initiated in 1995. As "wet weather sampling" suggests, the samples are taken during the rainy season, mostly during winter and early spring.

First flush grab samples and time-based composite samples are taken of stormwater discharges after three storm events occurring at least one month apart. The grab samples are taken during the first 15-30 minutes of runoff from a storm event. The grab samples are analyzed for 131 parameters as required by EPA/DEQ. The composite samples are taken using automatic sampling equipment. Samples are drawn at 15-minute intervals for a duration of three hours. The composite samples are then tested for 12 parameters: biological oxygen demand, (BOD), chemical oxygen demand (COD), total suspended solids (TSS), total dissolved solids (TDS), total nitrogen, total ammonia plus organic nitrogen, total phosphorus, dissolved phosphorus, cadmium, copper, lead, and zinc.

Results of wet weather monitoring are submitted to DEQ. The annual reports contain the raw data for the both the grab and composite samples. DEQ reviews the data. If the data suggests that pollutant loads have changed from previous years, DEQ may ask the City of Salem to modify the BMPs outlined in their NPDES stormwater permit in order to reduce the targeted pollutant (Namburi pers. comm.).

Water-quality monitoring of stormwater is conducted at four sample points in Salem (**Table 8-10**). These sample points were chosen to provide a means of quantifying the pollutant contributions and potential water quality impacts associated with stormwater runoff from particular land uses.

A brief description of the four selected sampling sites is provided in the following discussion.

Table 8-10. Monitoring Sites for Wet Weather Sampling

Location	Size	Land Use	Access
Site #1: Commercial St. SE	31 Acres	42 % Residential 58 % Commercial Includes ODOT ROW (Hwy. 99E)	Manhole (MH42458210)
Site # 2: Red Leaf, SE	72 Acres	100 % Residential	Manhole (MH3345020212)
Site #3: Edgewater, NW	35 Acres	100 % Industrial	Manhole (MH39474202)
Site #4: Cottage, SE	40 Acres	100 % Commercial	Manhole (MH42472295)

Source: City of Salem and ODOT (1996)

Commercial St. Site

The Commercial St. site is a 36-inch outfall that drains a mixture of residential and commercial development, including the main highway arterial of Commercial St. SE. The site is located between Commercial and 12th Sts. SE. The outfall discharges into the West Fork Pringle Creek within the Pringle Creek Basin. The sampling site is a manhole approximately 7 feet deep. A flow meter and automatic sampler were installed at this site.

Red Leaf Site

This sampling site is a manhole (approximately 7 feet deep) located along Red Leaf Drive SE at Serend Court. This site is a 42-inch outfall which discharges into Waln Creek within the Battle Creek Basin from a strictly residential development area in South Salem. The monitoring manhole is the downstream intersection of the piped storm drainage system serving single-family residential development. A flow meter and automatic sampler were installed in the manhole.

Edgewater Site

The sampling site is a manhole (approximately 18 feet deep) located near the intersection of Patterson Ave. NW and Edgewater St. in West Salem. The outfall discharges directly into the Willamette River from the West Bank Basin. This area represents industrial land use. A flow meter and automatic sampler were installed in the manhole.

Cottage Site

The sampling site was initially located in a manhole (approximately 8 feet deep) in the 100 block of Cottage St. SE. This area represents commercial land use. The outfall from the storm sewer eventually discharges to the Shelton Ditch, which in turn discharges to Pringle Creek. A flow meter and automatic sampler were installed in the manhole. In October 2000, this site was relocated to another manhole slightly "upstream" within the same drainage basin. Located at Peterson and 2nd, the move was prompted by manhole surging at the initial site during high river levels (Downs, 2003).

Surface Water Quality: 1982-2000

As part of Salem's water quality monitoring program, the city initiated a surface water monitoring program in 1982. Seventeen stream monitoring stations were set up in 6 watersheds including Claggett (includes Labish Ditch), Croisan, Glenn, Mill (includes Battle Creek and Waln Creek), Pringle (includes Clark Creek), and the Willamette. The number of monitoring stations was later expanded to include a total of 31 sites (**Table 8-11**), not including 11 sites on the Willamette River.

Table 8-11. Locations of Water Quality Monitoring Stations and Their Sampling Duration

Watershed	Data Source[1]	Site Number	Site Name	Site Location	Data Sampling Period
Claggett Creek	C	1	Claggett River Road	Claggett Creek at River Road	1982-1993
	C	2	Claggett Hyacinth	Claggett at Hyacinth St.	1982-1993
	C	3	Claggett Mainline	Claggett at Mainline Drive	1982-1993
	C	17	Hawthorne Ditch	Hawthorne Ditch at East Gate Basin Park between Hawthorne Ave. and Beacon St.	1982-1993
	C	24	Labish Ditch	Labish Ditch at River Road NE.	1983-1993
	S	1	Dearborne Ave.	Claggett Creek Park at Dearborne Ave.	1994-1995
Mill Creek	C	MC0010 (5)	Front	Mill Creek at Front Street	1982-1995
	C	MC0707 (12)	Turner	Mill Creek at Turner Rd	1982-1995
	C	MC0308 (14)	23rd	Mill Creek at 23rd	1982-1995
	C	16	Battle Creek	Battle Creek at Fairway Ave. SE	1982-1993
	C	21	Shelton Ditch	Shelton Ditch at Church St.	1983-1993
	C	MC0209	North Salem H.S.	Mill Creek at N.S. High School -- Between 12th and 14th Streets	1990-1995
	C	MC1006	Delaney	Delaney Road in Turner	1990-1995
	C	MC1305	70th	Mill Creek at 70th St.	1990-1995
	C	MC1604	Bishop	Mill Creek at Bishop Road	1990-1995
	C	MC1803	Shaff	Salem Ditch at Shaff Rd. Rd.	1990-1995
	C	MC1901	Cascade	Salem Ditch at Cascade Rd.	1990-1995
	C	MC1902	Pioneer	Salem Ditch at Pioneer Park, Stayton	1990-1995
Glenn-Gibson	C	6	Glenn Creek Orchard Heights	Glenn Creek at Orchard Heights Rd.	1982-1989
	C	22	Glenn Creek Salem-towne	Glenn Creek at Salemtowne	1990-1993
	W	1	Upper Glenn Creek	1168 Willow Creek Drive	1998-2000
	W	2	Winslow Creek	Gibson Creek at Grice Hill Dr.	1998-2000
	W	3	North Gibson Creek	North Gibson Creek at Private Road just west of confluence with South Gibson Creek	1999-2000
	W	4	South Gibson Creek	South Gibson Creek at Private Road just west of confluence with North Gibson Creek	1998-2000
	W	5	Lower Gibson Creek	South side of Wallace Road	1999-2000
	W	6	Lower Glenn Creek	Glenn Creek at River Bend Rd.	1999-2000
Pringle Creek	C	7	Clark Ratcliff	Clark Creek at Ratcliff	1982-1994
	C	8	Pringle 12th	West Fork Pringle Crk at 12th Street	1982-1994
	C	18	Pringle Bush	Pringle Creek at Bush Park	1997-1998
	C	19	Clark Bush Park	Clark Creek at Bush Park	1983-2000
	C	20	Cross Street	Pringle Creek at Cross Street	1983-2000
	C	26	Pringle Church	Pringle Creek at Church St.	1983-1994
	C	27	Ewald Street	Clark Creek at Ewald	1995-2000
	C	28	Cannery Park	W. Fork Pringle Crk at Cannery Park	1995-2000
	C	29	Woodmansee Park	West Fork Pringle Creek at Woodmansee Park	1995-2000
	C	30	Madrona Street	West Fork Pringle Creek at Madrona	1995-2000
	C	31	Pringle Park	Pringle Creek at Pringle Park	1995-2000

Twenty water quality parameters were measured at each of the monitoring stations: fecal coliform, dissolved oxygen (DO), total solids (TS), volatile solids (TVS), turbidity, pH, alkalinity, temperature, biological oxygen demand (B.O.D.), chemical oxygen demand (COD), hardness, conductivity, suspended solids (TSS), stream depth, visual observations, chlorides, and metals (copper, lead, zinc, cadmium and chromium).

The City of Salem has done some analysis on the water quality data they have collected in the last 20 years (Schweickert pers. comm.). Data collected in Pringle and Mill Creeks were made into presentations given at public forums in the 1990s. Findings from the data were also used to formulate a list of recommendations for the City of Salem's Stormwater Master Plan early in its development. As of March of 2001, publication of the surface water quality data in its entirety has not been attempted by the City of Salem. The watershed councils were able to obtain the databases and conduct their own analysis. The remainder of this chapter will concentrate on the analysis and results of the city-collected data, in addition to some supplemental data provided by schools and watershed councils.

Information Sources

Much of the data was collected by the City of Salem as part of a stream monitoring program initiated in 1980 (City of Salem 1982). Permanent stream monitoring locations were established throughout the city (**Maps 8-3, 8-4, 8-5, 8-6**). Mill Creek was sampled upstream from Stayton. Sampling frequency was monthly in most instances. The duration of sampling varies per stream (**Table 8-11**). Some stream segments, such as Glenn Creek at Salemtowne, only have three years of data from 1990 to 1993. In contrast, some monitoring stations along Mill Creek were sampled for longer durations (i.e., 1982 to 1995). Some monitoring stations were abandoned early on due to limited access (e.g., flooding); others were not established until the 1990s. Water quality monitoring was re-instituted in 2001.

Other information sources on water quality include the Oregon Water Resources Department (OWRD), watershed councils and schools involved in the City of Salem's Adopt-A-Stream program. The OWRD has a permanent monitoring station on Mill Creek near North Salem High School. The station currently monitors temperature and flow on a continuous basis. Glenn-Gibson Watershed Council initiated its own water quality-monitoring program in 1999 and has contributed the data to the watershed assessment. Schools involved in Salem's Adopt-A-Stream program collect basic water quality data and macroinvertebrates (City of Salem 2001).

Data Analysis

Information collected from different sources is graphed separately to avoid confounding data results due to the varying expertise of the data collectors. In order to compare the similarities and differences between the four watersheds, information for each watershed will be presented separately. Waters are considered temperature-limited if the stream exceeds 64 degrees F (17.8 C) for a moving seven-day average

(DEQ standard). In the absence of moving seven-day averages, we consider simple temperature values as indicative of temperature conditions. The same applies for dissolved oxygen. The standard of 8.0 mg/l for DO is based on a 30-day mean minimum (DEQ standard). Because water quality monitoring stations were not sampled daily, single sample DO values were compared to the 30-day mean minimum standard. Additional data, using DEQ protocols, will need to be collected to determine if listing is appropriate.

Data can be used to determine trends and seasonal changes in water quality parameters. It also can be used to determine where more monitoring may be necessary. The water samples were collected in the morning. Because stream temperatures typically don't reach their daily maximums until the afternoon, stream temperatures may get significantly warmer than what is reported. DO levels also undergo diurnal fluctuations. To measure the daily minimum DO level, water samples should be taken very early in the morning, immediately before sunrise, when photosynthesis and the production of oxygen is at its lowest.

In the absence of state standards for Total Phosphorus and Total Nitrates as they relate to cold-water fish health, standards suggested by the Oregon Watershed Assessment Manual (OWAM) were used to determine if these nutrients were at high or low concentrations in water samples.

Because bacteria samples were not consistently collected by the City of Salem prior to 1995 using DEQ protocol, fecal coliform counts were graphed, but could not be directly compared to any standard. However, we considered a fecal coliform count to be high above 400 cfu/100 ml. This self-imposed standard was set based on the old DEQ standard for fecal coliform, which stated that no more than 10% of the surface water samples taken in a 30-day period should exceed 400cfu/100 ml if the water is to be considered safe for water-contact recreation.

As of January 11, 1996, DEQ changed its bacteria standard for water contact recreation to read, "no single sample should exceed 406 *E. coli* organisms per 100 ml." When the standard for bacteria was changed to *E. coli*, the City of Salem began collecting data on *E. coli* levels. To determine if Claggett Creek, Glenn Creek and Gibson Creek are water quality limited for bacteria, water samples will need to be collected and counts of *E. coli* will need to be compared to the new DEQ standard for single samples. By 1996, Mill Creek was already determined to be water-quality limited for fecal coliform bacteria using the old DEQ standards for bacteria.

Gaps in data collection are indicated on graphs by the interruption of data curves. The lack of data may be due to several factors, including access difficulty, no flows during summer or fall months, or human error in transcribing field data.

Not all 20 parameters collected by the City of Salem were analyzed. Some of the databases lacked information on particular parameters. Parameters, such as conductivity, are weakly linked to pollution and were not considered for analysis. Because the sampling frequency was monthly in most instances, total suspended solids (TSS) and turbidity were also not analyzed. The best time to measure suspended sediments is during high flow and after storm events when soil erosion is at its peak. However, the monthly measurements of TSS and turbidity could be used to determine background levels of sediments in the streams. See results of the USGS study on stormwater (Laenen 1983) and the Salem Urban Area Water Quality Plan (City of Salem 1982) for the results of monitoring sediments in stormwater.

Results by Watershed

1. Pringle Creek

A total of 11 monitoring stations were established by the City of Salem in the Pringle Creek watershed (**Map 8-3**). Four monitoring stations are located along the main stem of Pringle Creek (C20, C18, C26, C31) from Cross Street to Pringle Park, which is located about a quarter mile upstream from the mouth of Pringle Creek at the Willamette River. Three monitoring stations are located on Clark Creek from its headwaters near the intersection of Ewald Street and Liberty Road (C27) to Ratcliff Drive (C7) to Bush Pasture Park (C19) where Clark Creek flows into Pringle Creek. Four monitoring stations were established along the West Fork of Pringle Creek. The first station is located near the headwaters at Cannery Park (C28). Less than a mile downstream a second monitoring station is located at Woodmansee Park (C29). A third station is at Madrona Street (C30). The fourth and final monitoring station at 12th Street (C8) is located just upstream from the confluence of the West Fork of Pringle Creek and the main stem of Pringle Creek.

Duration of water quality sampling varied between monitoring stations (**Table 8-11**). Monitoring stations along Clark Creek were typically sampled from 1982 or 1983 to 1994 or until May of 2000. Two of four of the monitoring stations along the main stem of Pringle Creek were initiated in 1983; one station was abandoned in 1994, while the other was sampled until May of 2000. Another station at Bush's Pasture Park was only sampled in 1997 and 1998. The fourth station at Pringle Park collected samples from 1995 to 2000. With one exception, all the stations along the West Fork of Pringle Creek were sampled from 1995 to May of 2000.

An exception to the monitoring protocol occurred in the mid 1990s when the City of Salem followed DEQ protocols for monitoring stream temperature and installed Hobo temperature monitors in Pringle and Clark Creeks. Data collected was sent to DEQ and used to designate Pringle and Clark Creeks as water quality-limited for temperature.

a. Water Temperature

Pringle Creek is water quality-limited for temperature, according to DEQ (**Table 8-4 and Table 8-5**). Water temperatures varied seasonally in Pringle Creek and in two of its tributaries, Clark Creek and West Fork of Pringle Creek. With one exception, temperatures in the West Fork of Pringle Creek remained below the DEQ standard of 17.8 degrees Celsius every year from 1982-2000, even during summer months (**Figures 8-3** and **8-4**).

Water temperatures in Clark Creek ranged widely, from 2 to 19 degrees Celsius (**Figure 8-5**). Of the three monitoring stations on Clark Creek, the two stations lowest in the system, Ratcliff (C7) and Bush's Pasture Park (C19), reported temperatures at or slightly above the DEQ standard of 17.8 Celsius during July, August and/or September at least a few times during the sampling period. Clark Creek flows through a 500-foot long steam sewer before daylighting briefly in Bush's Pasture Park where it flows into the main stem of Pringle Creek. According to a recent study (Andrus 2000), cutthroat trout have been documented in this small reach of Clark Creek (see Fish Chapter). Water temperatures taken in May indicate that afternoon temperatures in Clark Creek are almost six degrees cooler than in Pringle Creek (Andrus 2000). The trout may be using Clark Creek as a refuge to avoid the high afternoon temperatures in Pringle Creek.

Unlike the West Fork of Pringle Creek and Clark Creek, water-quality monitoring stations along the main stem of Pringle Creek (C20, C26, C31) exceeded 17.8 degrees Celsius during summer months almost annually (**Figure 8-6**). Recorded water temperature ranged from 2 to 22 degrees Celsius at these three monitoring stations. Additional data on Pringle Creek collected at Bush's Pasture Park (C18) from 1997-1998 also shows that July and August water temperatures did exceed 17.8 degrees Celsius (**Figure 8-7**).

b. Dissolved Oxygen

The West Fork of Pringle Creek kept above 8.0 mg/l of dissolved oxygen at the 12th Street monitoring station (C8) from 1982-1994 (**Figure 8-8**). This trend continued in the late 1990's for at least two of the monitoring stations along the West Fork (**Figure 8-9**). The Cannery Park monitoring station (C28), which is the station located highest in the West Fork watershed, reported dissolved oxygen levels lower the DEQ's standard seven times between 1995-2000. The low records occurred from July through October.

Clark Creek contains suitable levels of dissolved oxygen throughout the year according to information collected from three monitoring stations (C7, C19, C27) from 1982-2000 (**Figure 8-10**). Only two recordings of dissolved oxygen fell below the recommended minimum of 8.0 mg/l (DEQ standard). A record low of 0.8 mg/l was recorded in January of 1996 at Bush's Pasture Park. This oddity may be a recording error rather than an actual reading.

With only a few exceptions, the main stem of Pringle Creek also maintained suitable levels of dissolved oxygen for cold-water fish during most of the year (**Figures 8-11** and **8-12**). Dissolved oxygen levels fell slightly below 8.0 mg/l during some summer months. The lowest dissolved oxygen recorded was 6.6 mg/l at the Cross Street monitoring station (C20) in August of 1997.

Figure 8-3.

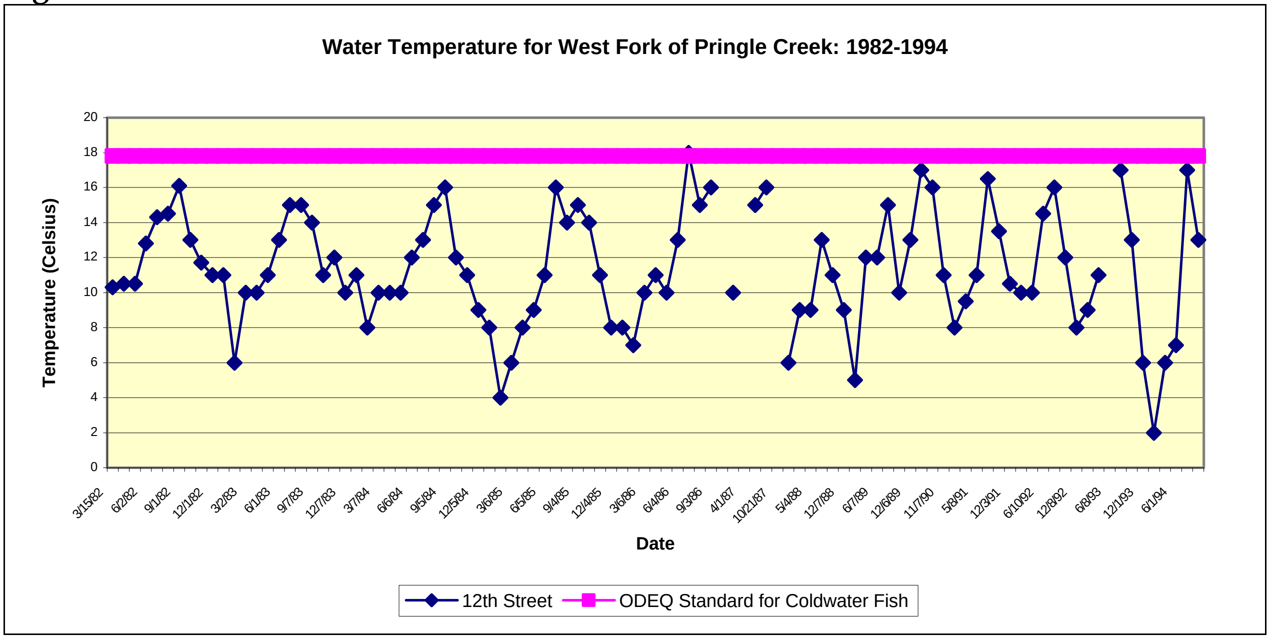


Figure 8-4.

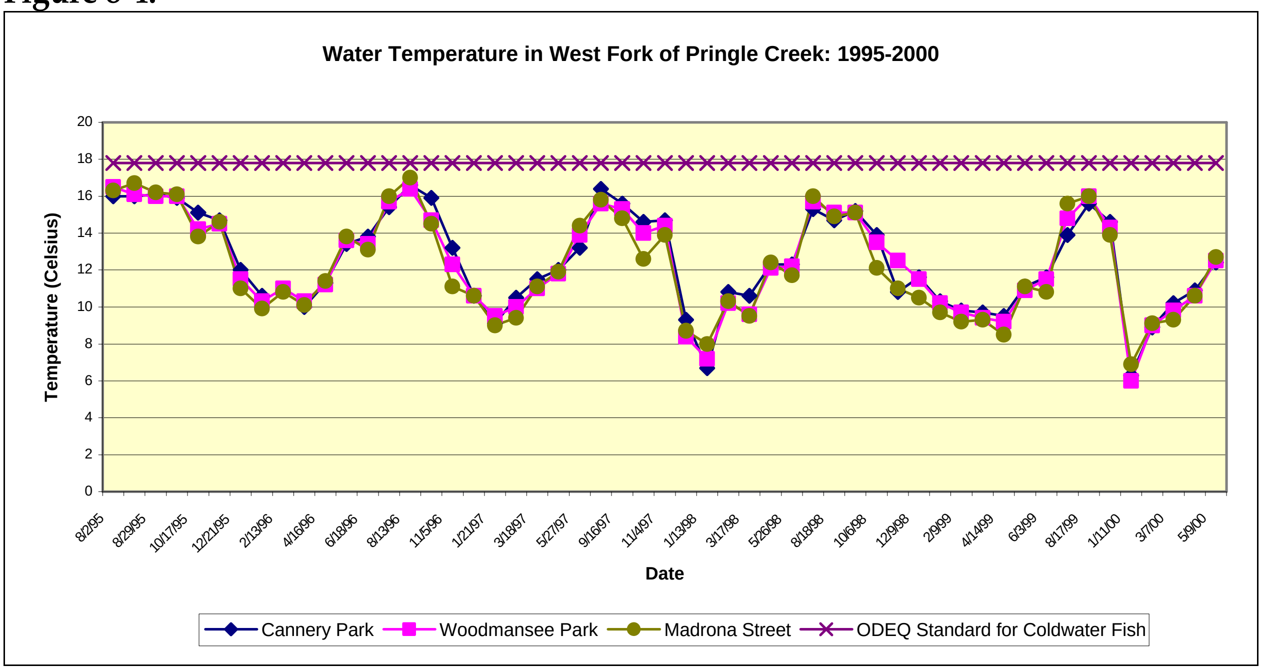


Figure 8-5.

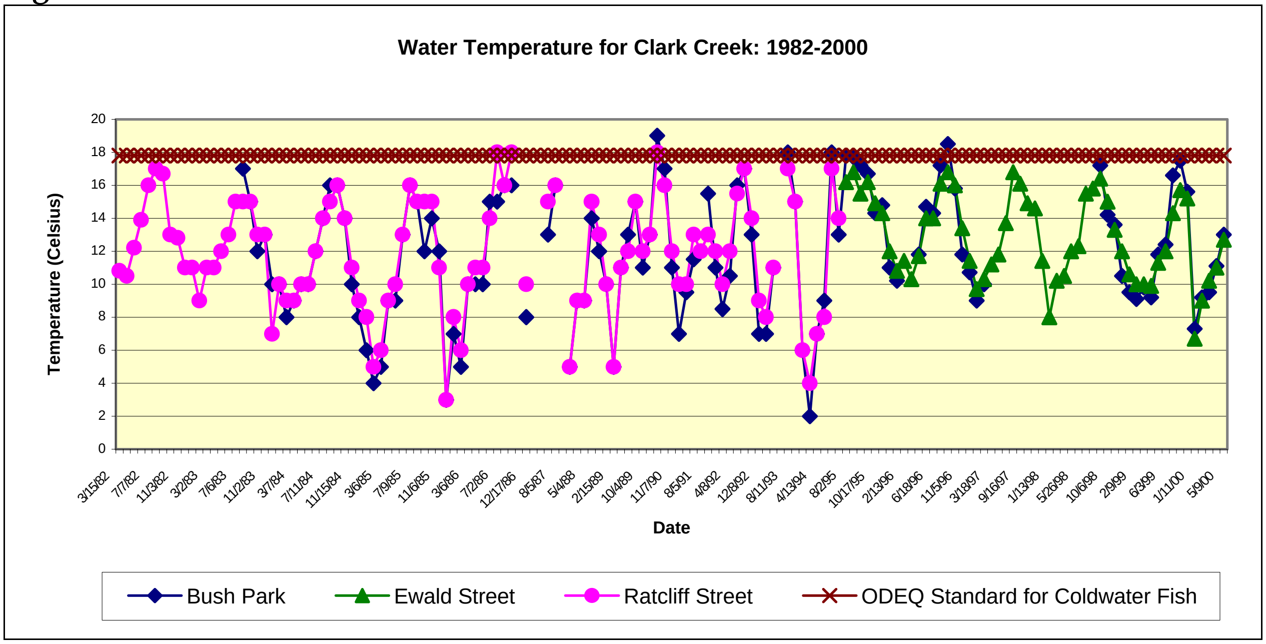


Figure 8-6.

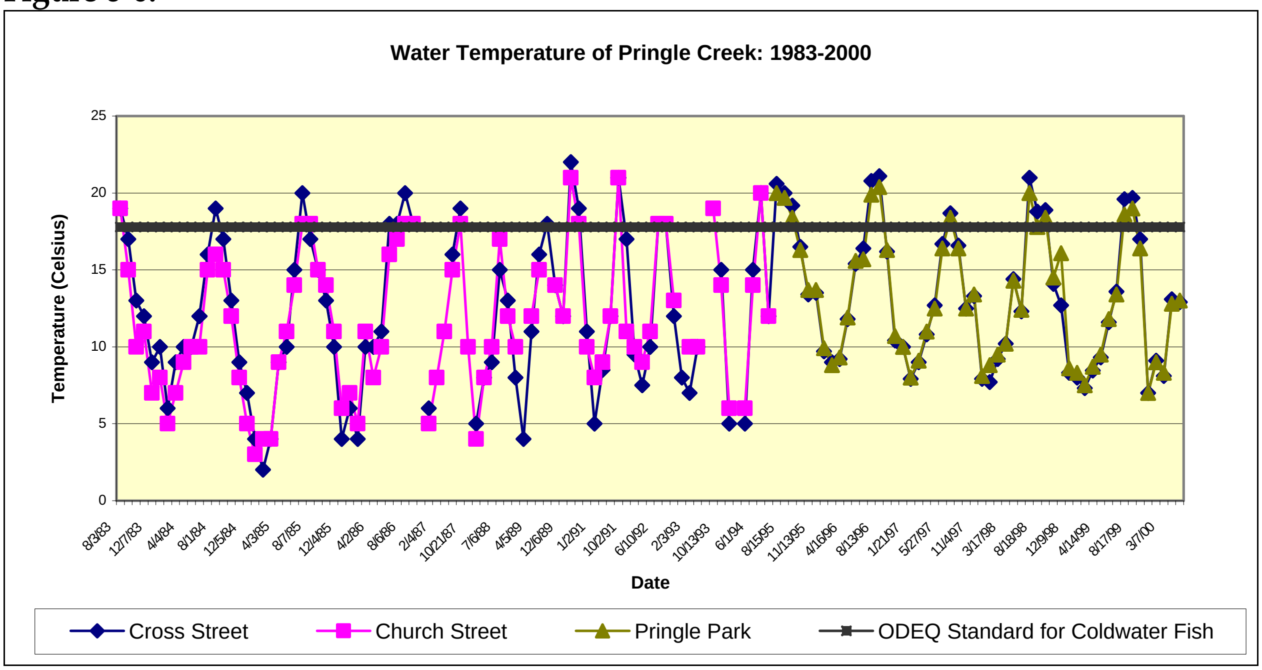


Figure 8-7.

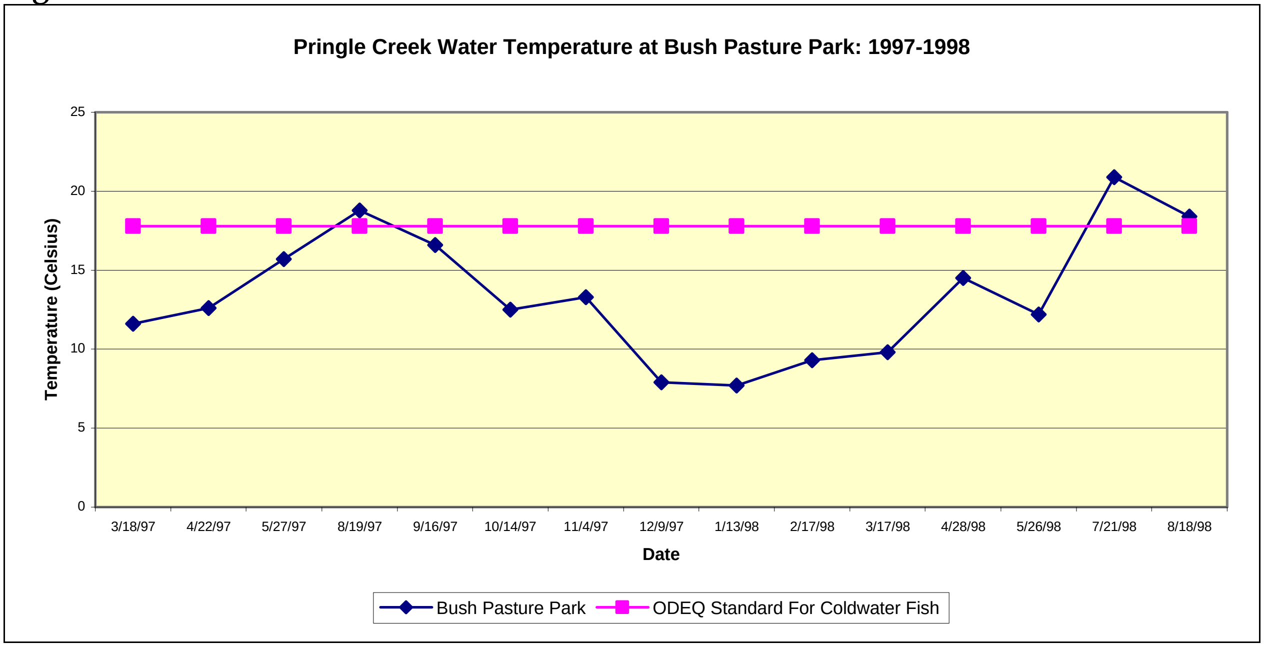


Figure 8-8.

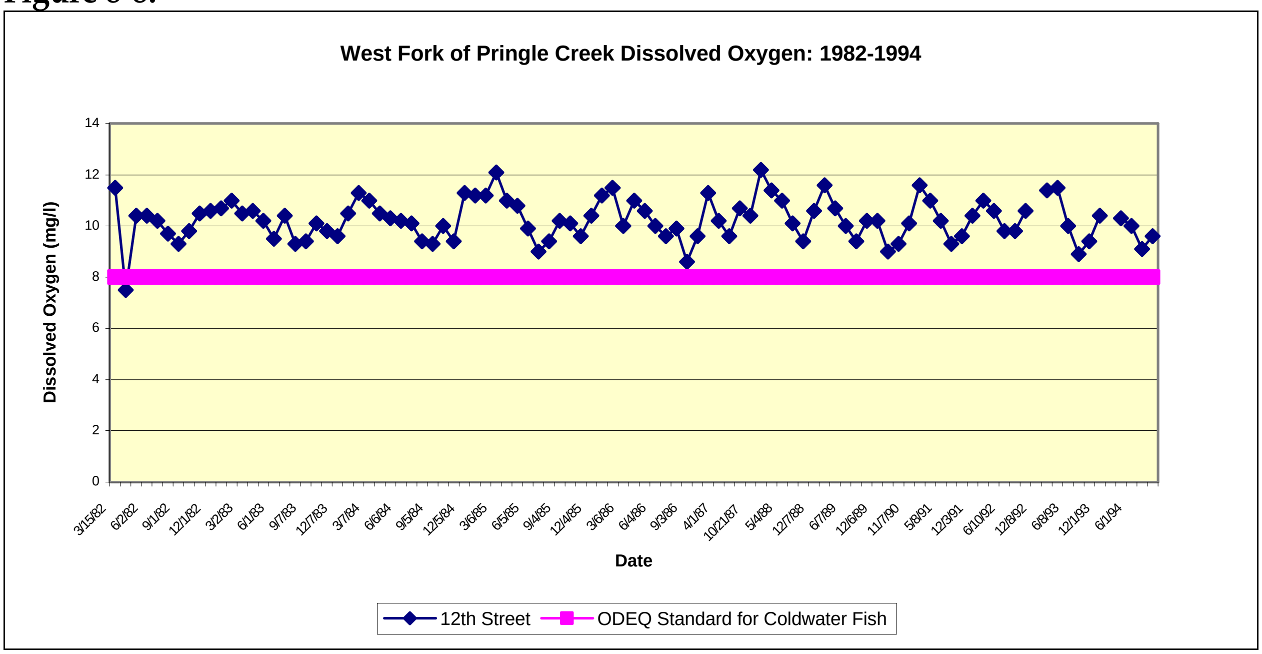


Figure 8-9.

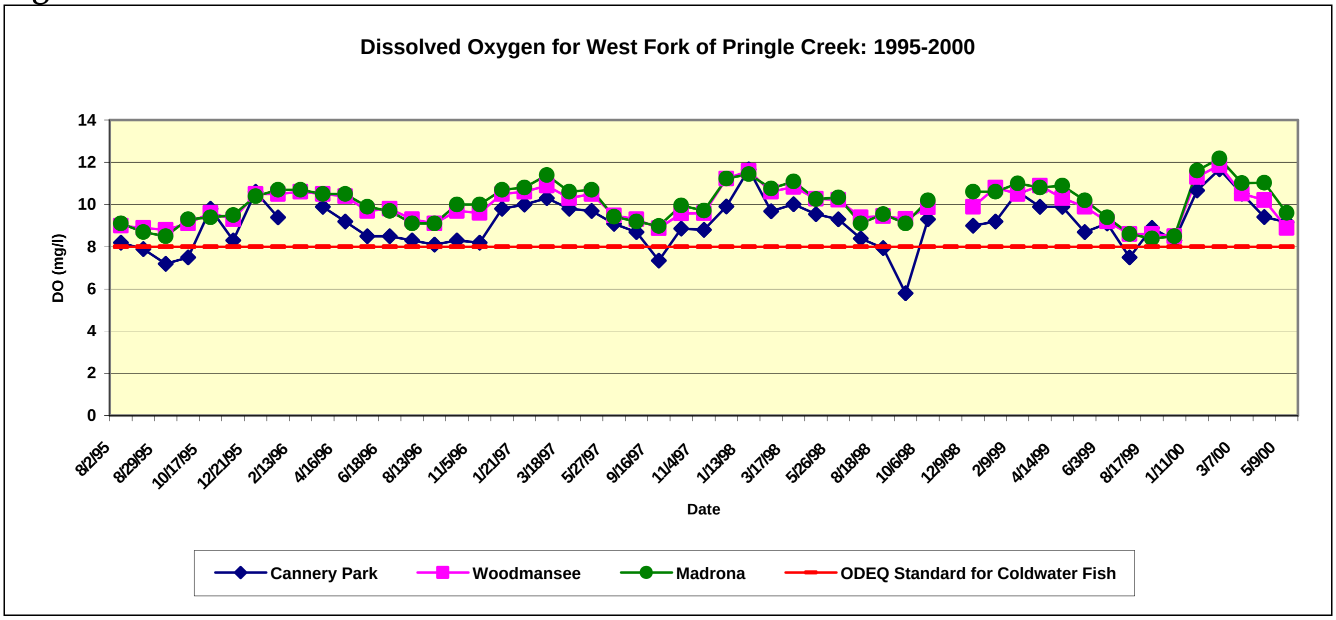


Figure 8-10.

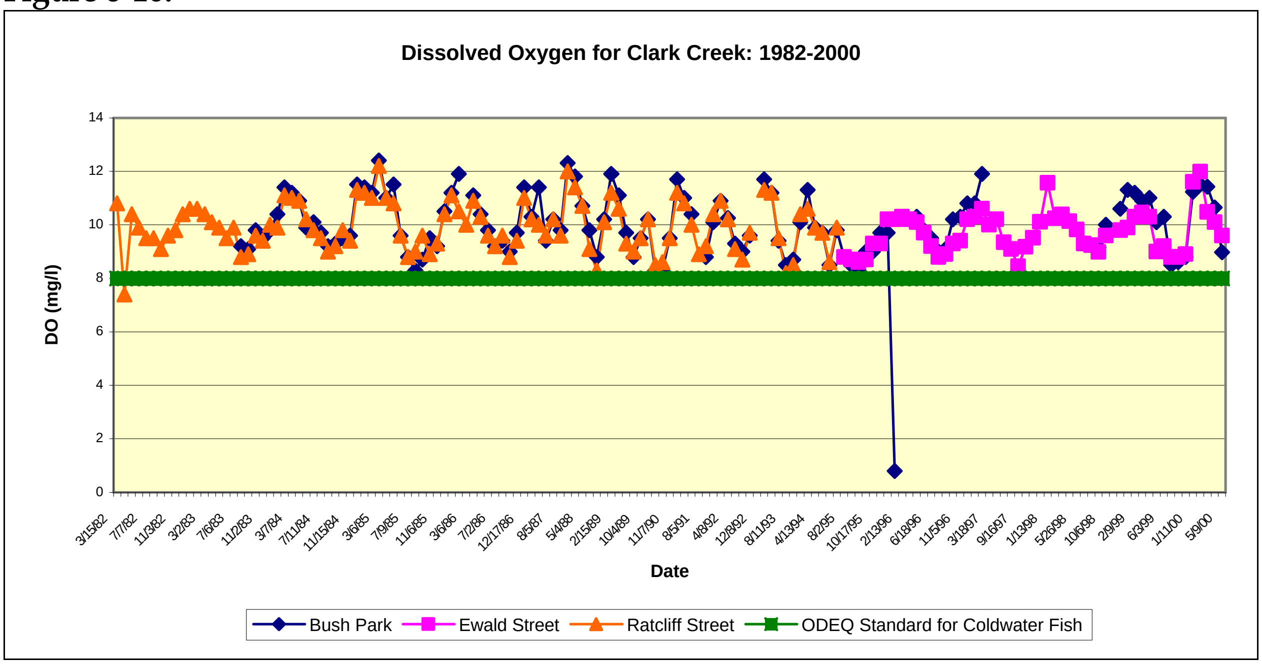
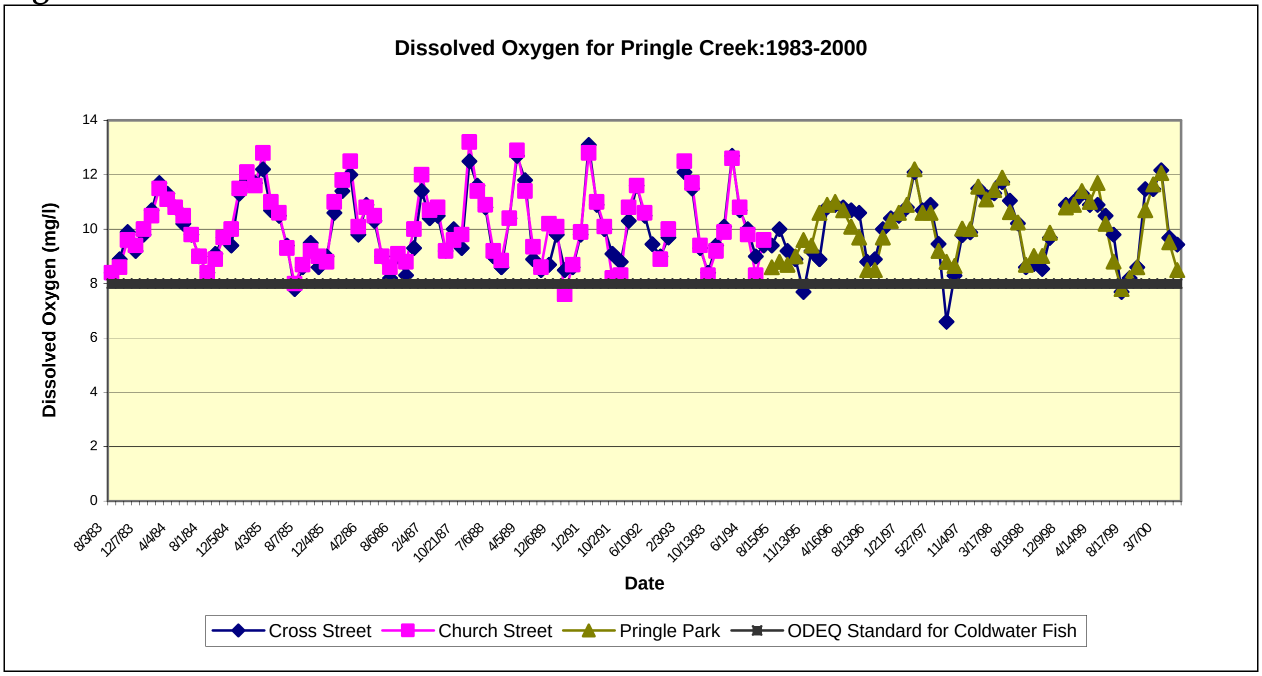
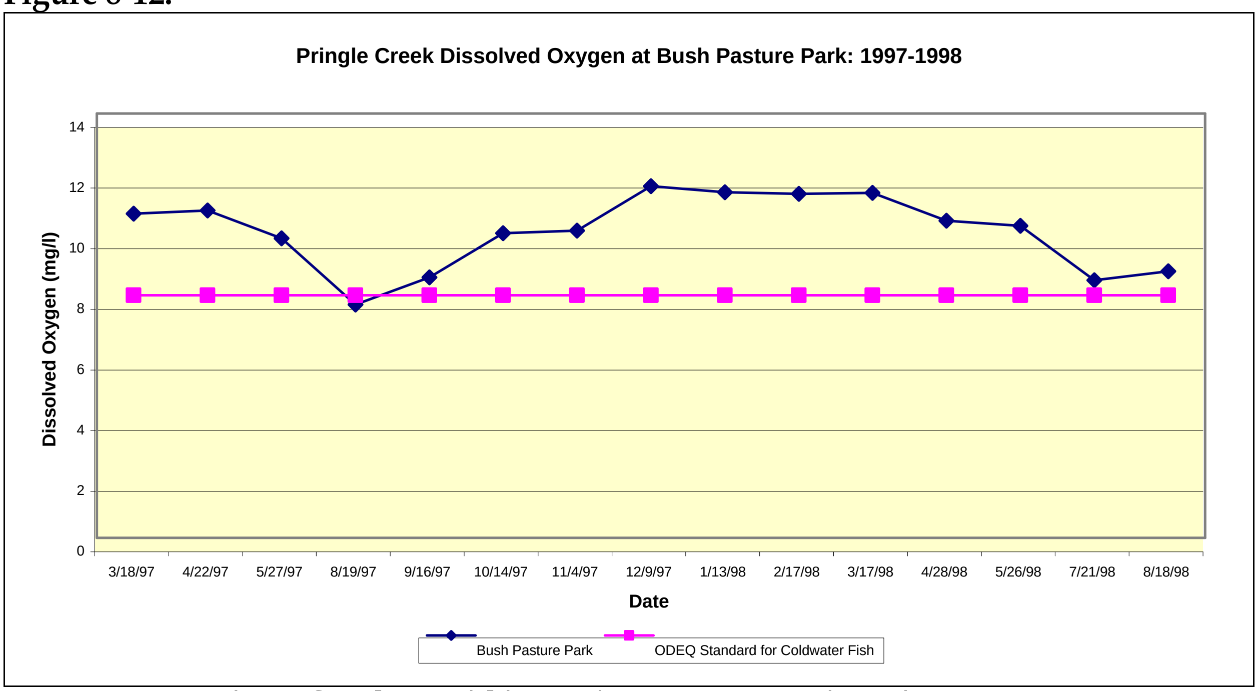


Figure 8-11.



Data source: City of Salem Public Works Department (2000)

Figure 8-12.



Data source: City of Salem Public Works Department (2000)

c. pH

Levels of pH ranged from a low of 5.6 to a high of 7.3 in the West Fork of Pringle Creek. Two monitoring stations located in the South Salem Hills along the West Fork of Pringle Creek, C29 and C28, consistently recorded pH levels below 6.5 (**Table 8-12**). However, most of the pH readings were only slightly below the recommended minimum.

Table 8-12. Counts of High and Low pH Samples from Pringle Creek Watershed: 1982-2000

Monitoring Station	Location	Low pH(<6.5)	High pH (>8.5)	Total	# of samples	% exceedence
Clark Creek						
C19	Clark Bush Park	6	0	6	117	5%
C7	Clark Ratcliff	0	0	0	99	0%
C27	Ewald Street	31	0	31	53	58%
West Fork of Pringle Creek						
C30	Madrona Street	6	0	6	53	11%
C29	Woodmansee Park	20	0	20	53	38%
C28	Cannery Park	34	0	34	52	65%
Pringle Creek						
C8	Pringle 12th	2	0	2	98	2%
C20	Cross Street	5	7	12	134	9%
C18	Pringle Bush	1	0	1	15	7%
C26	Pringle Church	0	0	0	82	0%
C31	Pringle Park	7	1	8	52	15%

Note: Normal pH levels of streams in Oregon range from 6.5 to 8.5 units.

Levels of pH in Clark Creek exhibited a similar pattern as the West Fork of Pringle Creek. pH levels ranged from a low of 5.6 to a high of 7.8. The Ewald Street monitoring station, C27, consistently recorded low pH levels throughout the year, most recordings only slightly below 6.5. The two monitoring stations lower in the Clark Creek basin, C7 and C19, almost always recorded pH levels within the recommended range.

The slightly lower pH of stream water may be the result of the low pH of the soils found in the headwaters of both the West Fork of Pringle Creek and Clark Creek. Jory Silty Clay Loam and Nekia Silty Clay Loam are prominent soil types in the south Salem hills. Both soils are on low, red foothills that are dissected by drainageways and streams. The Jory soil series has a surface pH of 5.9 and increases in acidity to 4.9 at a depth of 50 inches. The Nekia soil series has a surface pH of 5.6 and increases slightly in acidity to 5.3 at a depth of 36 inches (U.S. Soil Conservation Service 1972). Water in contact with these highly acidic soils, be it either surface runoff or groundwater, may also become acidic in nature.

The pH levels recorded in the main stem of Pringle Creek ranged from 5.4 to 9.4. Only 6% of all water quality samples taken from the five monitoring stations along Pringle Creek ever fell outside the recommended range of 6.5 to 8.5 units.

d. Nutrients

Total Nitrates in water samples taken throughout the Pringle Creek watershed basin were high, ranging from zero to 3.8 mg/l (**Table 8-13**). Approximately 98% of all water quality samples taken at the three monitoring stations along the West Fork of Pringle Creek exceeded OWAM's recommended standard of 0.30 mg/l. Clark Creek also exceeded the standard 98% of the time. Water samples from Pringle Creek exceeded the standard 91% of the time.

Table 8-13. Total Nitrates of Pringle Creek Watershed: 1983-2000

	Pringle Park	Church Street	Bush Park	Cross Street
Number	C52	C80	C15	C132
Minimum	0.24	0.3	0.369	0
Maximum	2.4	3.8	1.45	3.2
Median	0.967	1	1.102	0.9
Number (>0.30mg/l)	51	73	15	115
% exceedance	98%	91%	100%	87%

Total Phosphorus was only measured from 1995-2000. Water quality samples taken from the West Fork of Pringle Creek exceeded OWAM's suggested standard of 0.05 mg/l in 17% of the samples (**Table 8-14**). This percentage of exceedance was low compared to samples taken in the main stem of Pringle Creek where 65% of the samples exceeded the standard. In Clark Creek, frequency of samples with high Total Phosphorus differed greatly between a headwater monitoring station (C27) and a station lower in the watershed (C19), with the latter exceeding the standard 3 times as much as samples taken at C27.

Table 8-14. Total Phosphorus of Pringle Creek Watershed: 1995-2000

	Pringle Park	Church Street	Bush Park	Cross Street
Number	C51	no data collected	C15	C52
Minimum	0.007		0.031	0.031
Maximum	0.248		2.16	2.96
Median	0.056		0.051	0.056
Number (>0.05mg/l)	34		8	34
% exceedance	67%		53%	65%

e. Fecal Coliform and *E. Coli*

Pringle Creek and Clark Creek are water quality-limited for *E. coli* according to DEQ (**Table 8-4, 8-5**). Data collected from 1995-2000 show that approximately 41% of all water-quality samples taken within the Pringle Creek watershed exceeded DEQ's single sample standard of 406 *E. coli* colonies/100 ml. High levels were recorded in all seasons, but summer and early fall sample periods usually defined the highest fecal coliform counts for each year (**Figures 8-13, 8-14** and **8-15**). The highest *E. coli* count in the watershed occurred at Cannery Park (C28) in May of 2000, with a record count of 6080 cfu/100 ml.

Water quality samples taken in the Pringle Creek watershed prior to 1995 were tested only for fecal coliform. From 1982-1997, approximately 46% of water quality samples tested for fecal coliform in the Pringle Creek watershed exceeded 400cfu/100 ml.

f. Toxic Substances

Pringle Creek is on the 303(d) list for dieldrin. In order to protect aquatic life in fresh water, chronic levels of dieldrin are not to exceed 0.0019ug/l (microgram per liter)(DEQ standard). The dieldrin standard was exceeded at Bush Pasture Park in 1994 and 1996. According to USGS collected data, the average dieldrin level was 0.0025ug/l for two of three water samples taken in 1994 (Harrison et al. 1995). The dieldrin standard was exceededed in six out of six samples taken in 1996 at a level of 0.1ug/l.

Dieldrin is an insecticide that was widely used from the 1950s to the early 1970s. It has been used in agriculture for soil and seed treatment and in public health to control disease vectors such as mosquitoes. Because of concerns about damage to the environment and potential harm to human health, EPA banned all uses of dieldrin in 1974 except to control termites. In 1987, EPA banned all uses.

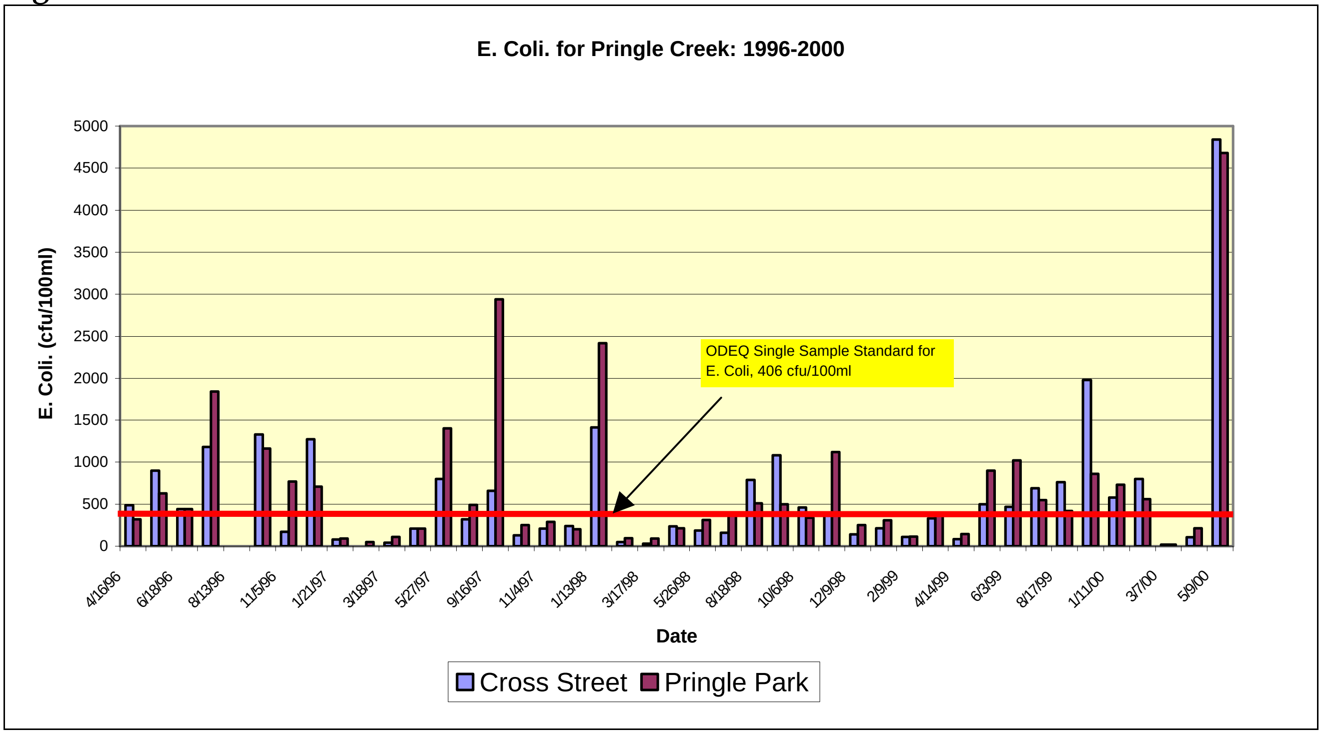
Once dieldrin reaches surface waters it will adhere strongly to sediments, bioconcentrate in fish and slowly photodegrade. Because dieldrin accumulates in sediment it may be detected for years after the chemical is no longer in use. Human exposure to dieldrin may occur by consuming fish that have accumulated this compound in their fatty tissues. Exposure to high levels of dieldrin result in convulsions and death. The effects of exposure to low levels of dieldrin over a long time are unknown.

High levels of lead and DDT have also been documented in Pringle Creek by the USGS (Harrison et al. 1995). However, Pringle Creek is not currently listed for these toxics because the minimum data requirements were not met. In both instances, only one water-quality sample was taken. DEQ requires that the toxic exceed the standard more than 10% of the time and for a minimum of two values. The proposed 2002 303(d) list lists Pringle for lead.

Lead is a naturally occurring metal found in the earth's crust. Lead is used in the production of batteries and can be found in ammunition, pipes, roofing and other products. Because of health concerns, lead from gasoline, paints and ceramic products, caulking, and pipe solder has been dramatically reduced in recent years. According to the USGS, lead concentrations in bed sediment are significantly higher for streams draining urban areas than for streams draining rural lands (Wentz et al. 1998). Past studies in Salem suggest that there is a strong relationship between lead content and traffic patterns and intensity (City of Salem and ODOT 1994). Health effects from lead poisoning include damage to the central nervous system, kidneys and the immune system. Exposure to lead is more dangerous for young children and the unborn.

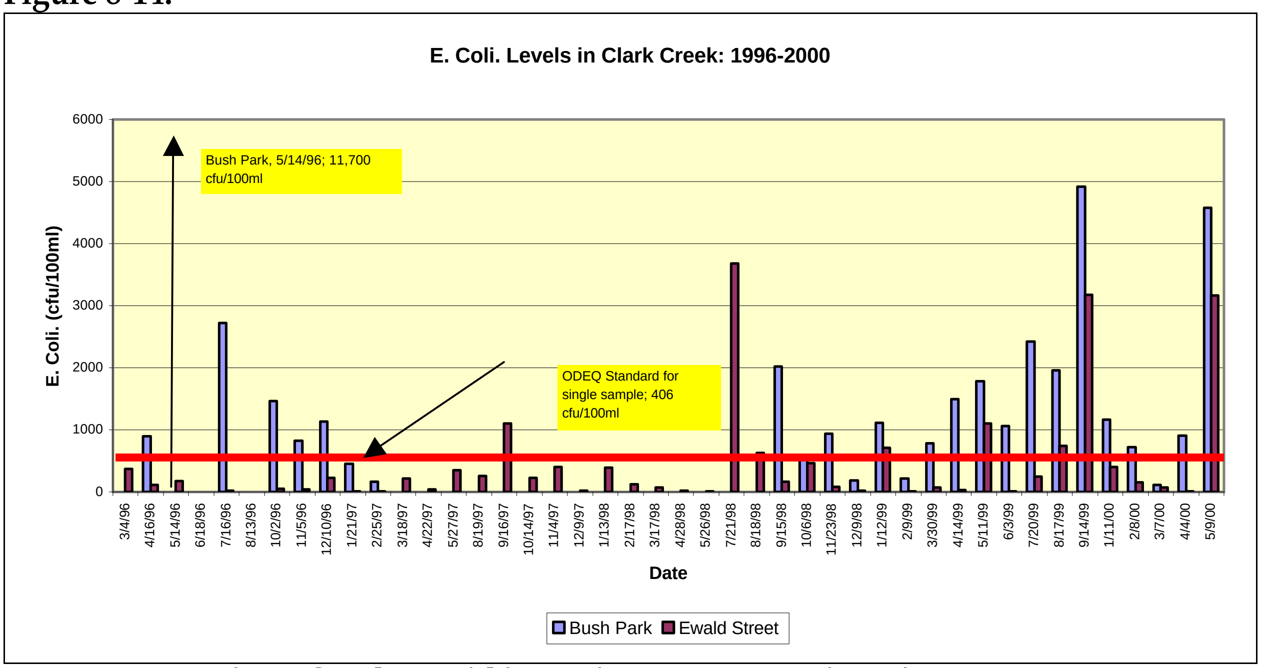
DDT is an organochlorine pesticide that has been linked to reproductive problems in aquatic invertebrates, fish, birds, and mammals. DDT is not metabolized very rapidly by animals; instead, it is deposited and stored in the fatty tissues. The use and manufacture of DDT has been banned since 1973, but it is still present in aquatic systems because of its environmental persistence.

Figure 8-13.



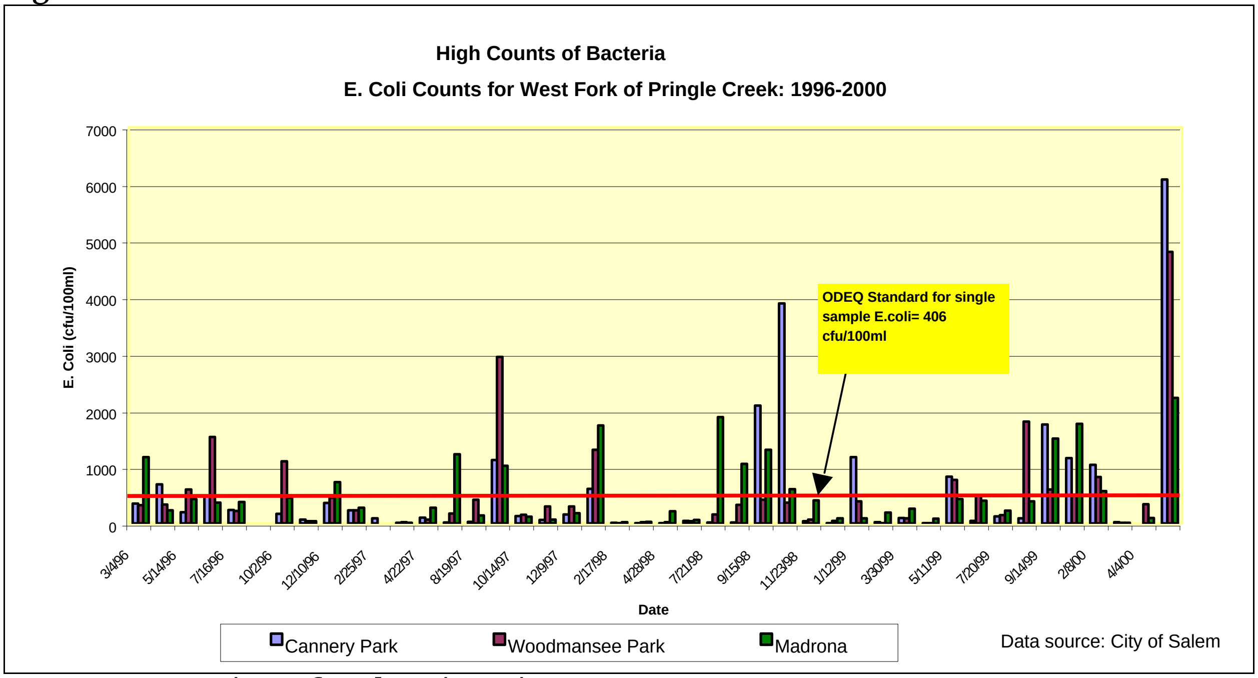
Data source: City of Salem Public Works Department (2000)

Figure 8-14.



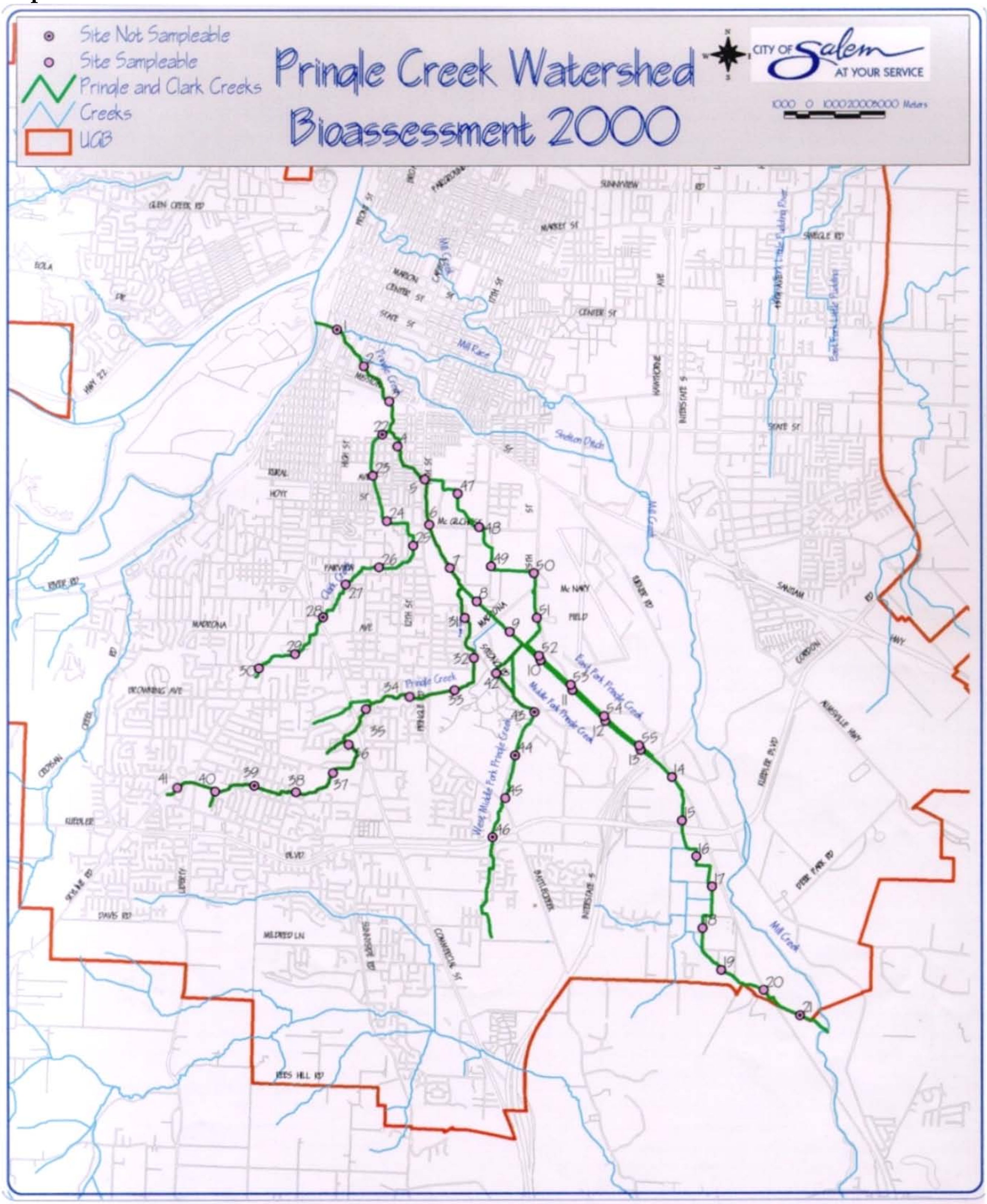
Data source: City of Salem Public Works Department (2000)

Figure 8-15.



Data source: City of Salem (1982)

Map 8-7.


Site Not Sampleable
Site Sampleable
Pringle and Clark Creeks
Creeks
UGB
Pringle Creek Watershed
Bioassessment 2000
CITY OF Salem
AT YOUR SERVICE

g. Pringle Creek Watershed Stream Bioassessment Project

The following background information was taken from the Pringle Creek Watershed Stream Bioassessment Project: Field and Laboratory Methods Manual (City of Salem 2000).

In 2000 the City of Salem embarked on an ambitious project to determine the current status, extent, changes, and trends in the condition of the Pringle Creek Watershed. The Pringle Creek Watershed Stream Bioassessment Project uses procedures outlined in the Environmental Monitoring and Assessment Program (EMAP), a program developed by the EPA to assess stream conditions.

The following two objectives guided the City of Salem's bioassessment research:

1. Estimate the current status, extent, changes and trends in indicators of the condition of the Pringle Creek watershed with known confidence.
2. Monitor indicators of pollutant exposure and habitat condition and seek associations between human-induced stresses and ecological condition.

The goal of the bioassessment was to answer three general assessment questions:

1. What proportion of stream within the watershed is in acceptable (or poor) biological condition?
2. What is the relative importance of potential stressors (habitat modification, sedimentation, nutrients, temperature, grazing, etc.) to the Pringle Creek watershed?
3. With what stressors are streams in poor biological condition associated?

A plethora of parameters were measured at 55 sample points throughout the Pringle Creek watershed (**Map 8-7**). The parameters included chemical, physical and biological attributes of the stream. Some of the chemical variables measured included dissolved oxygen, temperature, pH, total suspended solids and conductivity. Physical attributes included bank width, bank height, incised height of channel, canopy cover and fish cover. Macroinvertebrates were collected as part of the biological portion of the assessment.

- *Biological*

Macroinvertebrates were collected at 46 sample points. With few exceptions, macroinvertebrates were counted and categorized down to genus/species level for all specimens. Fifty-eight macroinvertebrate indices have been calculated from the data (**Table 8-15**). Although the macroinvertebrate data is currently undergoing analysis, we were able to make a few simple observations regarding the data using the indices.

Taxa Richness is the total number of invertebrate taxa identified from a sample. Theoretically, taxa richness will increase as habitat diversity increases.

Table 8-15. Benthic Macroinvertebrate Indices Used for the Pringle Creek Watershed Stream Bioassessment

Richness Measures	Composition Measures	Tolerance Measures	Trophic/Habit Measures
Taxa Richness	% EPT	# Intolerant Taxa	# Clinger Taxa
# Total Taxa	% Ephemeroptera	% Tolerant Organisms	% Clingers
# EPT Taxa	% Chironomidae	Hilsenhoff Biotic Index (HBI)	# Filterer Taxa
# Ephemeroptera Taxa	% Odonata	% Dominant Taxon	% Filterers
# Plecoptera Taxa	% Plecoptera	Hydropsychidae / Total Trichoptera	# Scraper Taxa
# Trichoptera Taxa	% Megaloptera	Baetidae / Total Ephemeroptera	% Scrapers
# Odonata Taxa	% Coleoptera	% Intolerant Ephemeroptera	# Predator Taxa
# Coleoptera Taxa	% Diptera	% Intolerant Trichoptera	% Predators
# Chironomidae Taxa	% Contribution of 1 dominant taxon	% Intolerant Plecoptera	# Collector-Gatherer Taxa
Ephemerellidae Richness	% Contribution of 5 dominant taxa	Community Loss Index	% Collector-Gatherer Taxa
Heptageniidae Richness	% Multivoltine		# Collector-Filterer Taxa
Caddisfly, Stonefly, and Shredder Richness	% Univoltine		% Collector-Filterer Taxa
Rhyacophilidae Richness	% Semivoltine		# Shredder Taxa
EPT index	Ration EPT & Chironomidae abundance		% Shredder
Benthic Index of Biological Integrity	Relative Abundance		Scraper / (Scraper + Collector-Filterer)
Total Individuals			Biotic Condition Index
			Ratio scrapers / filtering Collectors

Source*:* City of Salem (2000).

The number of taxa found at each sample point ranged from 19 to 48. **Map 8-8** shows the distribution of the sample points according to the number of taxa found. Several monitoring sites located in the East Fork of Pringle Creek had high taxa richness. Monitoring sites in the West Fork of Pringle Creek typically ranked Medium Low or Medium

High in taxa richness. No other discernible patterns are evident on the map.

Modified Hilsenhoff Biotic Index (HBI) is an index of a taxon's sensitivity to organic enrichment that typically occurs as a result of excessive nutrients (Oregon Plan Monitoring Team 1999). Index values range from 1 to 10. The higher the index number the more tolerant a taxon is to nutrient loading. For example, stonefly species have low index values, typically on the scale of zero to two, while species of gastropods, including snails, have HBI values of five to eight (Oregon Plan Monitoring Team 1999).

An HBI score for an individual sample point is calculated by using a weighted average of all the taxa found at that site. Thirty-six of the 46 sample points had HBI values greater than 5.0 (**Map 8-9**). Using scoring criteria presented in the Water Quality Monitoring Technical Guide Book (Oregon Plan Monitoring Team 1999), HBI scores over 5.0 indicate an invertebrate community very tolerant of high nutrient levels. Of the remaining 10 sample points, seven sites had HBI values of 4.0-5.0, indicating moderate tolerance of nutrients. Only three sites had low HBI values. With the exception of the lower reach of the West Fork of Pringle Creek, the distribution of sample points with medium or low HBI scores is scattered throughout the watershed. The reach of the West Fork of Pringle Creek with medium HBI scores is located on or near the Fairview Training Center and Leslie Middle School.

Sensitive Taxa are the identified taxa known to be very sensitive to stream disturbance. Stream disturbances include such activities as vegetation removal, channelization, dredging, stormwater and excessive bank erosion. These kinds of disturbance typically lead to degraded water quality, with high stream temperatures, low dissolved oxygen, high nutrient loads, increased sedimentation and simplification of in-stream habitat.

There were no sensitive taxa found in any of the 46 sample points. This would imply that Pringle Creek and its tributaries contain degraded habitat and/or degraded water quality.

- *Physical, Chemical and Biological*

The watershed councils have a copy of the raw data collected from the study. Data from this project is currently being analyzed by the City of Salem. Results of the analysis will be incorporated into the watershed assessment as a separate chapter at a later date. This includes a more thorough analysis of the macroinvertebrate data.

2. Glenn and Gibson Creeks

The City of Salem collected data on Glenn Creek at two monitoring locations: Orchard Heights (C6) and Salemtowne (C22) (**Map 8-4**). Frequency and duration of water quality monitoring varied at both sites (**Table 8-11**). Water samples were taken at the Orchard Heights monitoring station between 1982-1989 on a monthly basis. Data were collected sporadically at the Salemtowne site from 1990-1993.

More recent information was collected by members of the Glenn-Gibson Watershed Council from August 1998 to December 2000 (**Table 8-11**). Water quality information was collected at six monitoring stations; four in Gibson Creek (W2, W3, W4, W5) and two in Glenn Creek (W1, W6) (**Map 8-4**).

For the first two months, morning and afternoon samples were collected semi-weekly. The purpose of this early, intensive monitoring was to see if the morning and afternoon sample results at any of the five sampling sites were markedly different. In water with too much nitrogen and/or phosphorus, algae growth becomes excessive. When excessive nutrients are available in a stream, the pH, temperature, and dissolved oxygen will vary significantly from morning to afternoon. Starting in October of 1998, sampling was cut back to once per day, once a month. Using the data collected from the three sample sites that were monitored consistently between August 1998 and December 2000 (e.g., W1, W2, W6), information on diurnal fluctuations of temperature, dissolved oxygen and pH are included in this assessment.

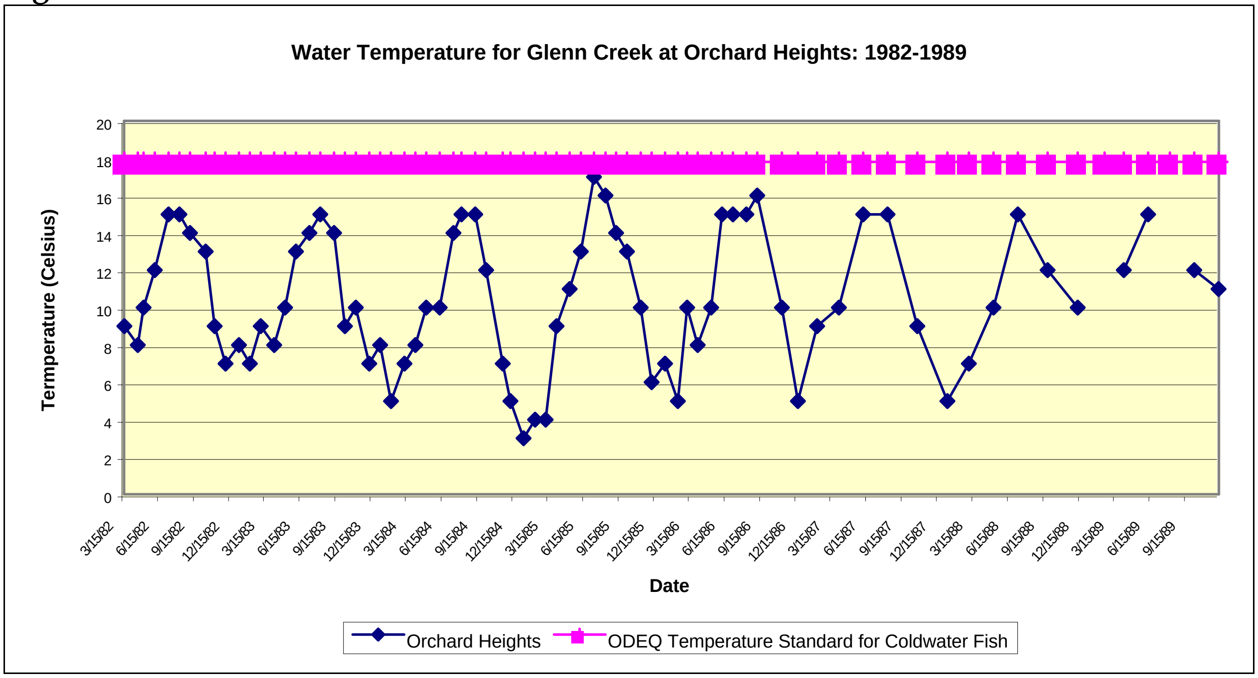
Data was also collected for a short period (August to December 1998) at the Salemtowne Pond in lower Gibson Creek. The site did not provide free flowing water, and showed the effects of ponding (algae, wide swings in pH and dissolved oxygen, and high temperatures). The site was dropped from the monitoring schedule and replaced with a more representative sample of stream conditions. The water quality data collected at the Salemtowne pond indicate poor water quality conditions for salmonids and trout. Poor water quality conditions may act as a barrier for upstream movement of fish. More data would be needed to substantiate this.

a. Water Temperature

According to city-collected data, water temperatures did not exceed the standard for cold-water fish in Glenn Creek during the duration of the sampling periods in the 1980's and early 1990's (**Figures 8-16** and **8-17**). Recent data show that water temperatures did exceed the DEQ standard of 17.8 Celsius in lower Glenn Creek (W6) in August of 1998 (**Figure 8-18**). Water temperatures exceeded the standard at two sites in Gibson Creek, North Gibson Creek (W3) and Lower Gibson Creek (W5) in August of 2000 (**Figure 8-19**).

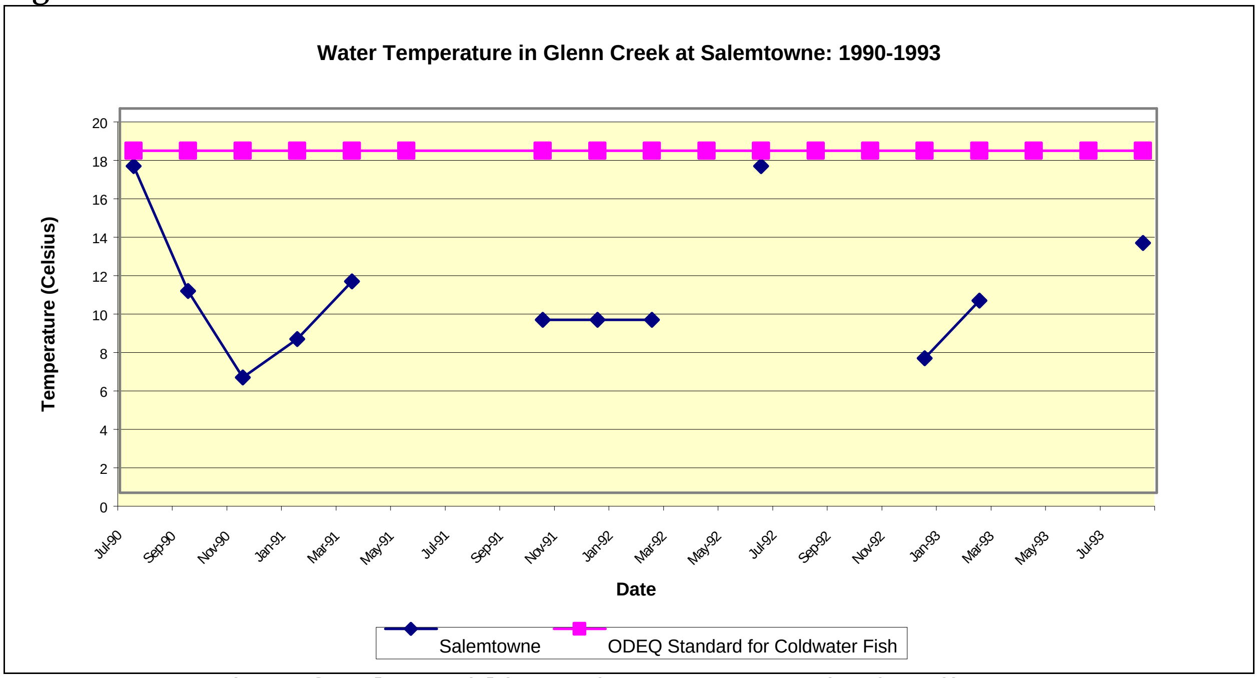
For the two months, August and September 1998, in which morning and afternoon samples were taken, stream temperatures increased by an average of 2.3 degrees Celsius in the afternoon.

Figure 8-16.



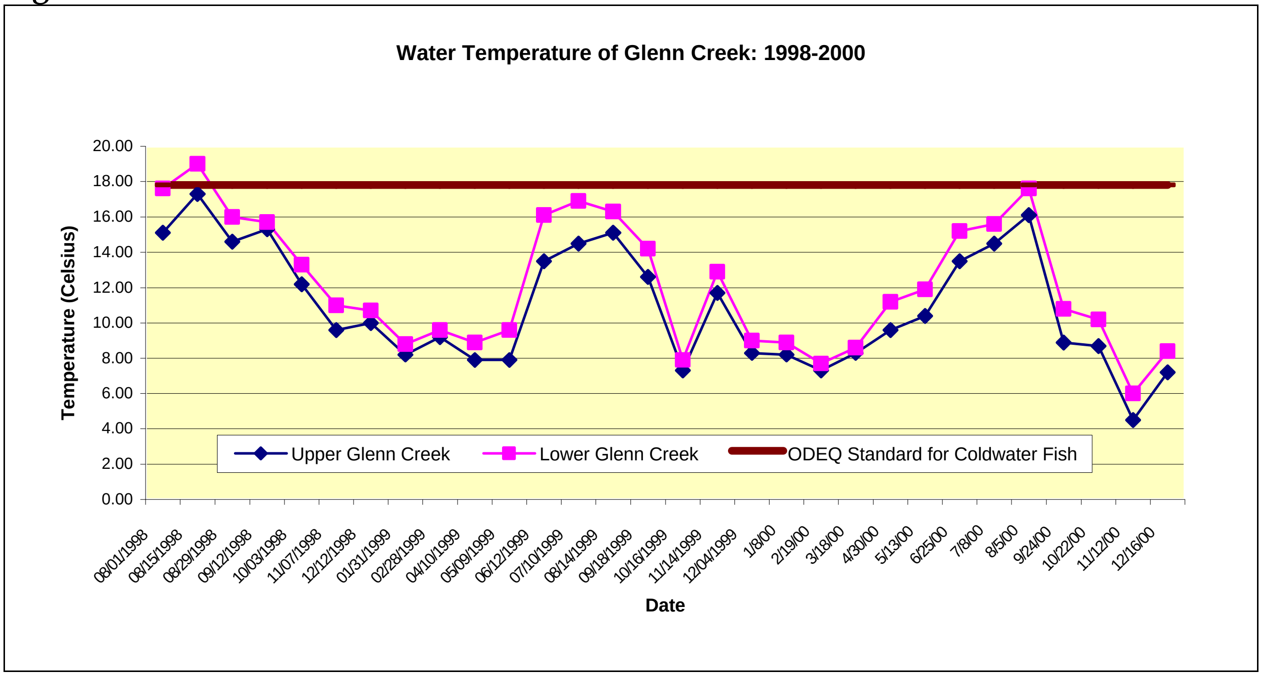
Data source: City of Salem Public Works Department (undated)

Figure 8-17.



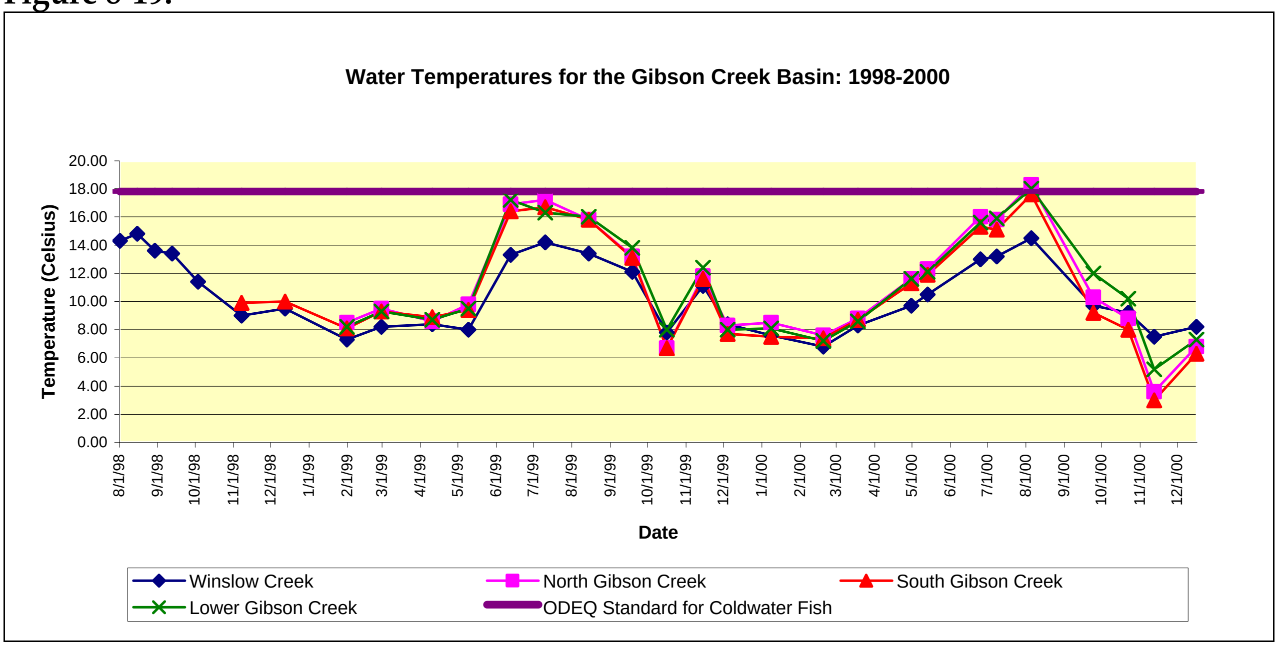
Data source: City of Salem Public Works Department (undated)

Figure 8-18.



Data source: Glenn-Gibson Watershed Council (2001)

Figure 8-19.



Data source: Glenn-Gibson Watershed Council (2001)

b. Dissolved Oxygen

City data indicate that dissolved oxygen dipped below 8.0 mg/l eight times between 1982-1989 at the Orchard Heights monitoring station (C6) (**Figure 8-20**). The low dissolved oxygen levels were recorded between July and October. A record low of 3.9 mg/l was recorded at this site in July of 1988. Low dissolved oxygen was recorded once in July of 1990 at the Salemtowne monitoring station (C22) along lower Glenn Creek (**Figure 8-21**). Data collected from 1998 to 2000 show that dissolved oxygen levels were slightly below the minimum of 8.0 mg/l in both upper (W1) and lower Glenn Creek (W6) during summer and early fall months (**Figure 8-22**).

Dissolved oxygen levels remained above the DEQ standard in all four seasons at the Winslow Creek (W2) and South Gibson Creek (W4) monitoring stations (**Figure 8-23**). North Gibson Creek (W3) recorded 7.9 mg/l for two consecutive months in the summer of 1999; otherwise dissolved oxygen levels were recorded above 8.0 mg/l. Lower Gibson Creek (W5) experienced low dissolved oxygen levels seven times during the sampling period during summer and fall months. A low of 6.4 mg/l was recorded in August of 2000.

During August and September of 1998, dissolved oxygen levels decreased an average of 1.32 mg/l between morning and afternoon sampling times.

c. pH

With only a few exceptions, pH levels remained within the recommended limits of 6.5 and 8.5. In March of 1991, the Salemtowne monitoring station (C22) recorded a pH of 5.8. On three occasions from 1998 to 2000, the pH of lower Glenn Creek at station W6 dropped to 6.4. Diurnal fluctuations in pH readings were negligible.

d. Nutrients

Data on Total Nitrates were collected at the two water quality monitoring stations sampled by the City of Salem (C6 and C22). Nitrate concentrations exceeded the standard of 0.30mg/l (OWAM standard) in over 90% of the samples (**Table 8-16**). Nitrate levels ranged from a high of 4.06mg/l to a low of 0.10mg/l. Total Phosphorus was not sampled in Glenn or Gibson Creeks.

Table 8-16. Total Nitrates in Glenn Creek: 1982-1989

Statistic	Orchard Heights	Salemtowne
Number	62	14
Minimum	0.30	0.10
Maximum	4.60	3.80
Median	1.00	2.05
Number (>0.30mg/l)	58	13
% exceedance	94%	93%

Data source: City of Salem

e. Fecal Coliform

Fecal coliform counts were taken only in Glenn Creek at the two city monitoring stations (C6 and C22). Fecal coliform counts exceeded 400 colonies/100 ml (DEQ standard) at Orchard Heights (C6) 19 times from 1982 to 1989 (**Figure 8-24**). Counts of fecal coliform colonies ranged from 0 to 1,910. High counts of bacteria happened in all four seasons. The highest count occurred in July of 1986. The Salemtowne monitoring station (C22) recorded a high fecal coliform level of 1020 cfu/100 ml in July of 1992 (**Figure 8-25**). No bacterial counts were taken in Gibson Creek.

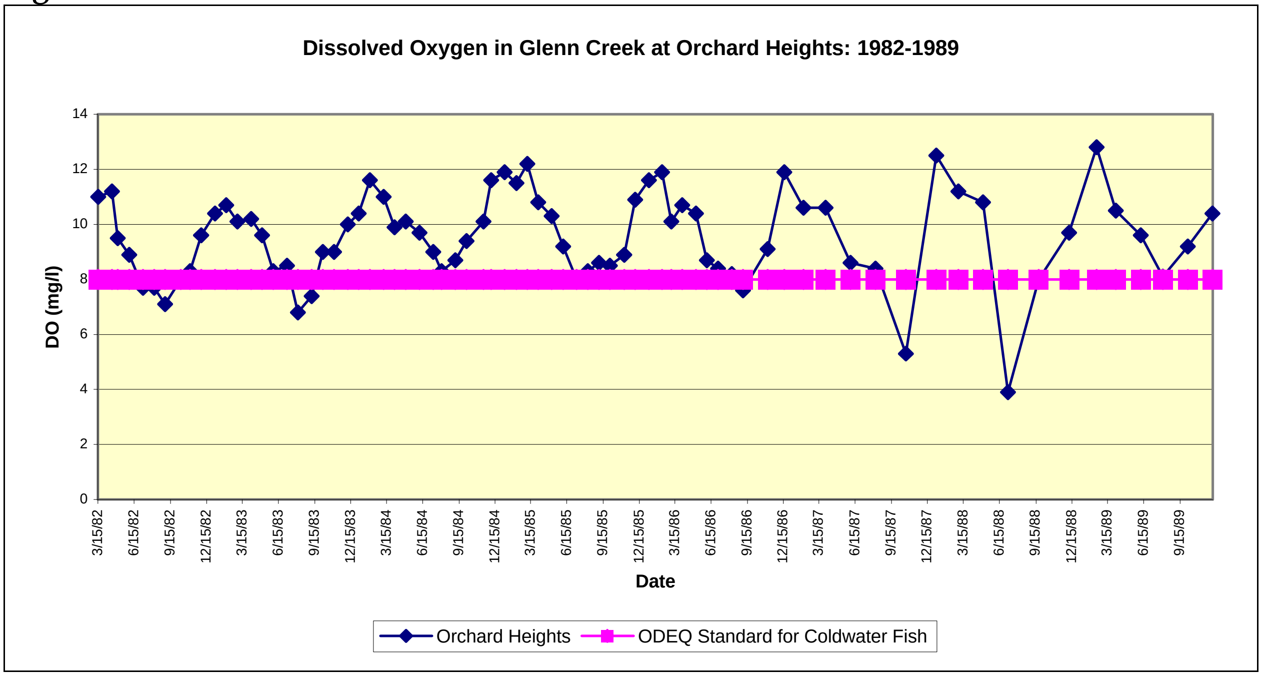
3. Claggett Creek

Five monitoring stations were established by the City of Salem in the Claggett Creek watershed (**Map 8-5**). Three of the stations are on the "main stem" of Claggett Creek: River Road (C1), Hyacinth Road (C2) and Mainline Drive (C3). Another station is in Hawthorne Ditch at East Basin Park (C17). Hawthorne Ditch is a remnant of Claggett Creek's headwaters and runs parallel to Hawthorne Drive, just west of Interstate 5. The fifth monitoring station is at the juncture of Labish Ditch and River Road (C24).

Monthly or semi-monthly samples were collected between March 1982 and December 1989 at all five monitoring stations. Data collection was interrupted in January of 1990 and resumed again in July of 1990. Data were collected every two months between July 1990 and October 1993.

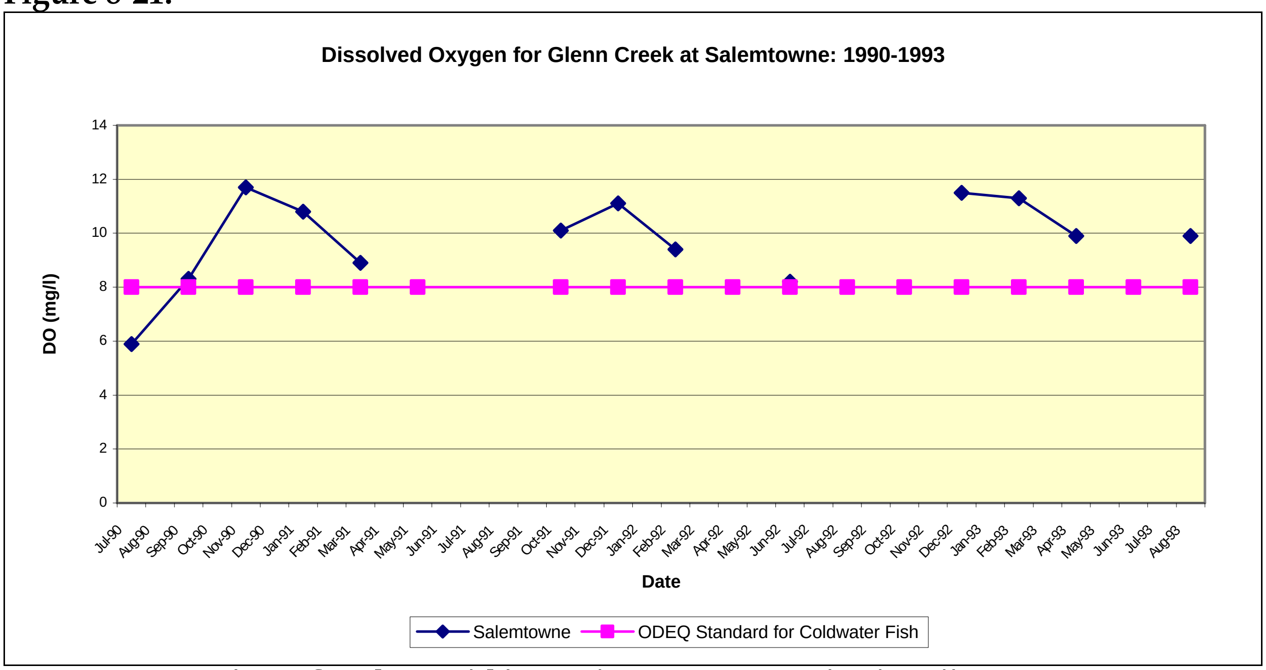
A science class at McNary High School established a monitoring station at Claggett Creek Park near Dearborne Avenue (S1) as part of the City of Salem's Adopt-A-Stream Program. They have been collecting data from this location since 1994.

Figure 8-20.



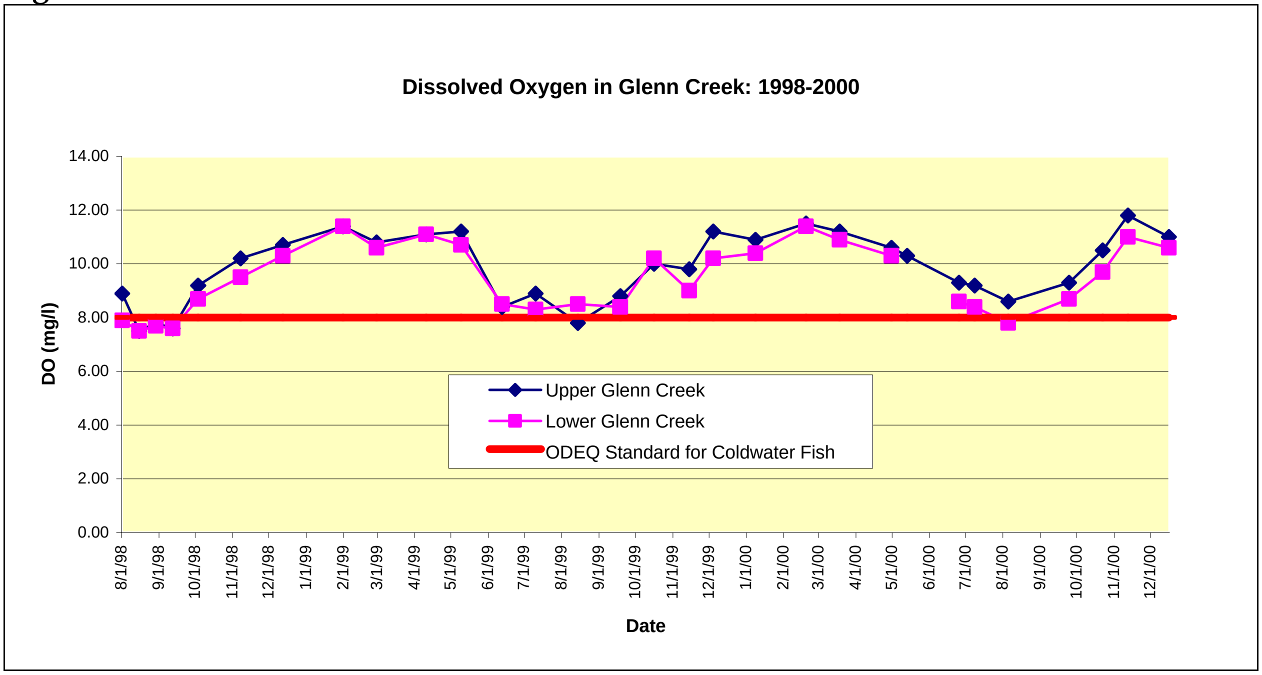
Data source: City of Salem Public Works Department (undated)

Figure 8-21.



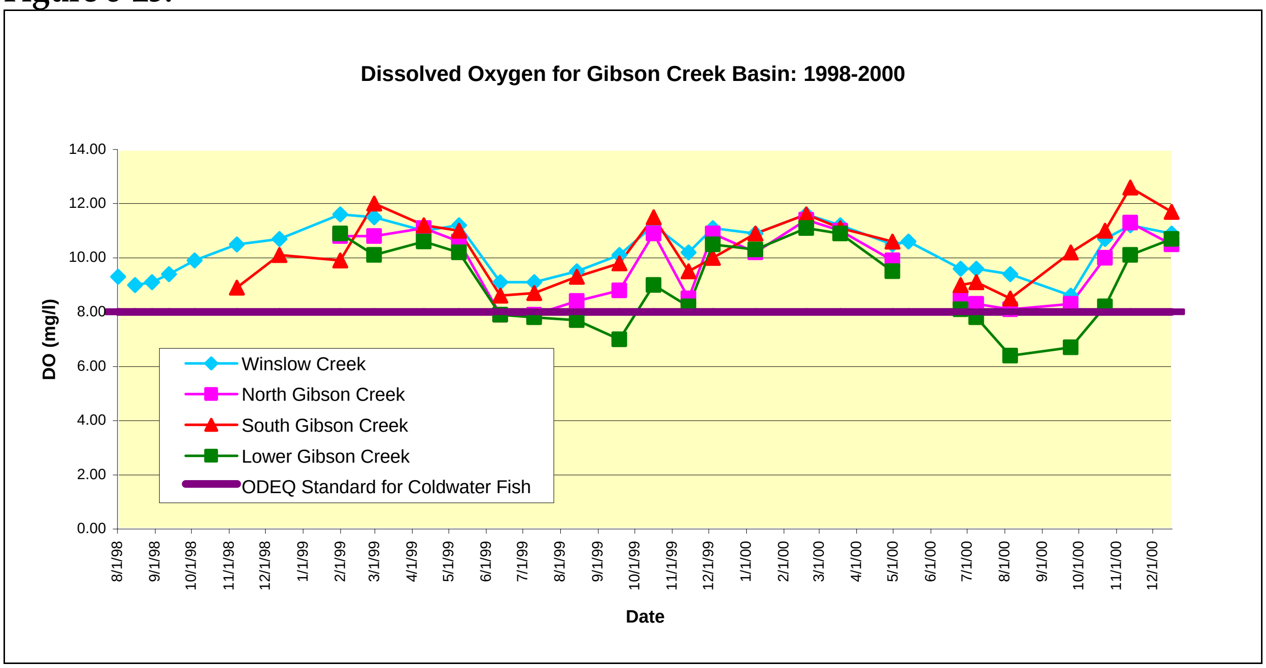
Data source: City of Salem Public Works Department (undated)

Figure 8-22.



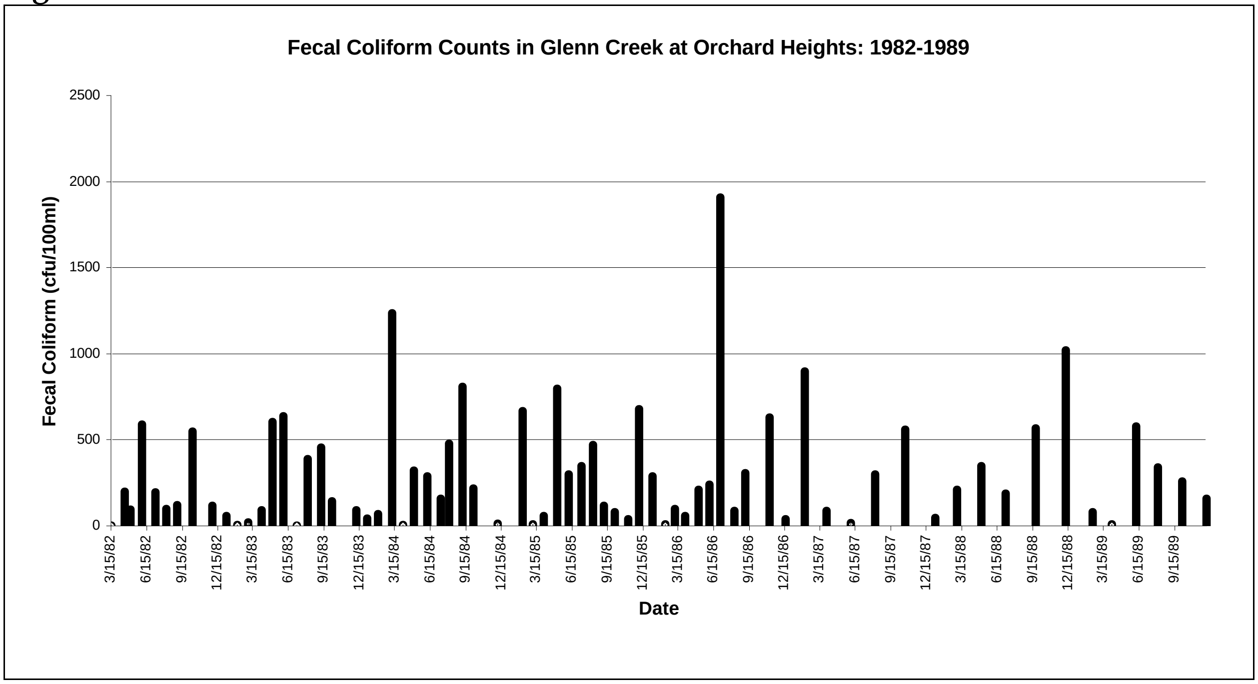
Data source: Glenn-Gibson Watershed Council (2001)

Figure 8-23.



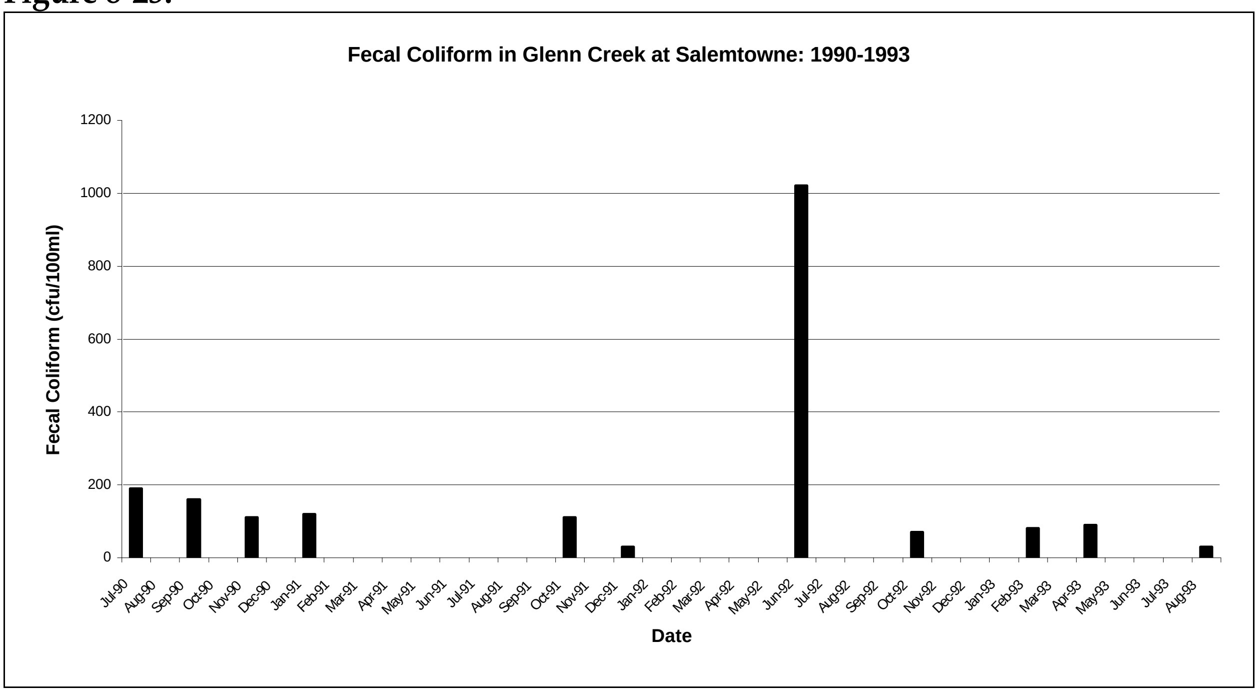
Data source: Glenn-Gibson Watershed Council (2001)

Figure 8-24.



Data source: City of Salem Public Works Department (undated)

Figure 8-25.



Data source: City of Salem Public Works Department (undated)

a. Water Temperature

Monthly sampling indicates that water temperatures along the main stem of Claggett Creek typically exceed the standard for cold-water fish during summer and early fall (**Figure 8-26**). Water temperatures exceeded standards at all three monitoring stations at least once during the 12-year sampling period.

Data collected by the Adopt-A-Stream class indicate high water temperatures during summer months and early fall (**Figure 8-27**).

Water temperatures for Hawthorne Ditch (C17) remained below 17.8 degrees Celsius (DEQ standard) during winter and spring months (**Figure 8-28**). However, the ditch experiences water levels of less than 1 inch during summer and early fall months, providing little to no habitat for aquatic species. Dry creek bed conditions were recorded several times during summer months.

Labish Ditch (C24) experienced high water temperatures during the summer months of 1990 and 1992. No data were collected during the summer in 1991 or 1993 (**Figure 8-29**). Data collected prior to July 1990 indicate that Labish water temperatures typically remained below the DEQ water temperature standard.

b. Dissolved Oxygen

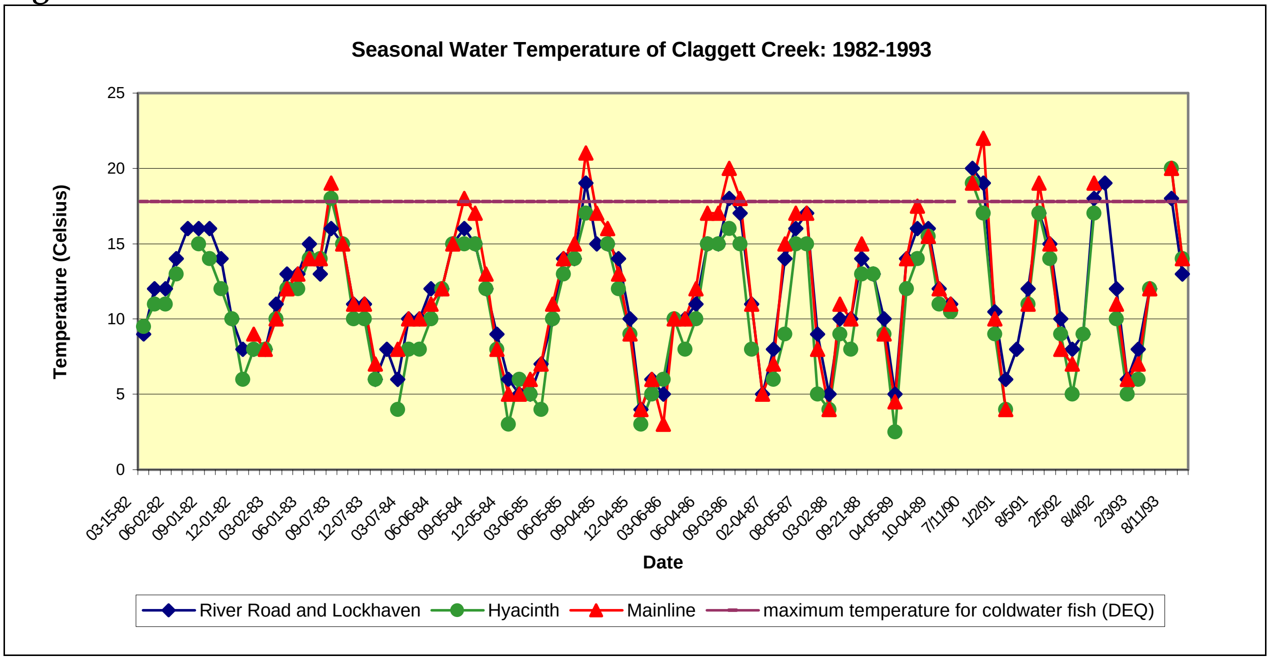
Claggett Creek is low in dissolved oxygen (DO) for five months a year between July and November (**Figure 8-30**). Claggett Creek has the longest duration of low oxygen levels of all the other creeks assessed in this report.

Data from the Adopt-A-Stream class indicate low DO levels during summer and early fall. DO levels were measured at or near the DEQ standard of 8.0mg/l during the spring and summer of 1995 (**Figure 8-27**).

Data collected at Hawthorne Ditch (C17) reveal low dissolved oxygen during summer and early fall for durations of three or four months (**Figure 8-31**). Water samples were only taken bi-monthly after 1986 for this monitoring station, so duration of oxygen depletion is probably longer than depicted on the graph for these years.

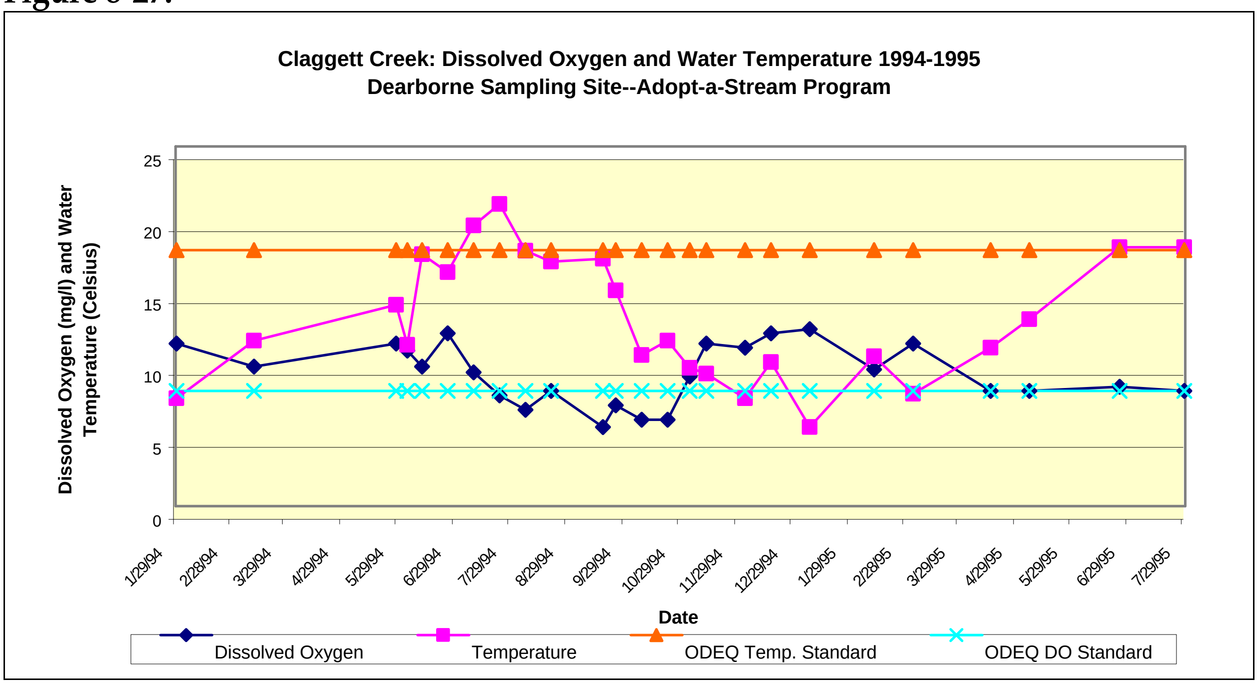
Labish Ditch (C24) experienced DO levels at or slightly lower than 8.0 mg/l from 1983 to 1987 (**Figure 8-32**). DO levels begin to fluctuate more dramatically after 1987. Water samples were only taken bi-monthly after 1986 for this monitoring station, so duration of oxygen depletion is probably longer than depicted on the graph for these years.

Figure 8-26.



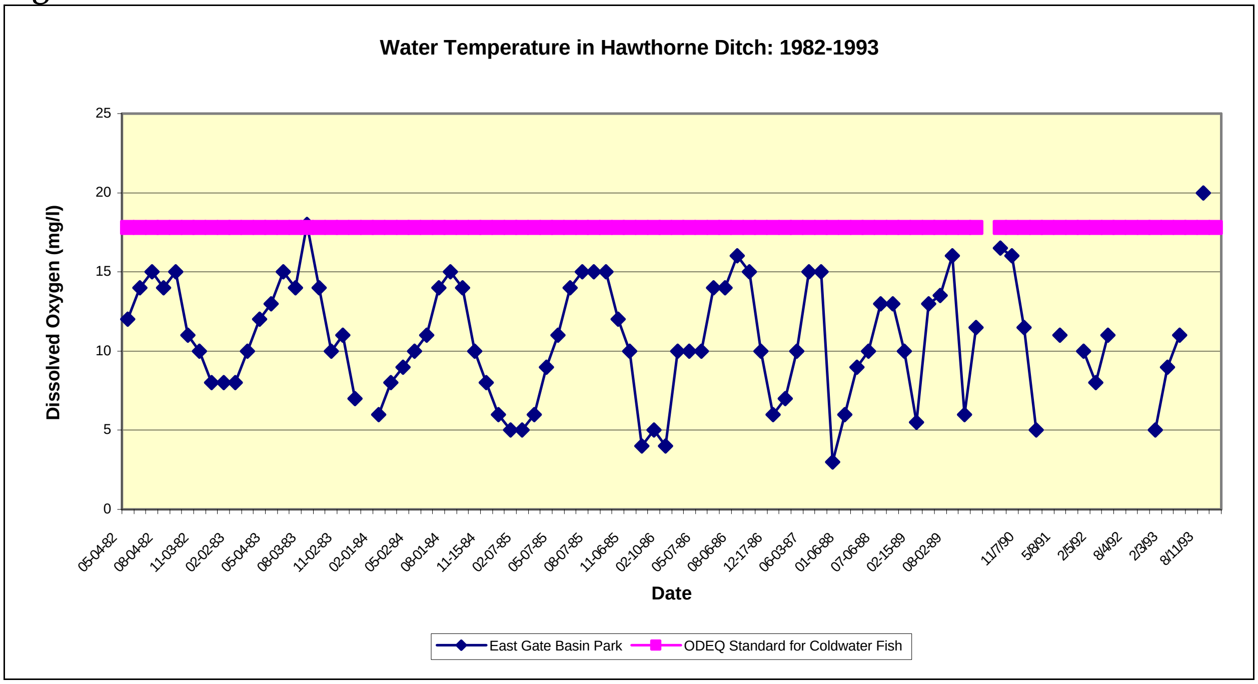
Data source: City of Salem Public Works Department (undated)

Figure 8-27.



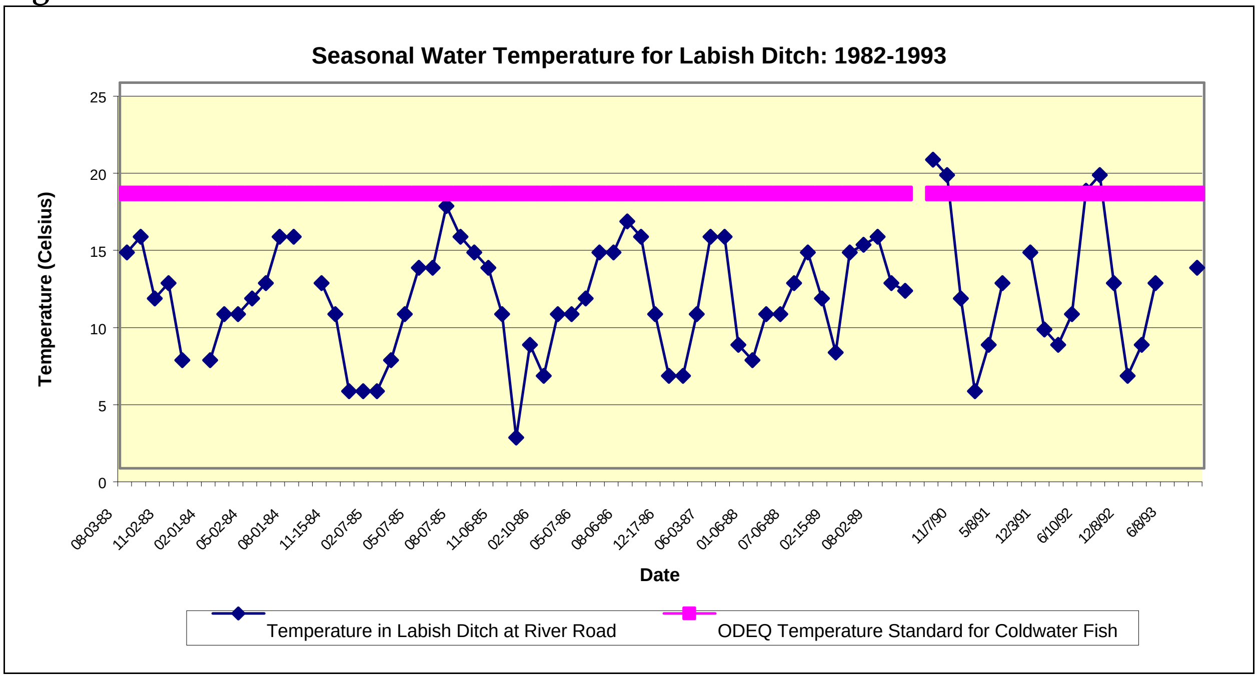
Data source: City of Salem Public Works Department (undated)

Figure 8-28.



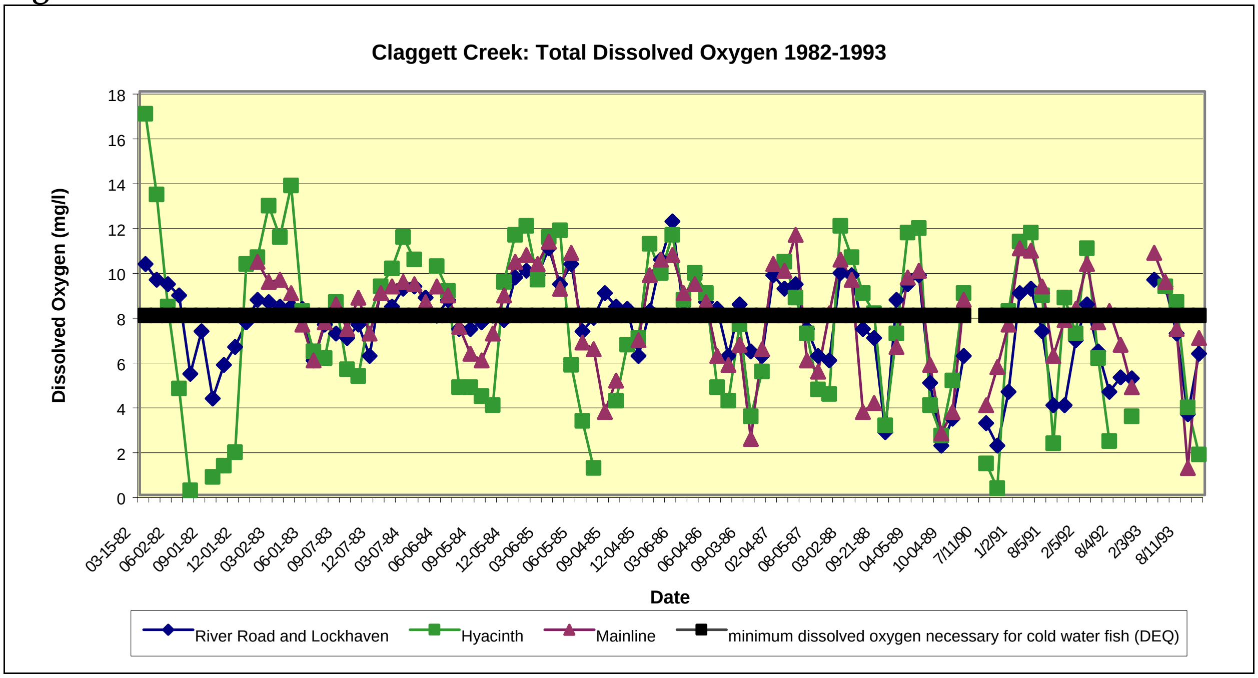
Data source: City of Salem Public Works Department (undated)

Figure 8-29.



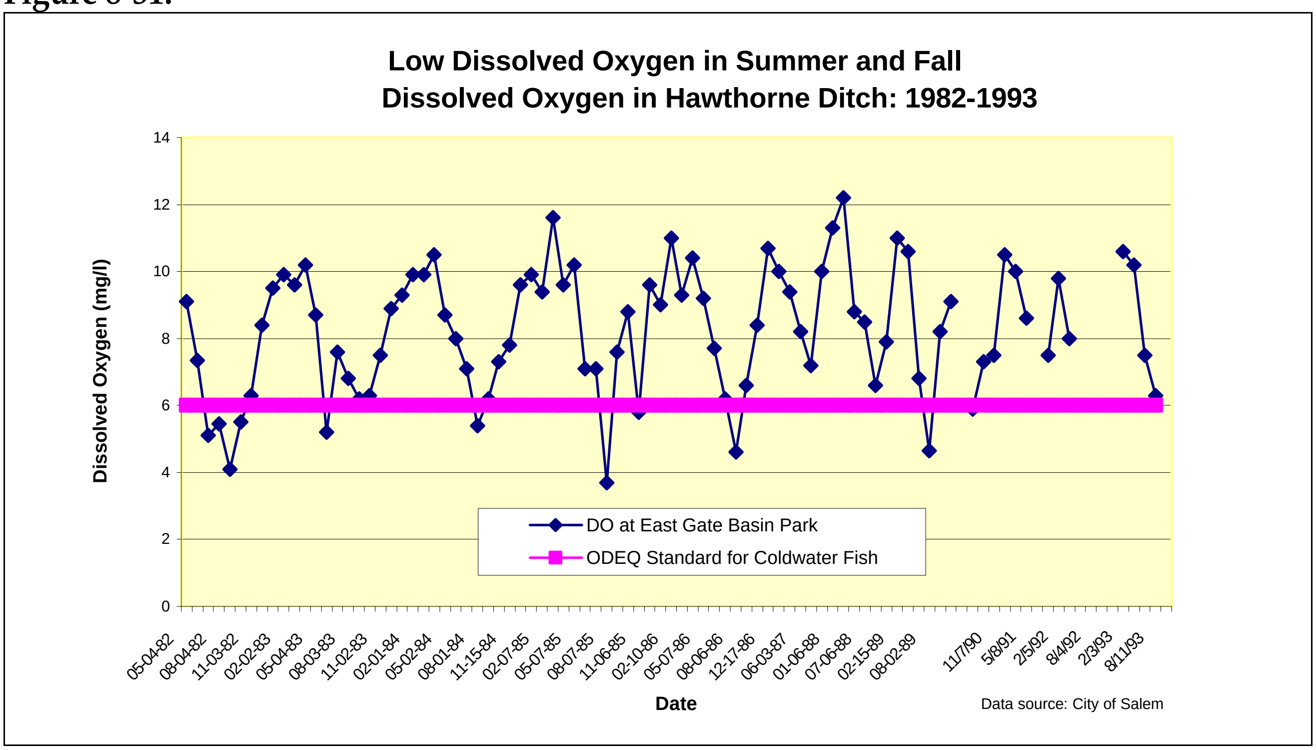
Data source: City of Salem Public Works Department (undated)

Figure 8-30.



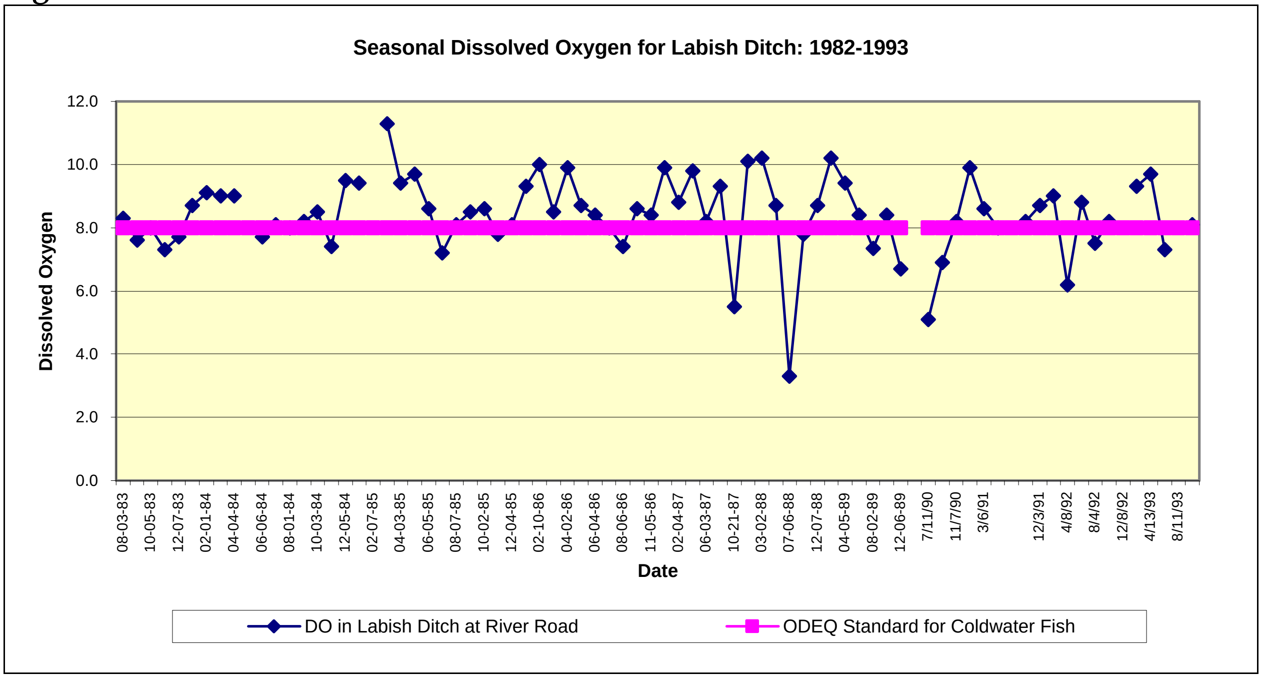
Data source: City of Salem Public Works Department (undated)

Figure 8-31.



Data source: City of Salem Public Works Department (undated)

Figure 8-32.



Data source: City of Salem Public Works Department (undated)

c. pH

From 1982-1993, city data indicate that Claggett Creek maintained normal pH levels (i.e., between 6.5 and 8.5) in all but five water quality samples taken. Three of the samples were only slightly more acidic than the recommended standard (e.g., 6.2, 6.4, 6.4). Two high pH recordings were documented at the Hyacinth water quality monitoring station (C2). A pH of 9.0 was recorded on March 15, 1982. On February 3, 1993, a pH of 10.8 was also recorded at this station.

d. Nutrients

Data on Total Nitrates were collected at all five monitoring stations sampled by the City of Salem. Nitrate concentrations exceeded the standard of 0.30mg/l (OWAM standard) at all five sites at least 47% of the time (**Table 8-17** and **Figure 8-33**). Water samples taken in Labish Ditch (C24) showed incredibly high nitrate concentrations, ranging from 1.3mg/l to 33 mg/l.

Total Phosphorus was not sampled in the Claggett Creek watershed.

Table 8-17. Total Nitrates for Claggett Creek Watershed: 1982-1993

	Sample Sites				
Statistic	**River Road**	**Hyacinth**	**Mainline**	**Hawthorne**	**Labish**
Number	82	79	81	76	73
Minimum	0.20	0.08	0.05	0.00	1.3
Maximum	3.70	3.90	5.00	9.20	33
Median	1.53	0.30	0.70	0.60	4.3
Number (>0.30mg/l)	80	37	59	47	73
% exceedance	97%	47%	73%	62%	100%

e. Fecal Coliform Bacteria

High fecal coliform levels (>400cfu/100ml) were detected frequently at all five sample sites between 1982-1993 (**Figures 8-34** and **8-35**). Counts of fecal coliform ranged from 0 to 16,760. High counts occurred in all four seasons, but were more frequent during summer and fall.

Fecal coliform levels in Labish Ditch (C24) (**Figure 8-35**) exceeded 400cfu/100 ml in 46% of the water samples taken, the highest of all five monitoring stations. The Hyacinth monitoring station (C2) (**Figure 8-36**) recorded high fecal coliform counts in 41% of the samples. The remaining three monitoring stations had high counts less frequently: Hawthorne, 15%; River Road, 28%; Mainline, 25%.

f. Macroinvertebrates

The McNary High School class collected macroinvertebrates as part of their Adopt-A-Stream program at the Dearborne monitoring station (S1) (**Map 8-5**). The students used hand-seining to collect the invertebrates. This method involves placing a net downstream and dislodging invertebrates from their hiding places by disturbing the streambed and shaking streamside vegetation upstream. The dislodged invertebrates then flow downstream into the net.

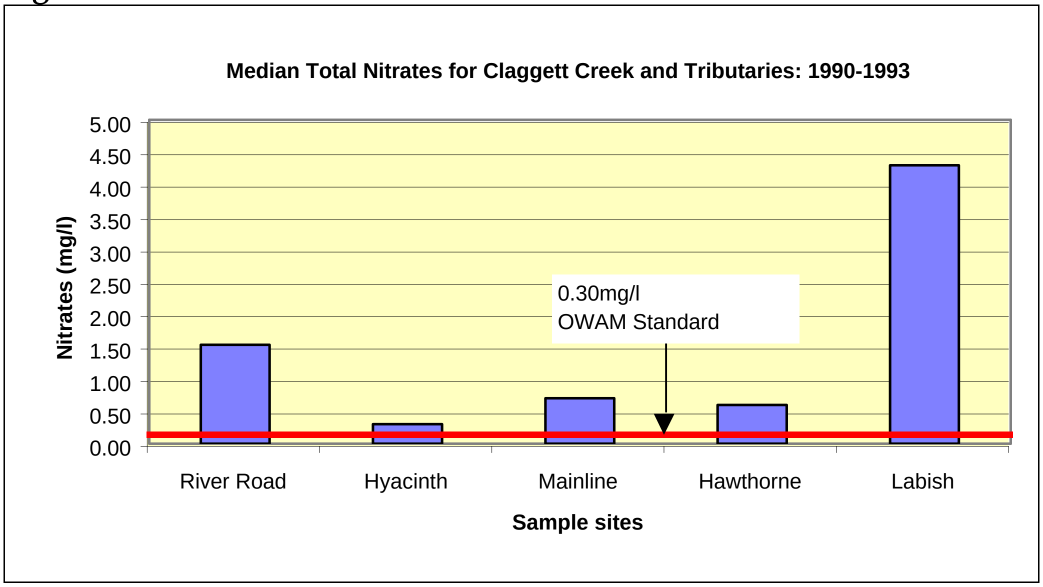
The macroinvertebrates collected ranged from species that were intolerant of poor water conditions (e.g., right-handed snails, caddisflies and stoneflies) to species that are commonly found in degraded streams (e.g., left-handed snails, aquatic worms and midge larvae). According to the analysis of data collected from spring of 1994 to spring of 1995, the most commonly collected invertebrate were scuds. Scuds are from the family Amphipoda. They look a lot like miniature freshwater shrimp, but they are only distantly related to marine shrimp. They live in the substrate of the streams. Scuds are “somewhat tolerant” of poor water quality.

Using the presence and abundance of different macroinvertebrate species as an indicator of stream health, Claggett Creek consistently ranks as having fair to good water quality.

4. Mill Creek

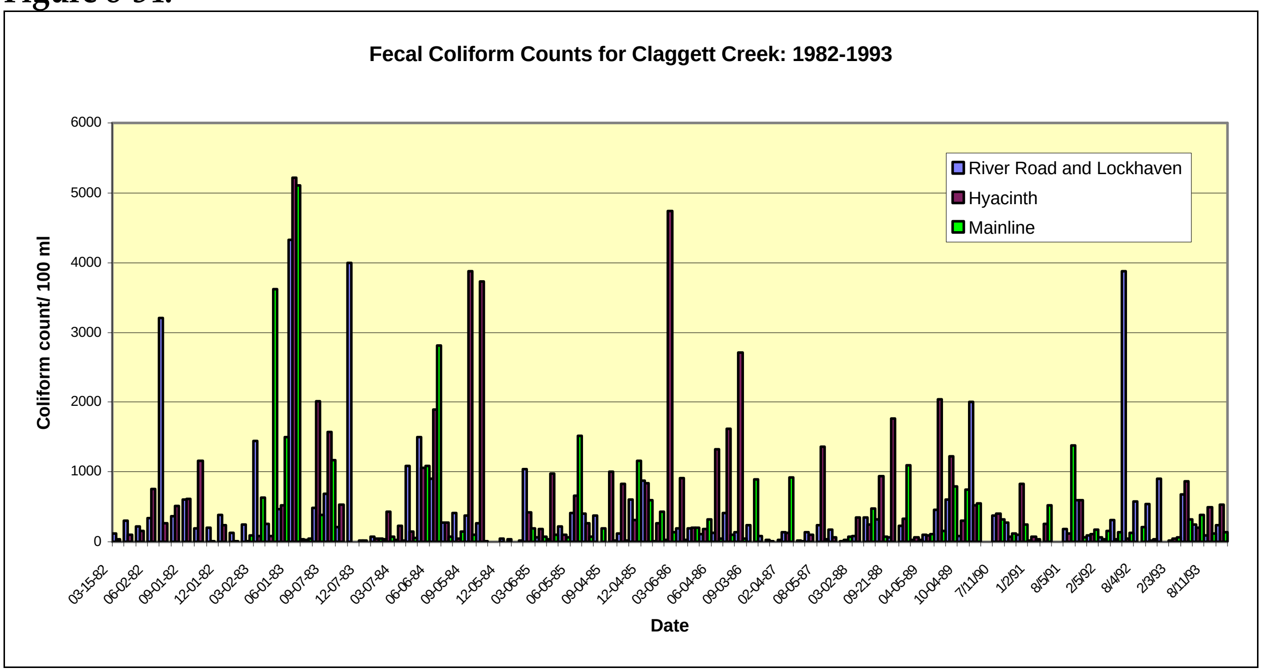
A total of 12 monitoring stations were established by the City of Salem in the Mill Creek watershed (**Map 8-6**). Seven monitoring stations are located along the mainstem of Mill Creek from Front Street (CMC 0707), near the mouth of Mill Creek at the Willamette River, to Bishop Road (CMC1604), located near Stayton just downstream from the creek’s confluence with the Salem Ditch. No monitoring stations were established in Mill Creek upstream from Salem Ditch. Three additional monitoring stations were established along the Salem Ditch (CMC 1803, CMC 1901, CMC 1902), a hand-dug channel that diverts water from the North Santiam River into Mill Creek. Water quality was also sampled in Shelton Ditch (C21), a ditch that diverts flow from Mill Creek into Pringle Creek. Finally, one monitoring station was established in Battle Creek (C16), a tributary to Mill Creek that is located in south Salem and flows west to east and empties into Mill Creek near Turner. No monitoring stations were established in any other tributary to Mill Creek, including Beaver Creek, which drains the northern portion of the Mill Creek watershed.

Figure 8-33.



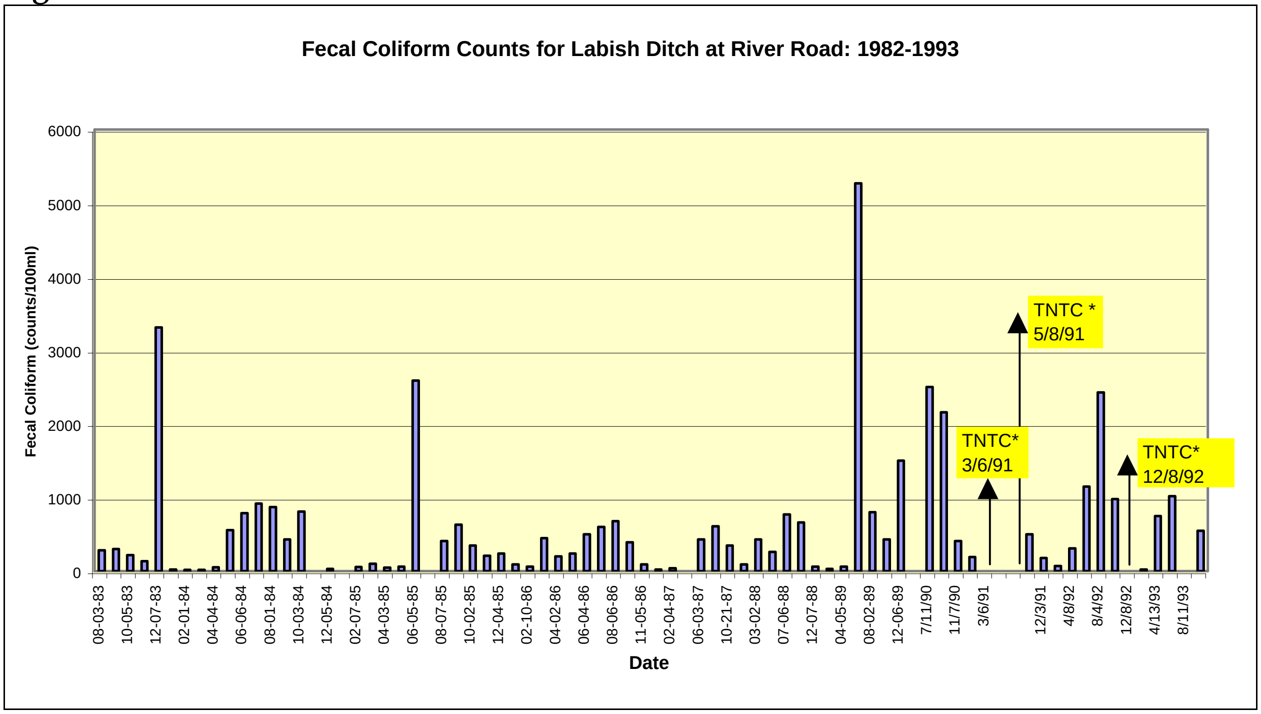
Data source: City of Salem Public Works Department (undated)

Figure 8-34.



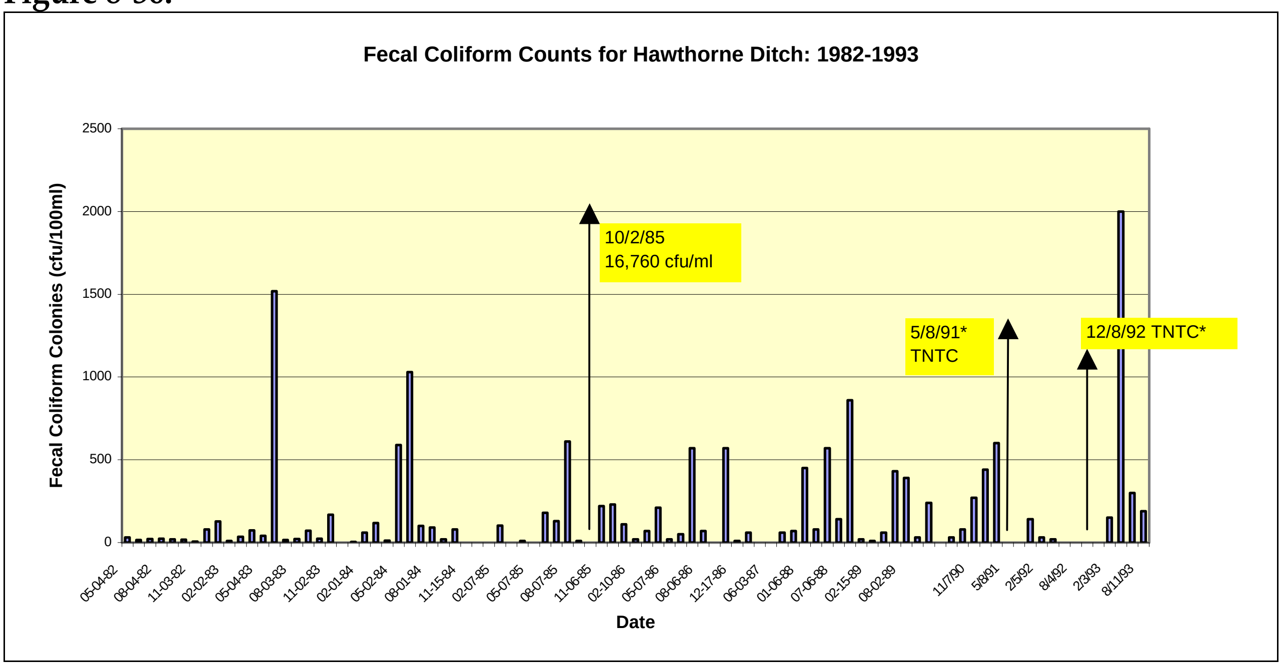
Data source: City of Salem Public Works Department (undated)

Figure 8-35.



*too numerous to count

Figure 8-36.



*too numerous to count

Data source: City of Salem Public Works Department (undated)

Duration of sampling at the 12 sites varied (**Table 8-11**). Monitoring stations at Front Street, 23rd Street (CMC 0308) and Turner Road (CMC0707) were sampled from 1982 to 1995. Battle Creek was monitored from 1982 to 1993. Shelton Ditch was monitored from 1983 to 1993. Monthly sampling occurred at the rural monitoring stations {i.e. Delaney Road (CMC1006), 70th Street (CMC1305), and Bishop Road (CMC1604)} and the Salem Ditch (i.e. Shaff Road, Cascade Road, and Pioneer Park) from 1990 to 1995.

Because of the number of sample points and the variation in collection times, Mill Creek water quality data is graphed based on location of monitoring stations. Data collected from the urban monitoring stations are graphed together, as are the data from stations near the urban growth boundary, and from the rural stations. For comparison of urban and rural monitoring stations, Front Street and Bishop Road were graphed together.

a. Water Temperature

The lowest and highest water temperatures recorded for Mill Creek vary by over 21 degrees Celsius. The lowest water temperature recorded was 1 degree Celsius in February of 1989 at the Turner (CMC 0707) monitoring station. In contrast, a water temperature of 22.4 degrees Celsius was recorded at both the Turner and Front Street (CMC 0010) sample sites in July of 1995.

Recorded water temperatures sometimes exceeded the DEQ standard of 17.8 degrees Celsius during July, August and/or September in Mill Creek (**Figures 8-37, 8-38** and **8-39**). Urban sites exceeded the standard every year between 1990-1995 with the exception of 1992 when no water samples were taken in July or August (**Figure 8-37**). Of the 170 samples taken between 1990 and 1995, the urban sites exceeded the standard 10% of the time. Samples taken near the urban growth boundary exceeded the standard 6% (21 out 352 samples) of the time (**Figure 8-38**). Only 1% (3 out of 267 samples) of the readings exceeded the standard at the rural monitoring stations. A comparison of urban and rural sample sites indicates that water temperatures are consistently lower in the rural area (**Figure 8-40**). However, temperatures taken at the Bishop Road (CMC 1604) monitoring station are probably influenced by North Santiam water flowing out of the Salem Ditch. Water temperatures in the ditch are cold (**Figure 8-41**). No data are available in Mill Creek above Salem Ditch. As for Shelton Ditch, water temperatures exceeded 17.8 degrees Celsius nine times from 1983-1993 (**Figure 8-42**).

Not all tributaries to Mill Creek had high summer temperatures. Only one sample taken from Salem Ditch in 1995 exceeded the DEQ temperature standard (**Figure 8-41**). Data collected from Battle Creek indicate that stream temperatures were below or at DEQ standard the duration of the monitoring period (**Figure 8-43**).

In addition to the surface water quality monitoring conducted by the City of Salem, OWRD has a permanent water quality monitoring station that continuously records temperature, flow and water levels in Mill Creek. The water quality-monitoring probes were installed at the OWRD gauging site on Mill Creek behind North Salem High School. While the probes are calibrated and working, the satellite link that was supposed to transmit the data to various websites is not functioning properly. Friends of Mill Creek received an OWEB grant in 2001 to purchase more equipment, including *E. coli* monitoring equipment, which is portable. The high school will be working with DEQ to use this equipment in its field biology classes and will make it available to other area schools and organizations.

b. Dissolved Oxygen

Dissolved oxygen does not seem to be a limiting factor for salmonids in the main stem of Mill Creek (**Figures 8-44, 8-45** and **8-46**) or in Shelton Ditch (**Figure 8-47**). With one exception on September 14, 1994, dissolved oxygen levels were above the DEQ standard of 8.0mg/l. The low DO level measured on this date may be a sampling error.

Unlike Mill Creek, Battle Creek seems to suffer from low DO levels from July to September. From 1982 to 1993 dissolved oxygen in Battle Creek dipped below the DEQ standard 10 times (**Figure 8-48**).

Low dissolved oxygen levels were routinely recorded in the Salem Ditch at the Cascade Road monitoring station (CMC1901) during summer and early fall months (**Figure 8-49**). Low dissolved oxygen was not recorded at the other two monitoring stations located above and below Cascade Road.

c. pH

Most water quality samples taken along the main stem of Mill Creek recorded normal pH levels (**Table 8-18**). A large percentage of low pH recordings were taken from Salem Ditch, especially at the Cascade water quality monitoring station (CMC1901). Most of the samples taken at Cascade were only slightly lower than 6.5. Only 4 of the 31 samples with low pH were below 6.0.

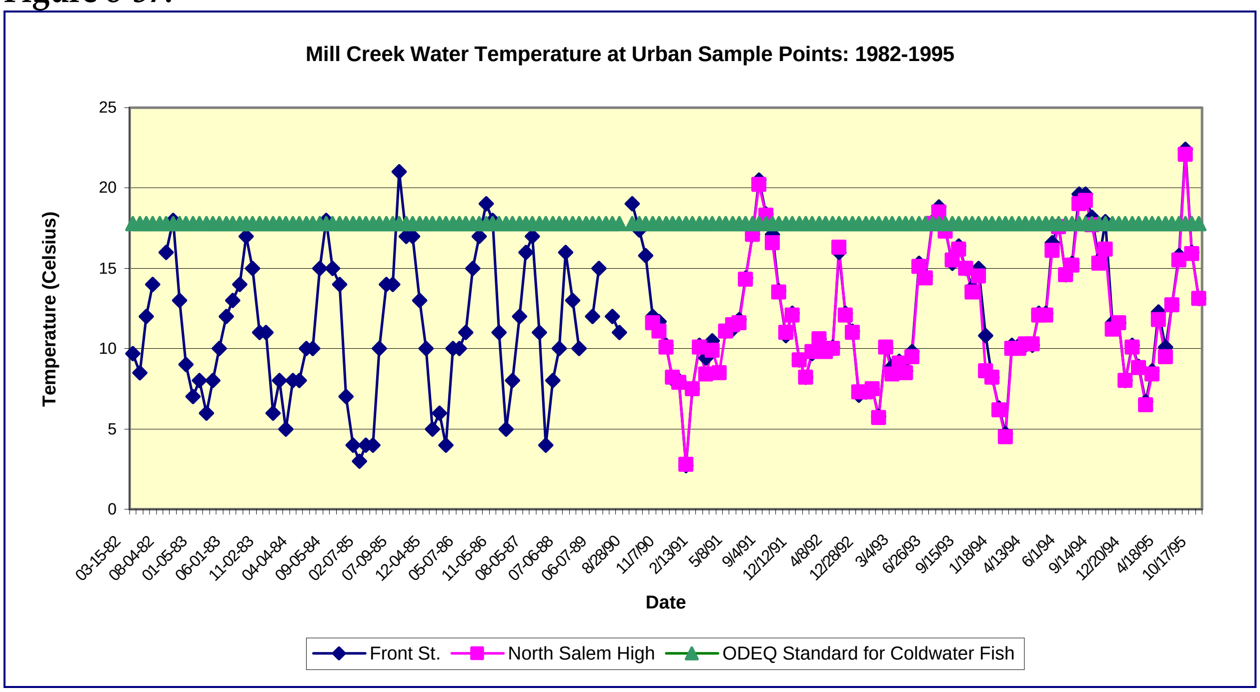
A high percent of low pH samples was also recorded in Battle Creek, however, none of the low pH recordings fell below 6.2.

Table 8-18. pH Levels for Mill Creek

		Low (<6.5)	High (>8.5)	Total	# of samples	%exceedence
Mainstem of Mill Creek						
MC0010	Front	2	0	2	86	2%
MC0209	North Salem H.S.	3	0	3	83	4%
MC0308	23rd	3	0	3	178	2%
MC0707	Turner	7	0	7	178	4%
MC1006	Delaney	4	0	4	90	4%
MC1305	70th	11	0	11	92	12%
MC1604	Bishop	8	0	8	85	9%
Salem Ditch						
MC1803	Shaff	14	0	14	86	16%
MC1901	Cascade	31	0	31	80	38%
MC1902	Pioneer	14	0	14	83	17%
Tributaries of Mill Creek						
16	Battle Creek	17	0	17	90	19%
21	Shelton Ditch	0	0	0	76	0%

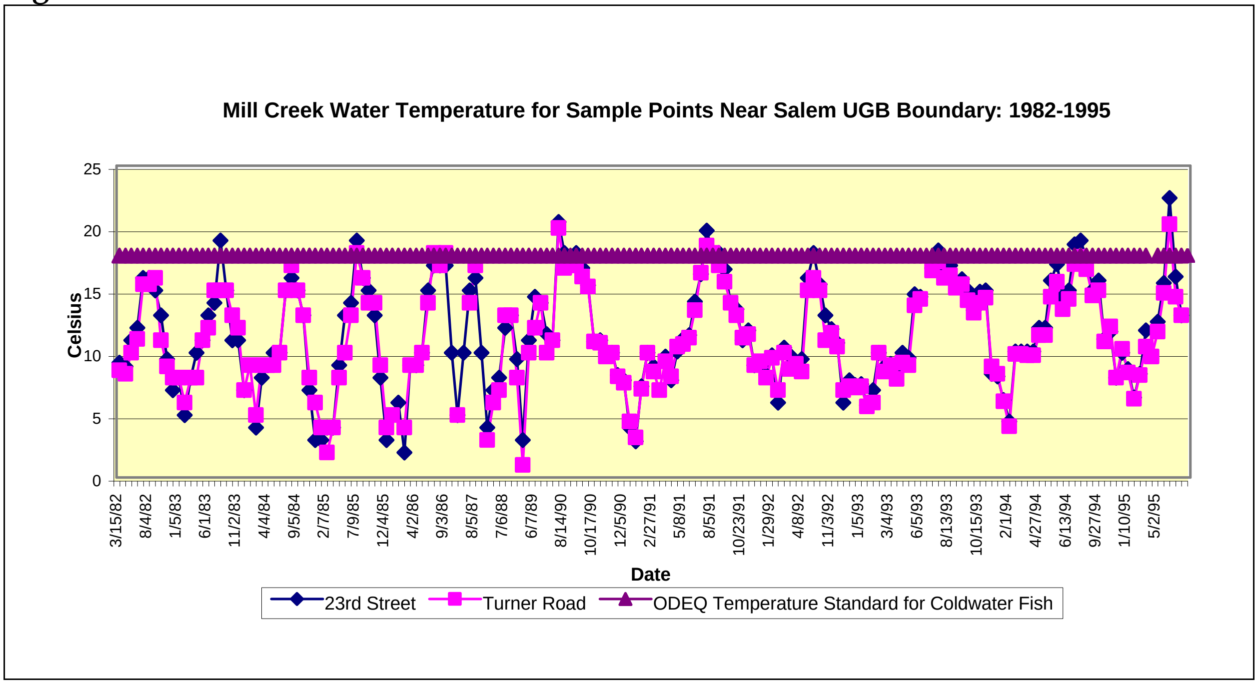
Data Source: ODWR (2001)

Figure 8-37.



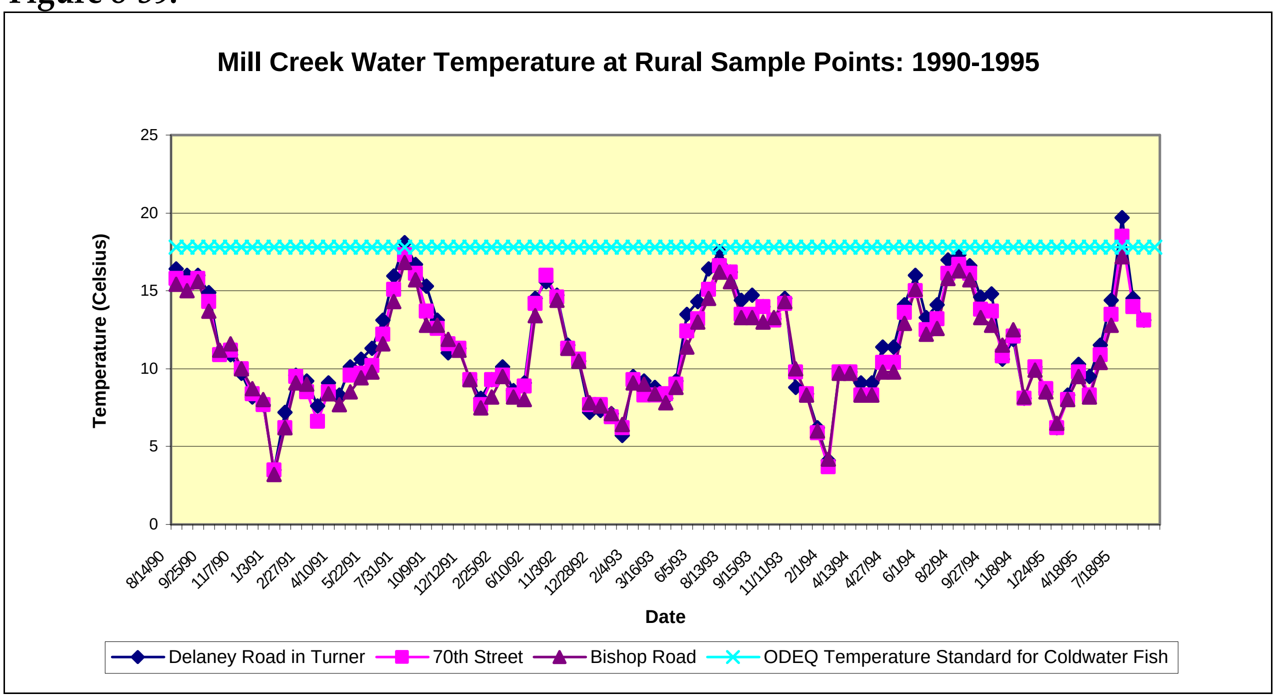
Data source: City of Salem Public Works Department (undated)

Figure 8-38.



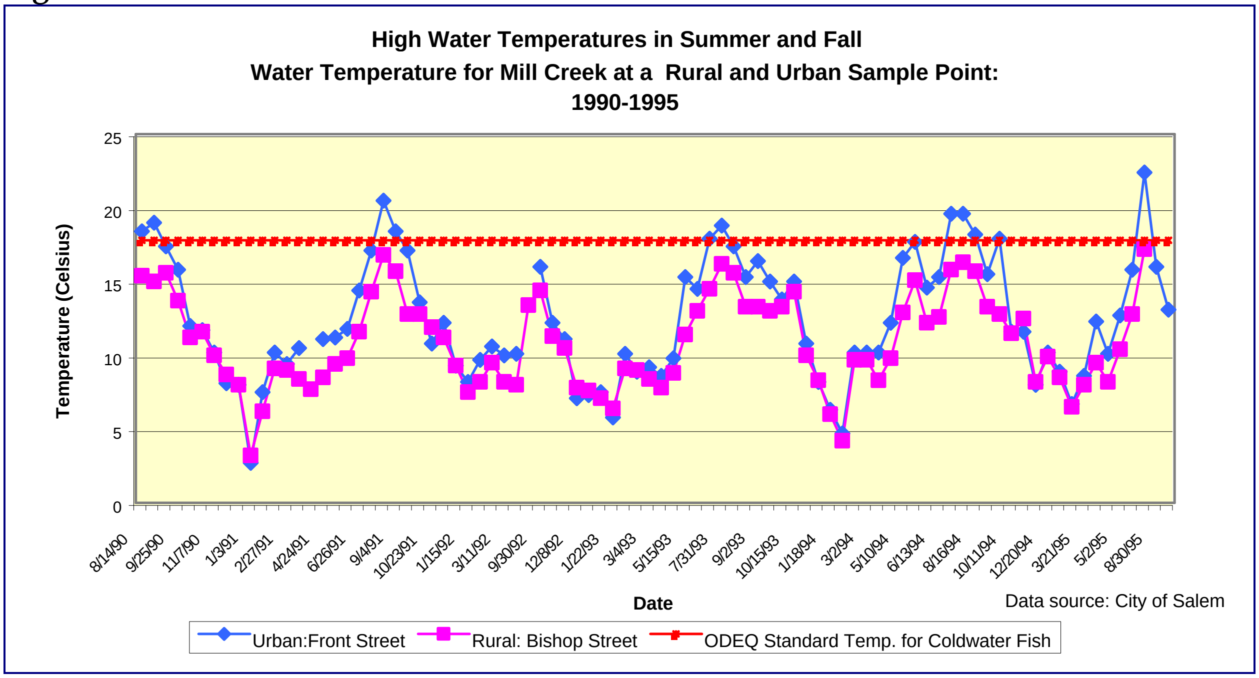
Data source: City of Salem Public Works Department (undated)

Figure 8-39.



Data source: City of Salem Public Works Department (undated)

Figure 8-40.



Data source: City of Salem Public Works Department (undated)

Figure 8-41.

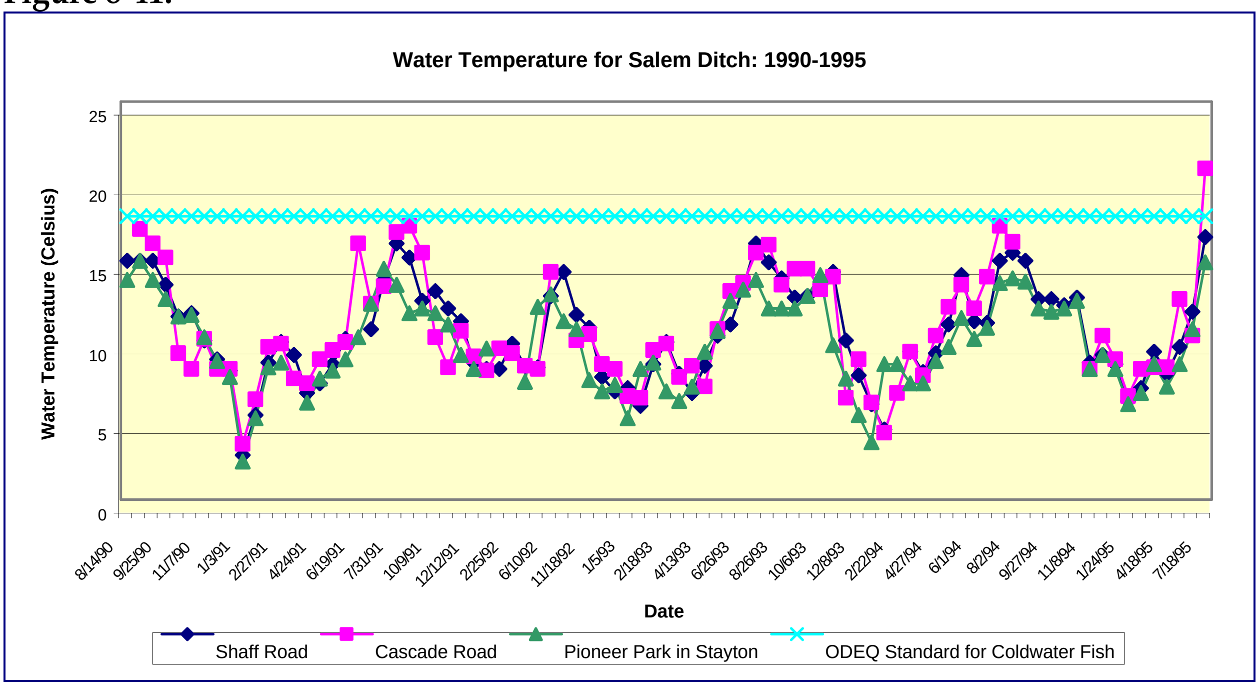


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Figure 8-42.

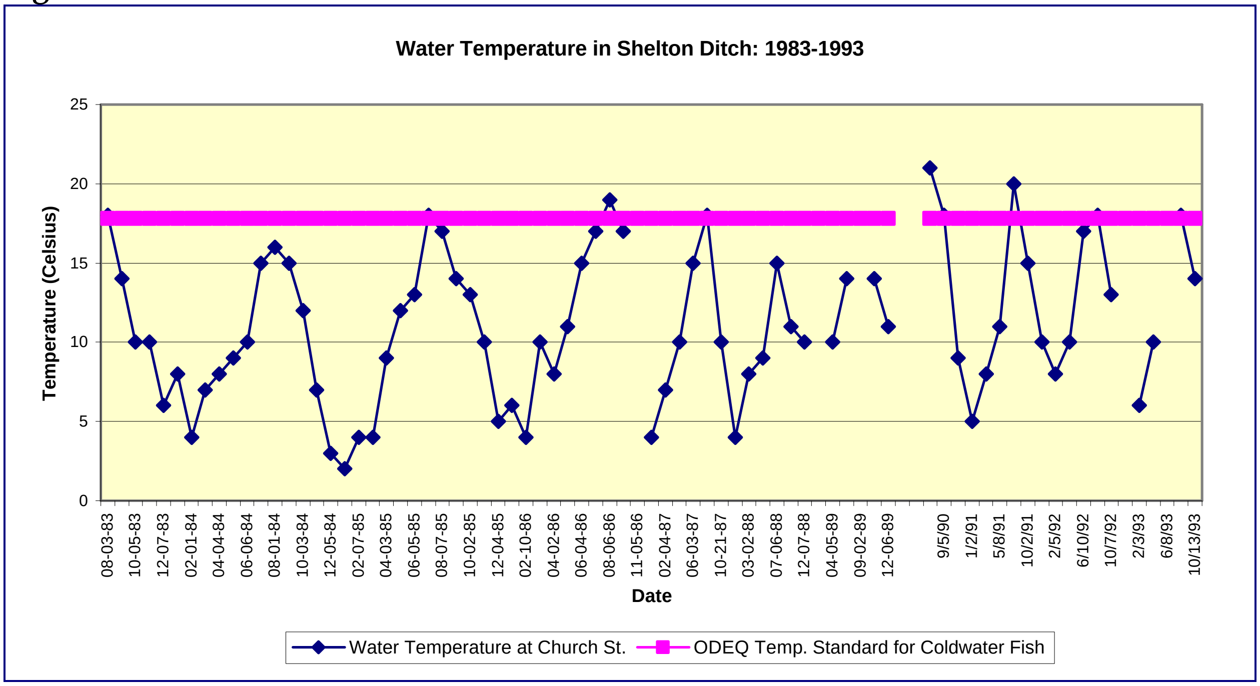

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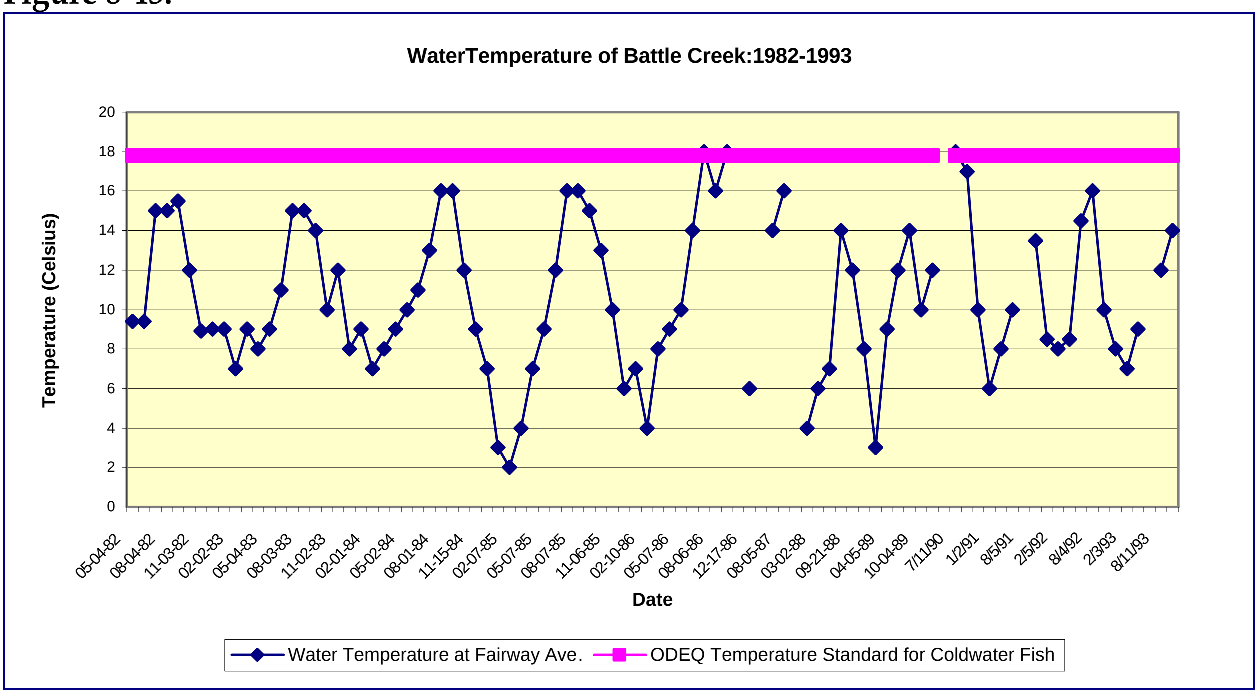
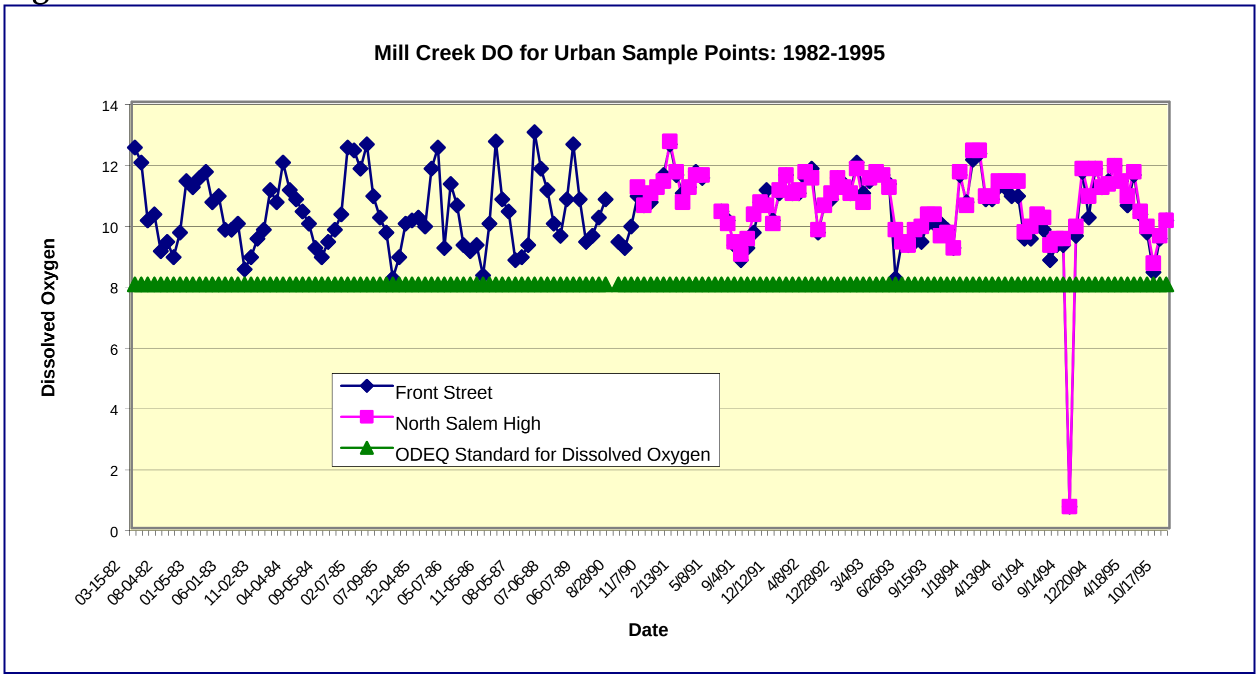
Figure 8-43.



Data source: City of Salem Public Works Department (undated)

Figure 8-44.



Data source: City of Salem Public Works Department (undated)

Figure 8-45.

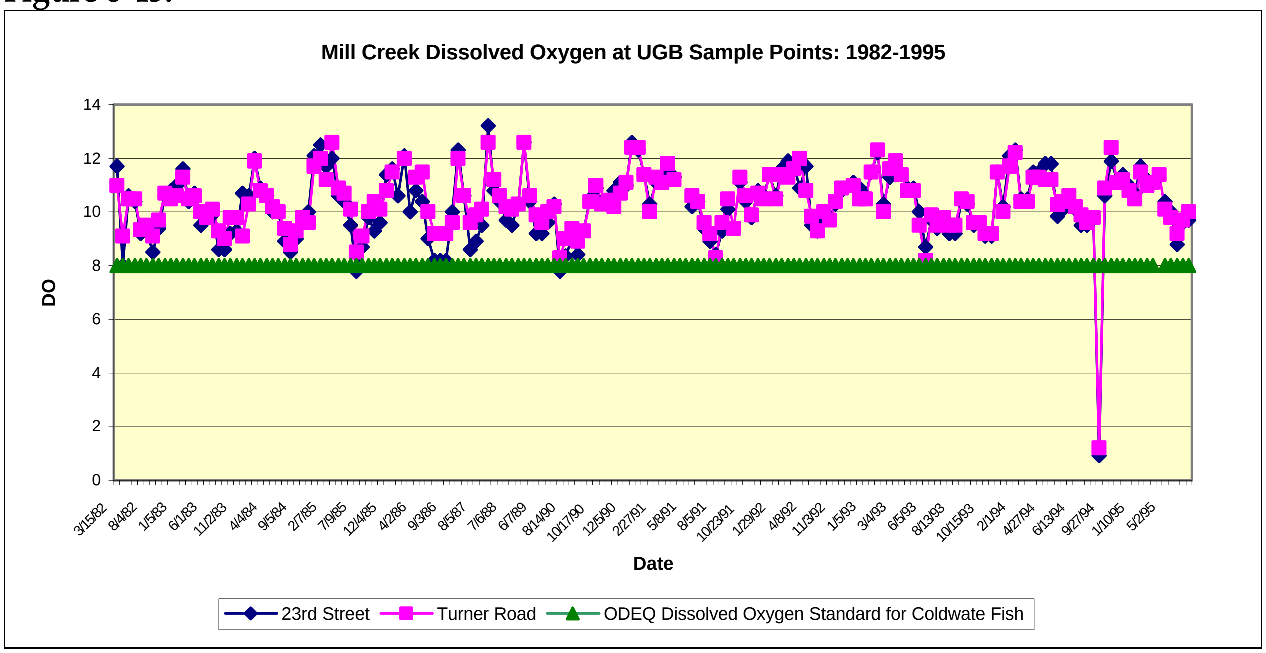


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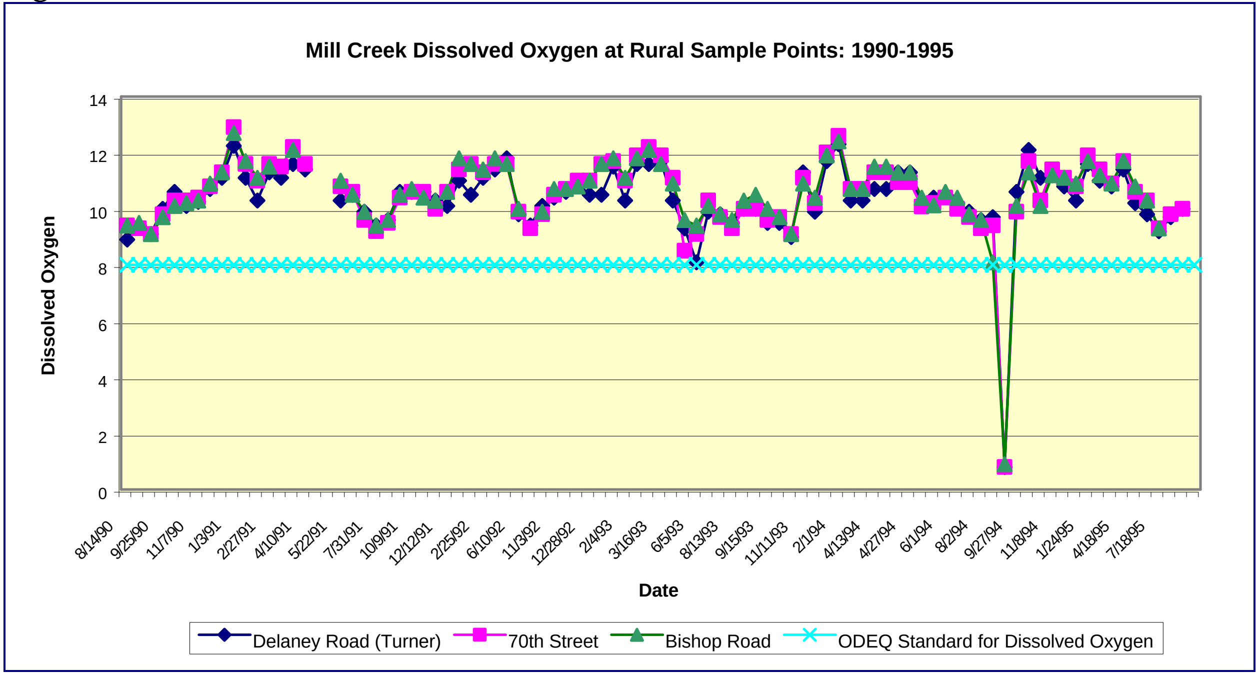
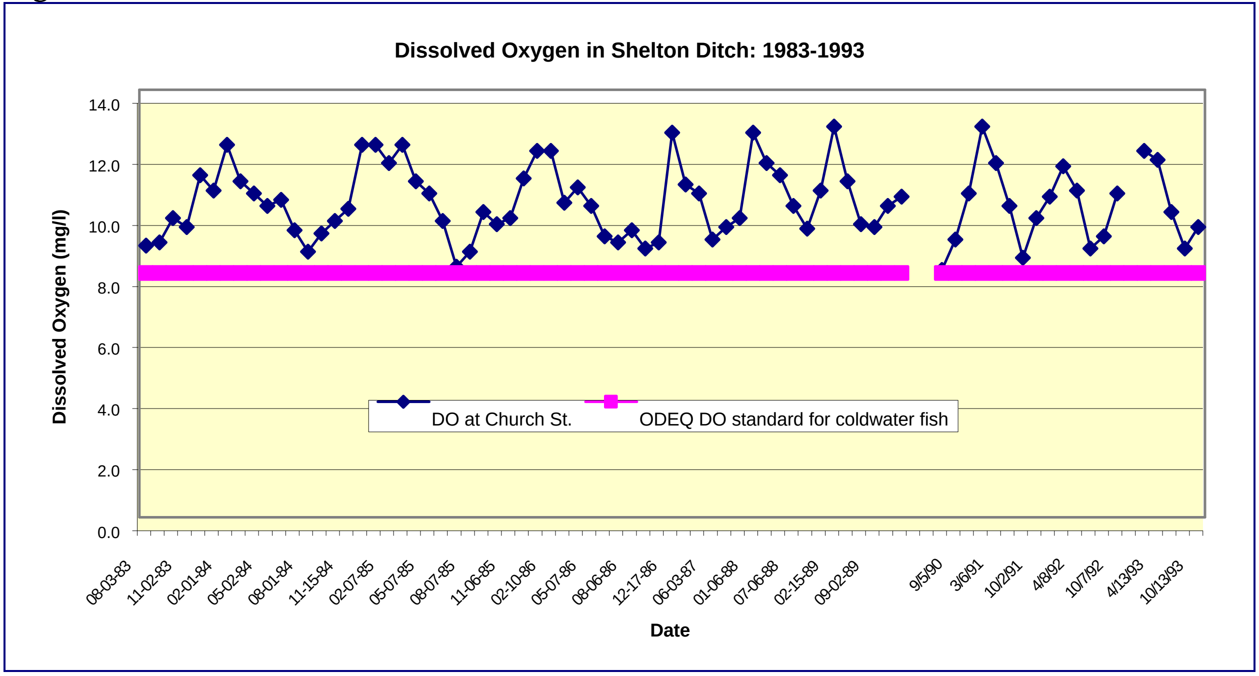
Figure 8-46.



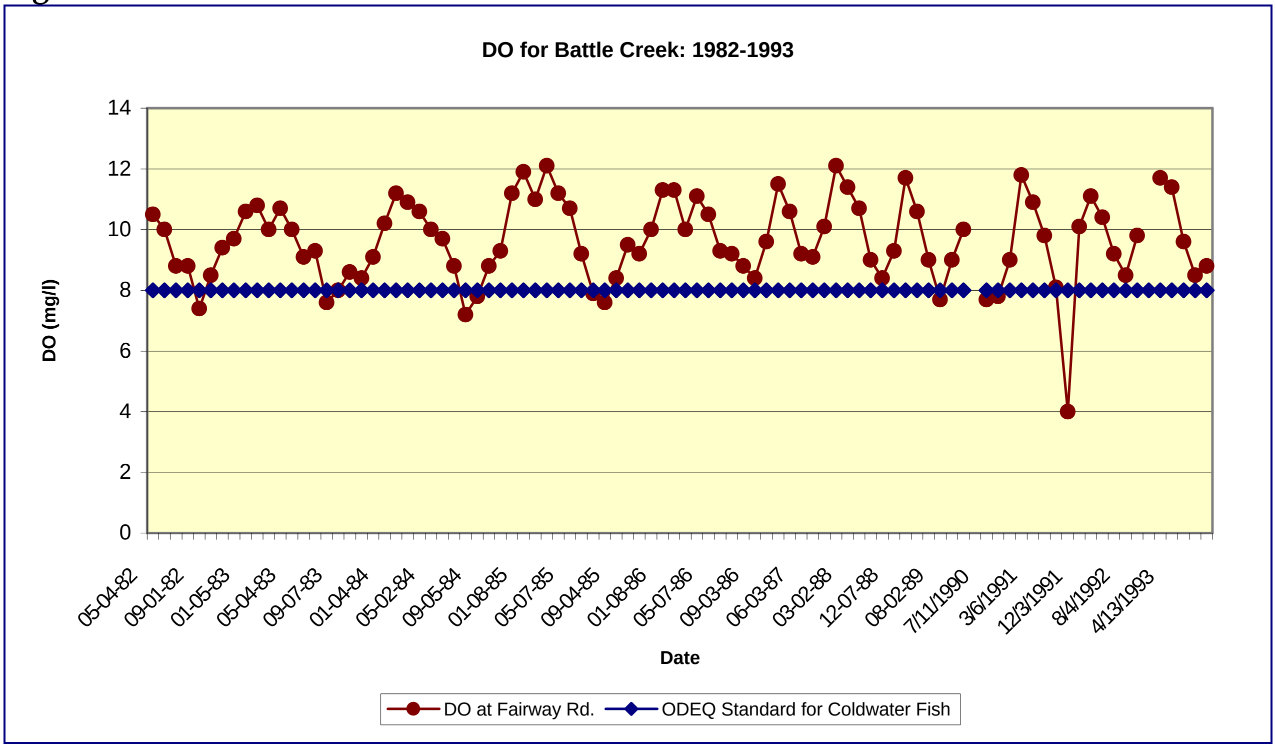
Data source: City of Salem Public Works Department (undated)

Figure 8-47.



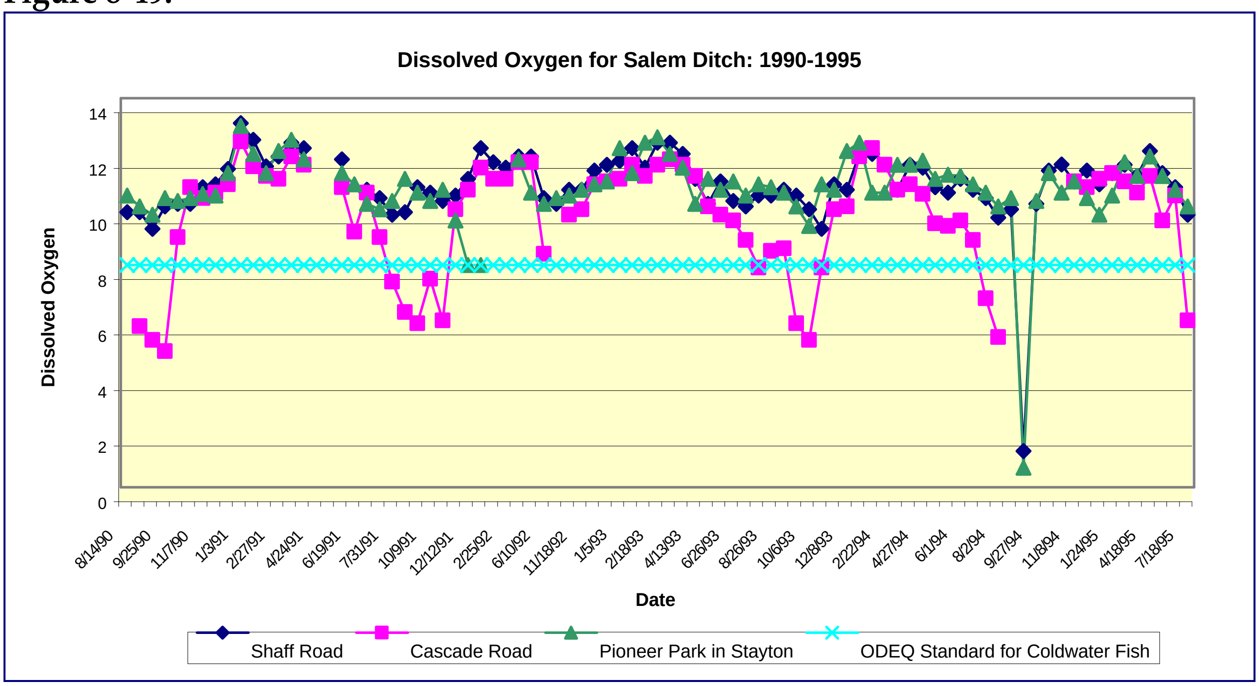
Data source: City of Salem Public Works Department (undated)

Figure 8-48.



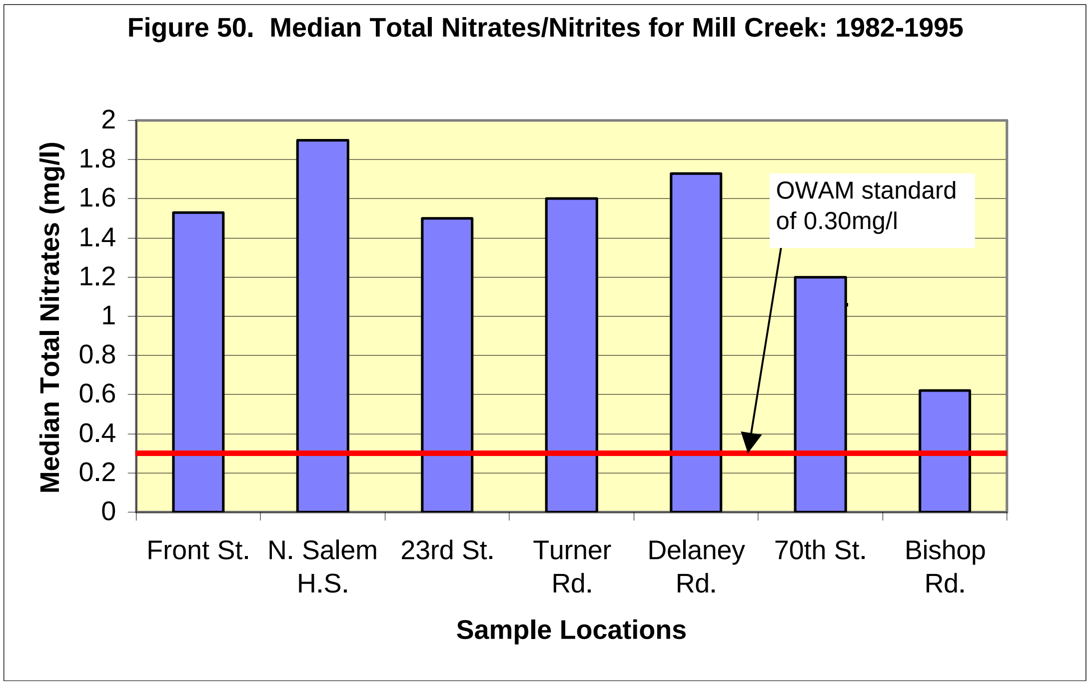
Data source: City of Salem Public Works Department (undated)

Figure 8-49.



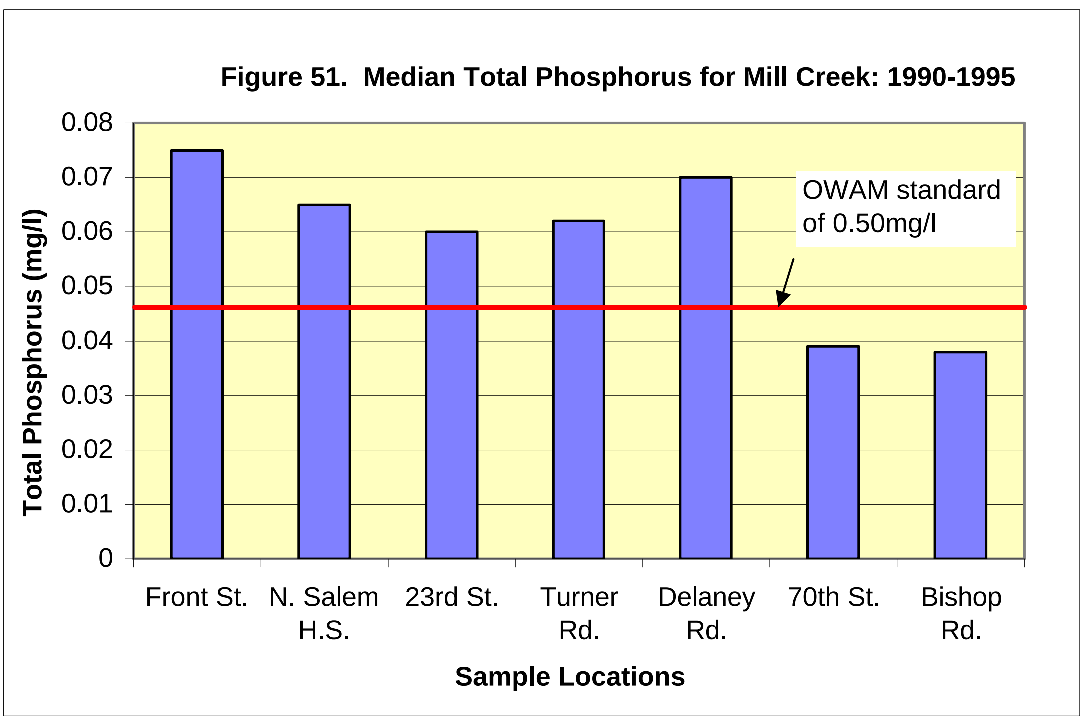
Data source: City of Salem Public Works Department (undated)

Figure 8-50.



Data source: City of Salem Public Works Department (undated)

Figure 8-51.



Data source: City of Salem Public Works Department (undated)

d. Nutrients

Total Kjeldahl Nitrogen exceeded OWAM's recommended standard of 0.30 mg/l in 88% of the samples taken along the main stem of Mill Creek. Over 90% of the samples taken from five of the seven monitoring stations exceeded the standard (**Table 8-19**). Graphing median Total Nitrates reveals two large jumps in Total Nitrates at the 70th Street monitoring station (CMC1305) and at Delaney Road (CMC1006) (**Figure 8-50**). Nitrate levels remained high for the lower portion of the creek.

Table 8-19. Total Nitrate/Nitrite Statistics for Mill Creek: 1982-1995

Total Nitrates	Front St.	N. Salem H.S.	23rd St.	Turner Rd.	Delaney Rd.	70th St.	Bishop Rd.
Number	145	80	164	164	87	87	83
Minimum	0.034	0.24	0	0	0.084	0.001	0
Maximum	7.25	7.68	7.65	7.95	66	5.1	2.691
Median	1.53	1.9	1.5	1.6	1.73	1.2	0.62
Number (>0.30mg/l)	132	76	150	152	81	69	53
% exceedance	91%	95%	91%	93%	93%	79%	64%

Measurements of Total Phosphorus in Mill Creek indicate a similar pattern as the nitrates/nitrites (**Table 8-20**). Approximately 58% of the water quality samples taken exceeded OWAM's recommended standard of 0.05mg/l. Median Total Phosphorus levels jumped at Delaney Road (CMC1006), exceeding the standard, and remained high during the remaining length of the stream (**Figure 8-51**).

Table 8-20. Total Phosphorus Statistics for Mill Creek: 1990-1995

Total Phosphorus	Front St.	N. Salem H.S.	23rd St.	Turner Rd.	Delaney Rd.	70th St.	Bishop Rd.
Number	85	81	84	85	87	87	83
Minimum	0.008	0.007	0.006	0.006	0.006	0	0.003
Maximum	0.82	0.8	0.83	0.901	2.35	1.082	1.101
Median	0.075	0.065	0.06	0.062	0.07	0.039	0.038
Number (>0.05 mg/l)	60	55	54	54	57	34	27
% exceedance	71%	68%	64%	63%	65%	39%	32%

The Delaney Road (CMC1006) monitoring station is below Mill Creek's confluence with McKinney Creek, Battle Creek and Beaver Creek. A jump of nitrate and phosphorus levels at this station may therefore indicate high levels of nutrients flowing from these tributaries.

North Santiam water flowing through Salem Ditch has lower levels of nitrates/nitrites and phosphorus (**Table 8-21 and 8-22**) compared to Mill Creek. The only exception is found at the Cascade Road (CMC1901) monitoring station where 93% of the samples taken exceeded the nitrate standard (**Figure 8-52**). Although 29% of the samples taken in Salem Ditch exceeded the phosphate standard, median total phosphate levels remained below 0.05 mg/l at all three stations (**Figure 8-53**).

Table 8- 21. Total Nitrate/Nitrite Statistics for Salem Ditch: 1990-1995

Total Nitrates	Shaff Road	Cascade Road	Pioneer Park
Number	80	81	80
Minimum	0.00	0.36	0
Maximum	1.54	3.4	1.19
Median	0.1	1.2	0.1
Number (>0.30mg/l)	25	75	20
% exceedance	31%	93%	25%

Table 8-22. Total Phosphorus Statistics for Salem Ditch: 1990-1995

Total Phosphorus	Shaff Road	Cascade Road	Pioneer Park
Number	80	75	80
Minimum	0	0.002	0
Maximua	0.72	0.7	0.531
Median	0.03	0.04	0.022
Number (>0.05 mg/l)	24	28	17
% exceedance	30%	37%	21%

Shelton Ditch exceeded the total nitrate standard in 93% of the samples taken (**Table 8-23**). Battle Creek exceeded in 90% of the samples (**Table 8-24**). The influx of nutrients from Battle Creek may have been contributing to the high nitrate levels recorded in Mill Creek at the Delaney Road monitoring station. Beaver Creek's contribution of nutrients to Mill Creek is unknown. Total Phosphorus was not measured in Shelton Ditch or Beaver Creek.

Table 8-23. Total Nitrates For Shelton Ditch: 1983-1993

Statistic	Shelton
Number	75
Minimum	0.10
Maximum	5.40
Median	1.40
Number (>0.30mg/l)	70
% exceedance	9

Table 8-24. Total Nitrates For Battle Creek :1982-1993

Statistic	Battle
Number	81
Minimum	0.20
Maximum	2.50
Median	0.90
Number (>0.30mg/l)	74
% exceedance	91%

e. Fecal Coliform Bacteria

According to DEQ's 303(d) list, Mill Creek is listed as water quality-limited for fecal coliform bacteria (**Table 8-4 and Table 8-5**) according to the pre-1996 standard. Data collected from all 12 monitoring stations in the Mill Creek watershed, including monitoring stations in the Salem Ditch, support this listing (**Figures 8-54, 8-55, 8-56, 8-57, 8-58** and **8-59**). High levels were recorded in all seasons, but summer and early fall sample periods usually recorded the highest fecal coliform counts for each year. Battle Creek data show the seasonality of fecal coliform counts (**Figure 8-58**). Five years of data show that water quality samples taken from an urban monitoring station tend to have higher fecal coliform counts than water samples taken from a rural setting (**Figure 8-60**).

Pesticides in an Urban Environment

Historical information on the presence and concentrations of pesticides (i.e., herbicides, insecticides and fungicides) in Salem's streams is scarce. However, two recent studies may shed some light on the type and concentrations of pesticides that are currently found in Salem's urban streams.

Water-Soluble Pesticides

Some pesticides are soluble in water, whereas others attach to soil particles and remain in stream sediments. In 1996, the USGS initiated a study to determine the distribution of dissolved pesticide concentrations in selected small streams throughout the Willamette Valley (Anderson et al. 1997). Of the twenty sample sites, 16 were in primarily agricultural areas and four were in urban areas. Two of the urban sample sites were Claggett Creek at North River Road and Pringle Creek at Bush's Pasture Park.

According to the study, the four most frequently detected pesticides in small streams in the Willamette Valley are atrazine, desethylatrazine (a degredation product of atrazine), simazine, metolachlor, and diuron (**Table 8-2**) (Anderson et al. 1997). These compounds were found in three-quarters of all samples regardless of land use.

While there were similarities in the chemical compounds found at urban and rural sample points, some pesticides had a definite "urban signature," being more closely associated with urban than rural sample points. **Table 8-25** lists six pesticides that were associated with urban land use according the USGS study. Most of these chemical compounds are used frequently on gardens and lawns in both residential and commercial areas (Anderson et al. 1997). Carbaryl, diazinon and dichlobenil are available through retail stores and are used by both homeowners and commercial landscapers. Prometon and triclopyr are widely used by homeowners who desire "complete vegetation control." Some formulations of prometon and triclopyr compounds are marketed as an all-purpose herbicide. While these two compounds can be used to control weeds along rights-of-ways, the Oregon Department of Transportation no longer uses prometon for roadside applications; triclopyr is only used to spot-spray along roadsides in some parts of the state. The presence of these pesticides in our creeks implies that homeowners and other users of pesticides may be overspraying.

Table 8-25. Pesticides Associated with Urban Land Uses in the Willamette Valley

Pesticide	Common Name	Use	Location of Use
Carbaryl	Sevin	Insecticide	home and garden care
Diazinon		Insecticide	home and garden care
Dichlobenil	Casoron	Herbicide	home and garden care
Tebuthiuron		Herbicide	rangeland, pasture, right-of-ways, under asphalt, industrial settings
Prometon		Herbicide	landscaping, rights-of-ways, industrial settings
Triclopyr	Garlon	Herbicide	landscaping, rights-of-ways, industrial settings

Source: USGS (1997)

As for the impact of pesticides on aquatic life, toxicity criteria have been established by the U.S. Environmental Protection Agency for only 5 of the 86 pesticides analyzed in this study. The complete impact of pesticides on aquatic life, including salmonids, has been determined. When pesticide exposure is combined with high stream temperatures, low dissolved oxygen, and high nutrient loads, impacts are more complex. Pesticides also bio-accumulate in humans; presenting health concerns, especially for infants and children.

Although toxicity to aquatic organisms for a specific chemical may be unknown, misapplication of pesticides can indirectly affect the habitat of aquatic organisms. Pringle Creek, which parallels the Union Pacific (UP) railroad tracks for approximately 3.5 miles, is vulnerable to pesticide applications used to keep the railroad right-of-way free of plants. An overspray of three herbicides, including diuron (**Table 8-2**), along the (UP) Railroad in March of 2000 may be the cause of death and chemical burn to some plant, tree and shrub species on the banks of Pringle Creek. Any loss of vegetation along Pringle Creek means less shade for the stream and a possible rise in water temperatures as the waterway becomes more exposed to the sun. Because Pringle Creek is already water quality-limited for temperature (**Table 8-4 and Table 8-5**), the shade provided by streamside vegetation is of the utmost importance. UP railroad tracks are also found paralleling or intersecting Claggett and Mill Creeks.

Pesticides and Sediments

In 1999, the USGS initiated a study in cooperation with the City of Salem. The objective was to identify the occurrence and potential sources of trace elements and hydrophobic organic compounds (including pesticides) in streambed sediments in the Salem area (USGS 2001). There were two main reasons for analyzing the streambed sediment: 1) fine grained particles and organic matter are accumulators of trace elements and hydrophobic organic constituents; and 2) streambed sediments provide a time-integrated sample of intermittent or storm-related contaminants.

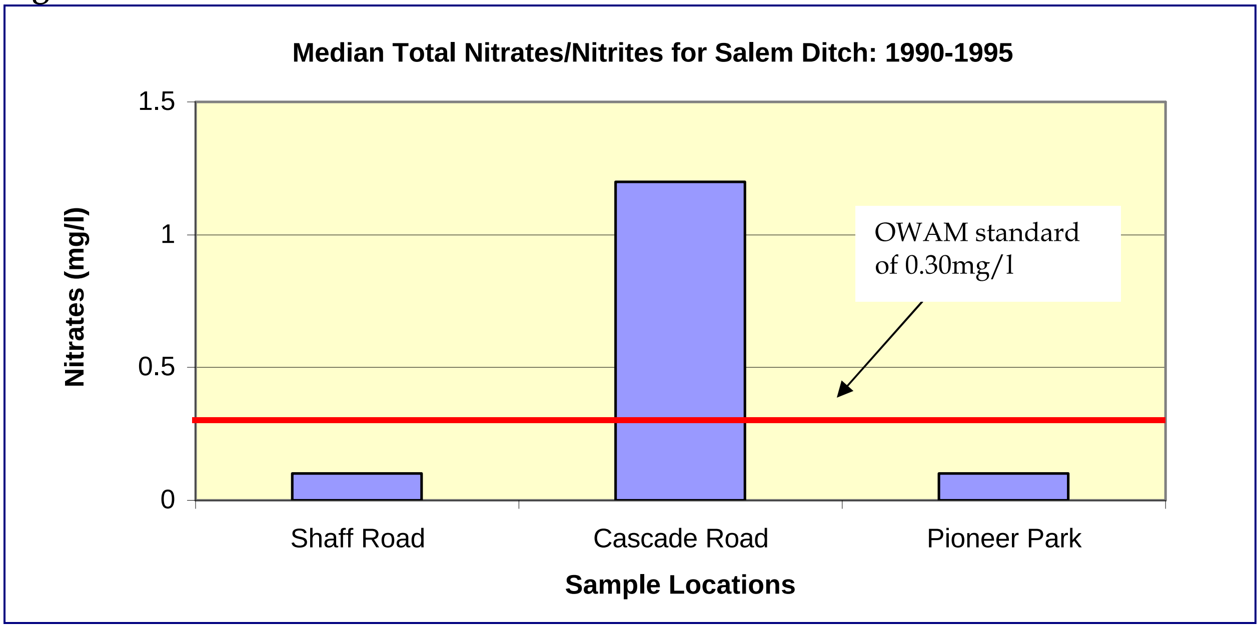
Sampling was done in October of 1999 at 14 sites in Salem and Keizer's streams. The sites were selected upstream and downstream from anticipated point and non-point sources of contaminants. Claggett Creek contained one sample point at the Salem Parkway. Glenn and Gibson Creeks contained one sample point each. The Mill Creek watershed contained six sample sites, including one in Shelton Ditch and one in Battle Creek. The Pringle Creek watershed had three sample sites. The remaining sample points were located in Pettyjohn and Croisan Creeks.

Samples were analyzed for 45 trace elements, 79 semivolatile organic compounds and 31 organochlorine pesticides. Results of the sampling can be viewed online (USGS 2001). Analysis of the data, including a comparison of contaminant levels in Salem's streams compared to streams nationally, will be included in an USGS technical paper scheduled for completion in 2003 (Tanner pers. comm.).

Other Studies

In the summer of 2001 the City of Salem expanded its stream bioassessment work beyond the Pringle Creek watershed. Approximately 50 sites were sampled throughout all of Salem's watersheds, including Mill, Glenn-Gibson and Claggett Creek watersheds. These sites, as well as the Willamette River, are now sampled approximately once a month. Physical parameters, water chemistry data and macroinvertebrate samples were taken at each site. The data will be analyzed and made available to the public at an undetermined date.

Figure 8-52.



Data source: City of Salem Public Works Department (undated)

Figure 8-53.

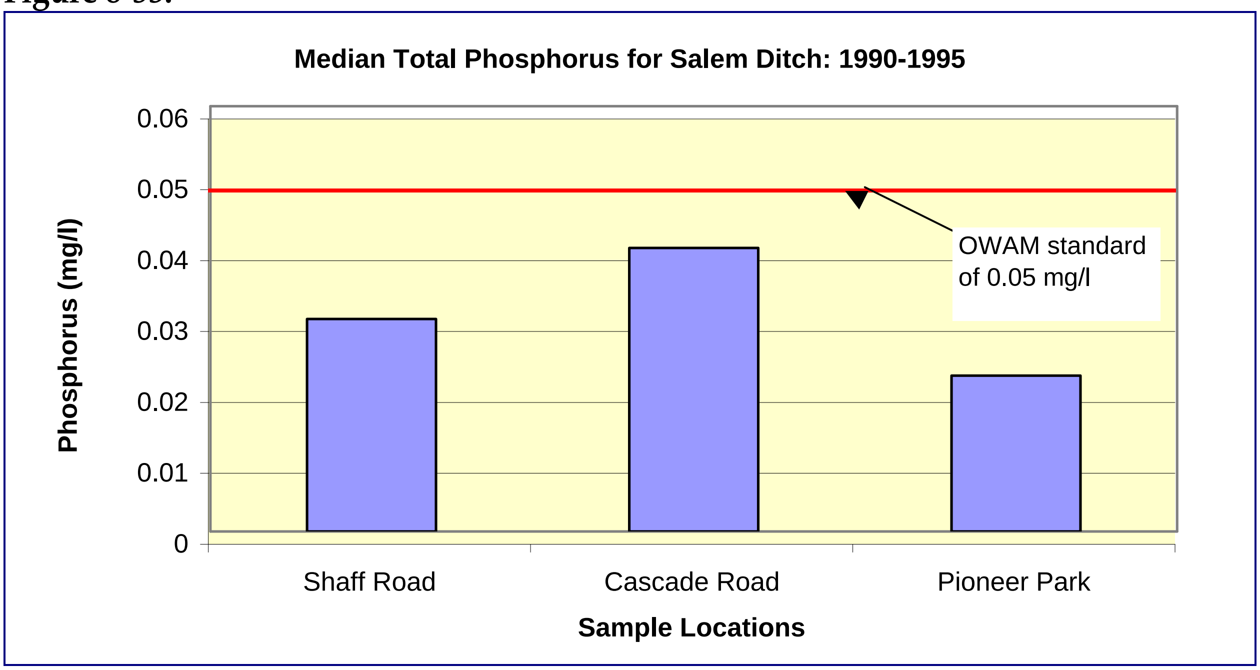


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Figure 8-54.

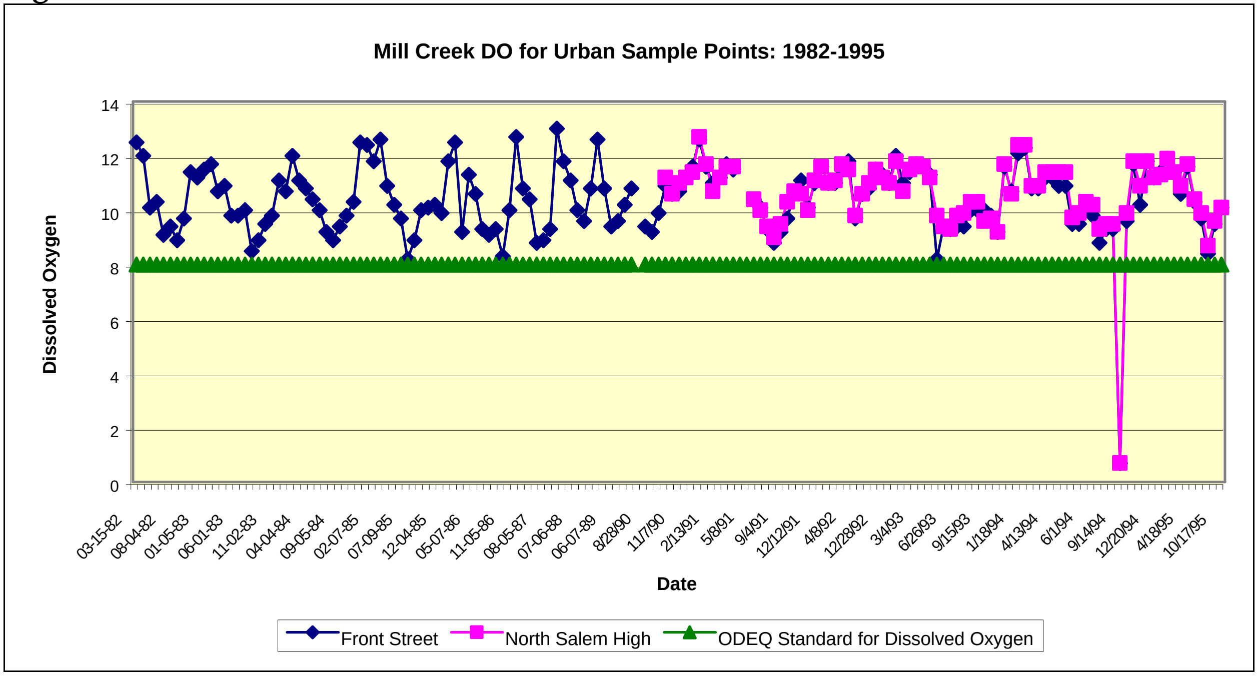

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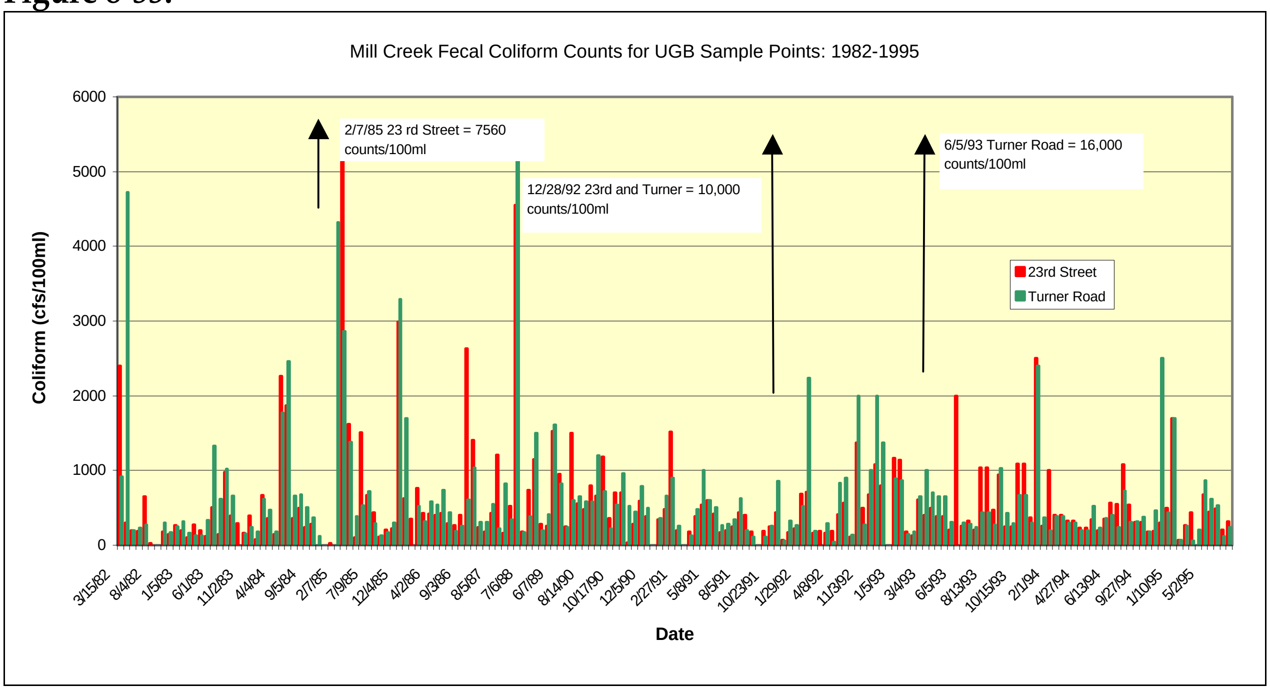
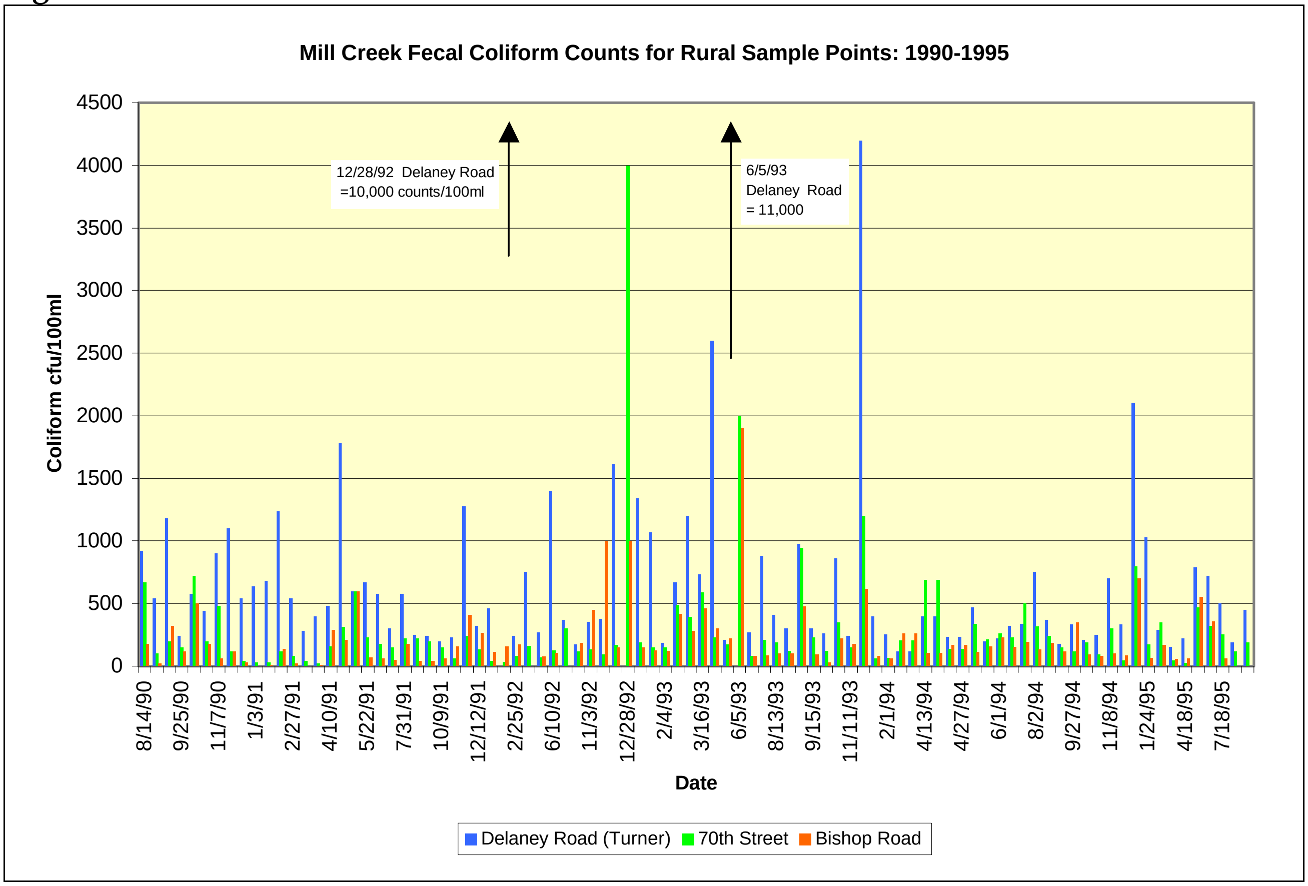
Figure 8-55.



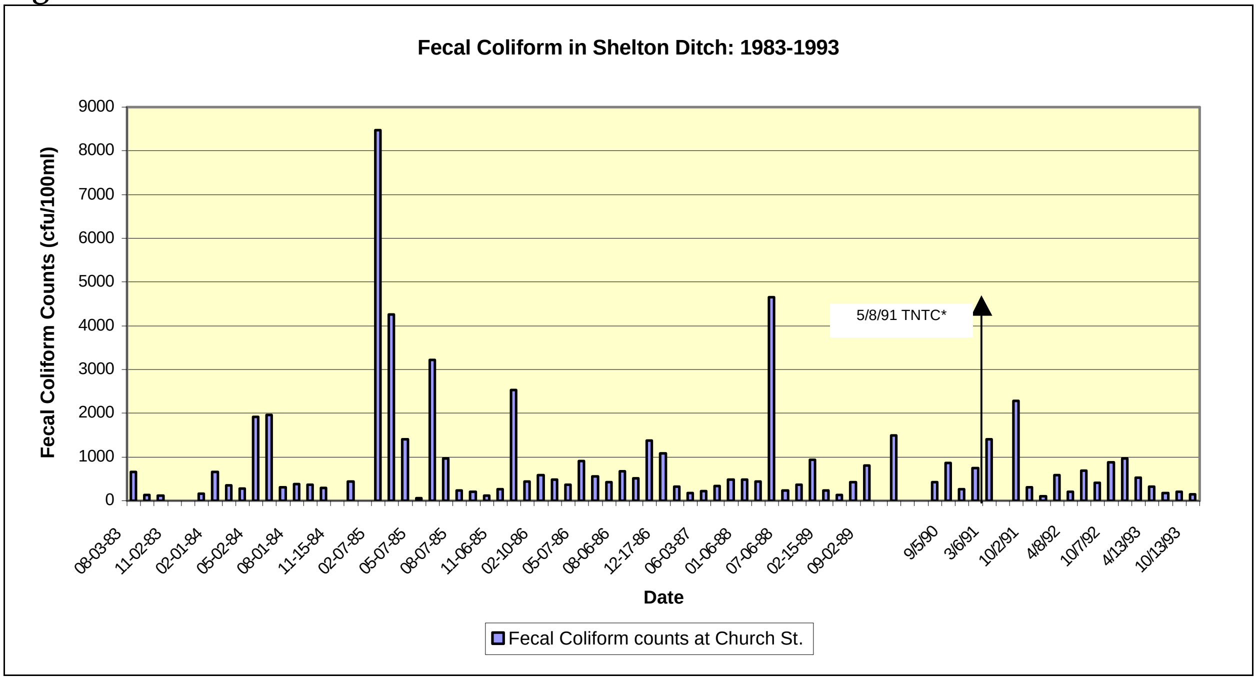
Data source: City of Salem Public Works Department (undated)

Figure 8-56.



Data source: City of Salem Public Works Department (undated)

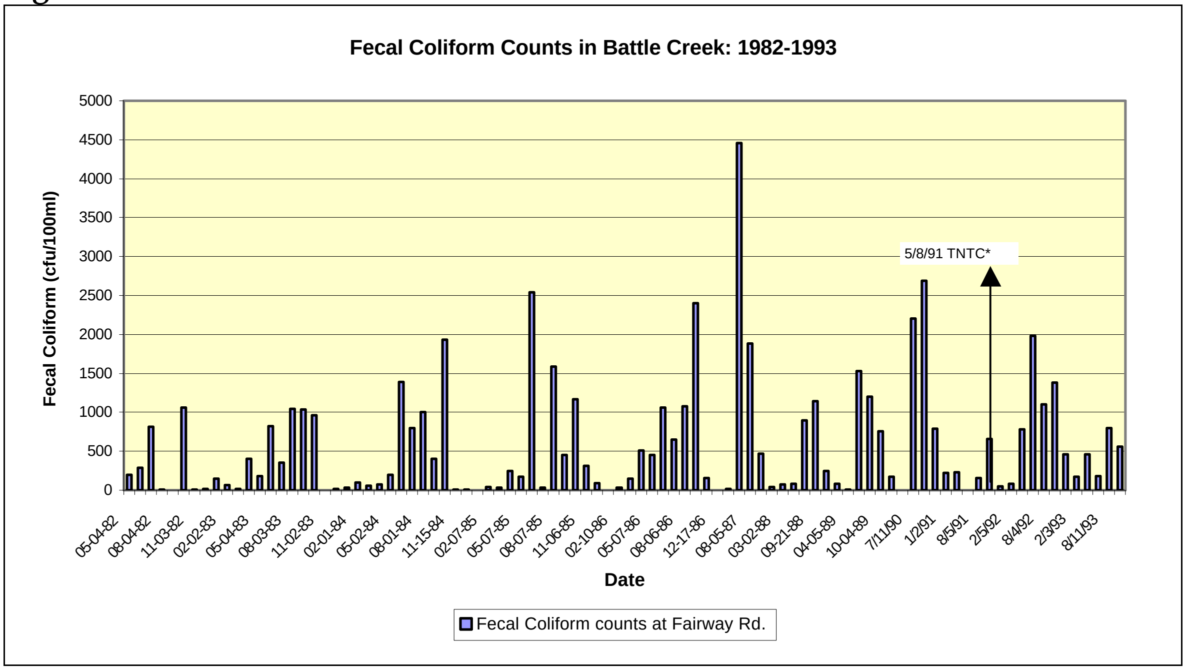
Figure 8-57.



* too numerous to count

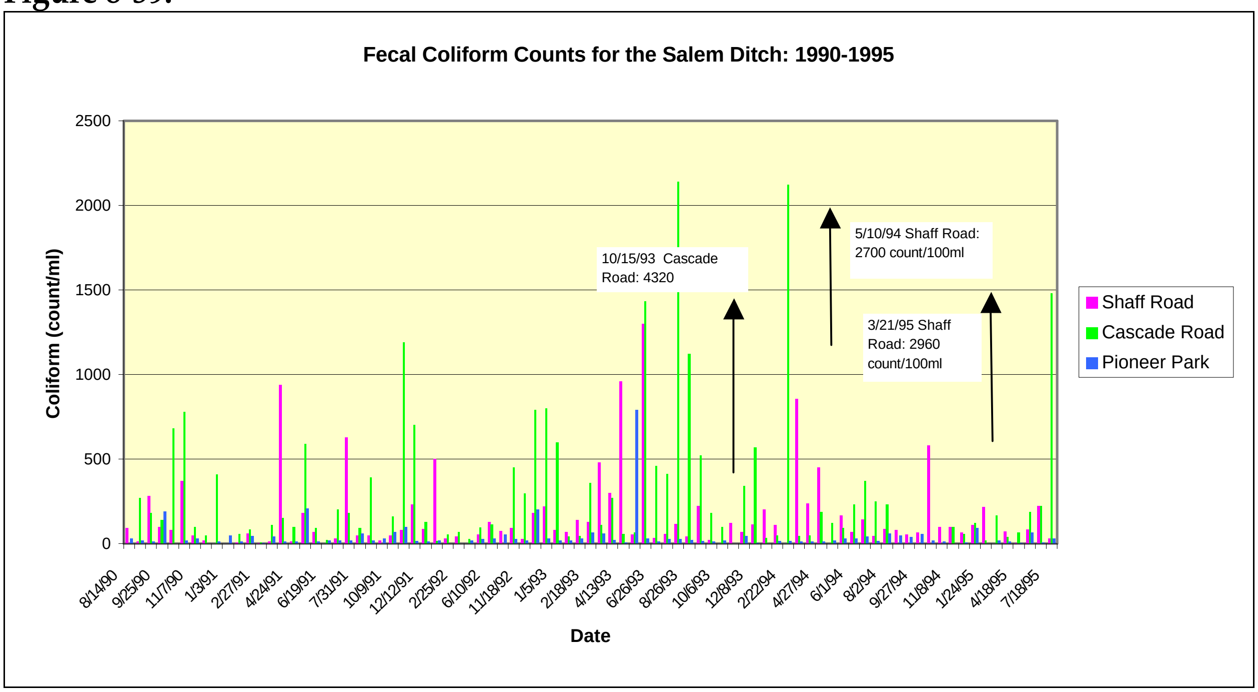
Data source: City of Salem Public Works Department (undated)

Figure 8-58.



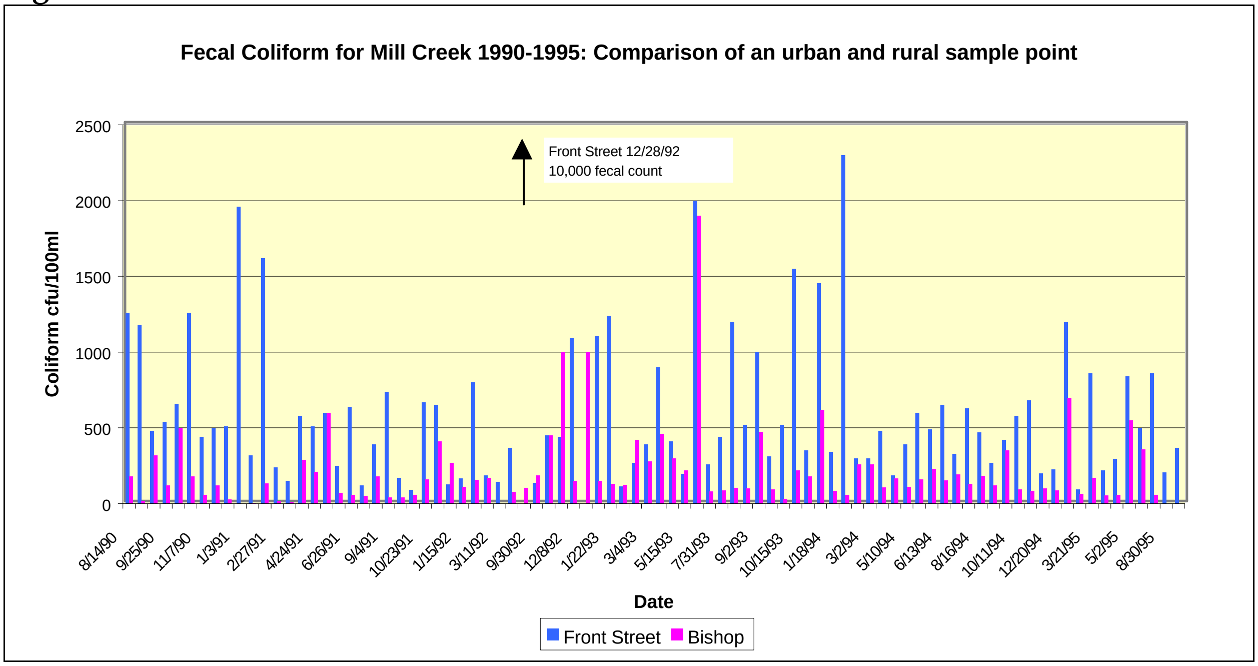
*too numerous to count
Data source: City of Salem Public Works Department (undated)

Figure 8-59.



Data source: City of Salem Public Works Department (undated)

Figure 8-60.



Data source: City of Salem Public Works Department (undated)

Summary

The information presented in this chapter of the assessment is summarized below. **The data collected by the City of Salem in the surface water-monitoring met DEQ Level 1 standards.** Data can be used to determine trends and seasonal changes in water quality parameters. It can also be used to determine where more monitoring may be necessary. The data cannot be used to determine if a stream should be listed on the 303(d) list.

Water Temperature—Claggett, Mill and Pringle Creeks routinely exceed 17.8 degrees Celsius during summer months. Since 1998, water temperatures in Glenn and Gibson Creeks have exceeded the DEQ standard a few times in the month of August only. According to DEQ's 303(d) list, Pringle Creek is water quality-limited for temperature.

Dissolved Oxygen—Records show that Claggett Creek has low dissolved oxygen in the summer. Lower Gibson Creek and Glenn Creek experience DO levels slightly below the DEQ standard of 8.0 mg/l during summer months. Mill Creek maintains high dissolved oxygen levels year-round with the exception of its tributary, Battle Creek, and at the Cascade monitoring station in Salem Ditch. Pringle Creek maintains high DO level year round with the exception of the upper reaches of the West Fork Pringle Creek at Cannery Park.

pH— Recorded pH levels outside of the recommended range of 6.5 to 8.5 were intermittent and rare. The only stream reaches that routinely recorded low pH levels were in the upper reaches of Clark Creek and the West Fork Pringle Creek, where pH values were only slightly below 6.5. Consistently low pH readings may be due to acidic soils near the headwaters. In the Mill Creek basin, the Cascade monitoring station in the Salem Ditch and Battle Creek also recorded pH values slightly lower than 6.5 throughout the years.

Nutrients—Using the standard for nitrogen supplied by the Oregon Watershed Assessment Manual (OWAM) (Watershed Professionals Network 1999), nitrogen exceeded 0.30 mg/l in over 90% of the samples taken at 15 of the 23 monitoring stations analyzed in this assessment. Total Phosphorus was sampled at 13 sites in the Pringle and Mill Creek watersheds. Total Phosphorus exceeded OWAM's standard of 0.05mg/l in over 50% of the samples taken from 8 of the 13 monitoring stations.

Fecal coliform and *E. coli*—High counts of fecal coliform or *E. coli*. were found in all four watersheds. An analysis of Mill Creek's fecal coliform counts indicates that water quality samples taken from an urban monitoring station have higher bacteria counts than water samples taken from a rural monitoring station. Mill, Pringle, and Clark creeks are water quality-limited for bacteria.

Stormwater--The studies by or with the City of Salem suggest that the surface water quality of Salem's streams is affected by stormwater quality. High concentrations of lead have been found in stream reaches near high traffic areas. High levels of fecal coliform are ubiquitous in Salem's streams and elevated levels of suspended sediment are associated with urbanization, poor channel and bank design, and construction activities (City of Salem 1982; Laenen 1983). Illicit dumping and illicit discharges of contaminants into Salem's stormwater have resulted in high levels of detergents and chlorine, in addition to solid waste, surface scum, oily deposits and strong odors at stormwater outfalls (City of Salem and ODOT 1994). Monitoring of storm water quality continues, as part of the requirements for Salem's NPDES stormwater permit, with wet weather sampling at four locations in Salem.

Pesticides—Six pesticides are commonly found in streams in urban areas: carbaryl, diazinon, dichlobenil, prometon, triclopyr, and tebuthiron. Most of these chemical compounds are used frequently on gardens and lawns in both residential and commercial areas (Anderson et al. 1997).

Recommendations

Nationally, urban runoff is considered a major source of the pollution flowing into our rivers and streams (O'Mara 1978). The water quality of our urban streams is highly dependent on the actions of thousands of private landowners and businesses that collectively contribute significant amounts of pollution to our surface and ground water. Improving water quality in the future will require a combination of monitoring, education and regulation. The key to improving water quality will be identifying sources of pollution and educating the public on its roles and responsibilities in protecting local streams. The following recommendations are **initial steps** that can be taken to improve water quality in Claggett, Mill, Glenn-Gibson and Pringle Creeks.

All Basins

1. Future surface water monitoring should follow DEQ protocol in order to determine the legitimacy of including Salem streams on the 303(d) list.

2. Include quality assurance/quality control procedures in all future water quality-monitoring programs in order to assess environmental variability, sampling procedures validity, and repeatability of the sample methods.

3. Work with the City of Salem, Marion County and Polk County on developing a surface water quality-monitoring program that determines the **sources** of water quality problems in the four watersheds. A determination of pollution sources will require extensive monitoring efforts. (The objective of surface water monitoring in the 1980's and 1990's was to determine if a problem existed. This recommendation takes the monitoring program one step further.) This recommendation includes determining the sources of pollution at stormwater outfalls, as well as the quality of surface water as it enters the urban area from upstream tributaries and rural areas.

4. Continue to support water quality-monitoring programs such as the City of Salem's Adopt-A-Stream program. This program works with teachers and students ranging from elementary to high school. Students learn about water quality in local streams while collecting valuable information on stream health. Data is posted on the City of Salem's web site (City of Salem 2001).

5. Incorporate the results of the City of Salem's stream bioassessment work into the watershed assessment. Use the results to help determine which stream reaches are most in need of restoration or enhancement.

6. Continue to promote non-structural Best Management Practices (BMPs) such as public education and the enforcement of government regulations and

ordinances protecting water quality. This includes supporting the Watershed Enhancement Team (WET). WET is a partnership effort involving state and local governments and community volunteers working together to enhance and protect the Pringle Creek watershed. WET is a volunteer effort to get homeowners and businesses to go beyond regulatory requirements. Its goal is to educate the public and private businesses on how they can improve water quality in our streams by making small changes in their lives (e.g., plant drought-resistant plants to save water, reduce pesticide and fertilizer use on lawns and gardens and dispose of hazardous wastes properly). Promote the initiation of this program in other watersheds.

7. Promote the use of structural BMPs such as parking lot bioswales, diverter valves in parking lots to divert car wash water into the sanitary sewer system, stormwater detention ponds that incorporate native plants, the use of porous pavement, and the restoration of wetlands and riparian areas along streams. All of these "structures" help filter or divert urban runoff that would otherwise flow directly into our streams and degrade water quality.

8. Identify and map leaky underground storage tanks by watershed. Analyze their proximity to sensitive areas such as wetlands, springs, seeps and streams.

9. Contact the Salem Fire Department for information regarding the number and location of spills from motor vehicle accidents to determine where there is a pattern of pollution.

10. Participate with local jurisdictions, DEQ , and other stake-holders to identify local pollution reduction scenarios for Salem-Keizer watersheds.

11. Take samples from the same sites and stormwater outfalls noted in earlier work using current DEQ protocols to determine if problems such as detergents, pH levels, chlorine, copper, DDT, lead and water quality have declined or increased at Salem's stormwater outfalls.

12. Collect and analyze current data to determine what, if any, correlation exists between traffic counts and median lead concentrations in Salem's streams. Compare with data analyzed earlier from the 35 sites where lead levels equaled or exceeded DEQ's standard for drinking water.

13. Support establishing a state standard for nitrate/nitrites and phosphorus levels which meets or exceeds that proposed in the Oregon Watershed Assessment Manual.

14. Analyze available data for water temperature, dissolved oxygen and pH for each watershed, and graph all exceedances to determine where patterns or commonalities exist. Compare with known fish locations to determine if they act as a barrier to fish health, spawning and migration.

15. Analyze available data for nutrients (nitrates/nitrites and phosphorus) and toxics (pesticides) and graph all exceedances to determine where patterns or commonalities exist. Identify upstream and nearby riparian land uses.

16. Compare locations where E. coli samples exceeded the E. coli standard with City of Salem Parks Operations' "Mutt Mitt" program areas and places where ducks and geese congregate. Analyze data to determine if there are seasonal patterns or commonalities.

17. Support fast-track federal and state action to establish toxicity criteria for the impact of pesticides on aquatic life, both singly and in combination with the high stream temperatures, low dissolved oxygen and high nutrient loads of urban streams.

Pringle Creek

1. Follow up with DEQ's Environmental Cleanup Program to determine current status on the two dry cleaning sites contaminated by chlorinated solvents (perchloroethylene) in the Pringle Creek watershed.

2. As an "early action" item, continue working with Union Pacific Railroad representatives to implement adequate procedures for weed control along tracks paralleling fish-bearing streams and other sensitive areas.

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Chapter 9 – Fish and Wildlife

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Fish and Wildlife

Introduction

Intercouncil Watershed Assessment Committee Questions/ Issues

1) **What is the distribution and abundance of species (not just fish)?**
   - Past and present?
2) **Where is fish habitat and what is its condition?**
3) What are the fish passage restrictions? And where are the restrictions needed?

This chapter of the watershed assessment will discuss fish presence, fish habitat and known migration barriers in the Pringle, Glenn-Gibson, Claggett and Mill Creek watersheds. A brief discussion on the presence of wildlife and plant species in the Salem-Keizer area is also included at the end of the chapter.

Data Sources

Data was collected from Oregon Department of Fish and Wildlife (ODFW), United States Geological Survey (USGS), United States Fish and Wildlife Service (USFWS), Oregon Natural Heritage Program (ONHP), National Oceanic Atmospheric Administration (NOAA), the City of Salem, Marion County Public Works, Marion Soil and Water Conservation District (MSWCD), Willamette Restoration Initiative (WRI), the Mill Creek Watershed Taskforce, Water Work Consulting, and McNary High School.

Fish Species in the Mid-Willamette Basin

Five current and/or potential "sensitive" fish species are found in the Mid-Willamette Basin (**Table 9-1**). The species are considered sensitive either because they face some known level of challenge to their continued population levels or existing information on the condition of their population is limited.

Table 9-1. Listed Fish Species Found in the Mid-Willamette Basin[1]

Aquatic Species (common name)	State Status	Federal Status
Spring chinook	--	Threatened
Winter steelhead	Sensitive-Critical	Threatened
Upper Willamette cutthroat trout	--	Species of Concern
Pacific Lamprey	Sensitive-Vulnerable	Species of Concern
Oregon chub	Sensitive-Critical	Endangered

[1]Information as of November 2001

Salmonids

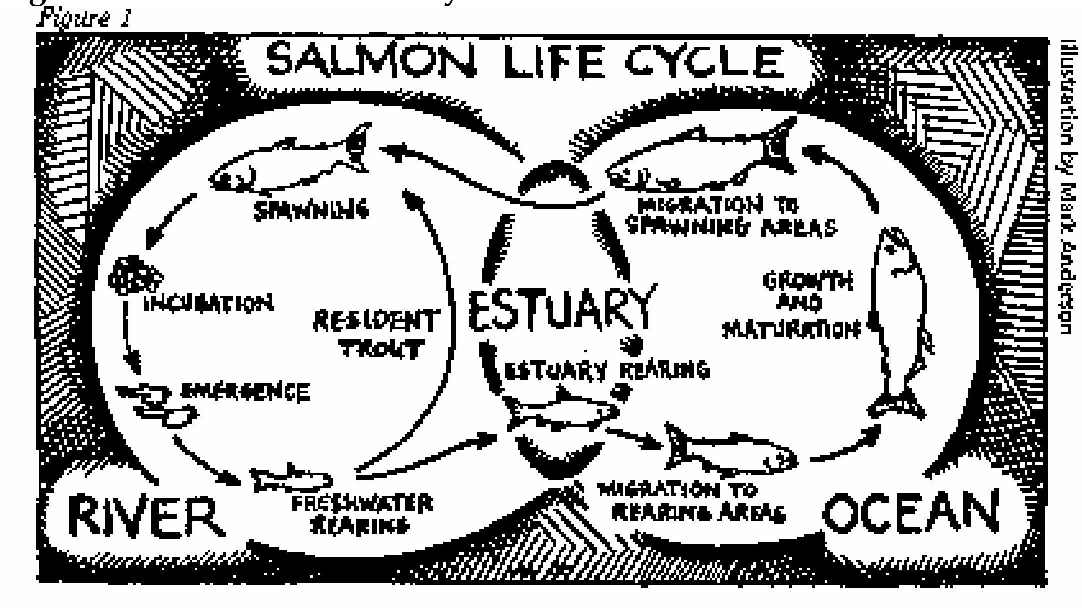
Salmon, steelhead and trout are members of the family *Salmonidae* and are often collectively referred to as salmonids. Native salmonids in the upper Willamette basin include spring chinook salmon, winter steelhead, cutthroat trout, rainbow trout, and bull trout. Salmon and trout from other areas in the Northwest have been introduced in the upper Willamette, and can compete with native fish for habitat and food (Institute for the Northwest 1999). These include fall chinook salmon, coho salmon, summer steelhead and a hatchery stock of rainbow trout. The general salmon life cycle is depicted in **Figure 9-1**. Life cycles can differ from river to river and among species (i.e., fall vs. spring chinook, winter vs. summer steelhead, sea-run vs. resident cutthroat trout). Where several salmonid species coexist in a river system, each species has its own schedule for rearing, spawning, and migration, although it is not uncommon for juveniles and adults to occupy the same stream areas throughout the year (OSU Extension 2000).

Salmonid life history patterns and habitat preference vary depending on the type of species and stage in the life cycle (**Table 9-2**). Over time, salmonids developed different life histories that allowed them to adapt to different sections of the watershed. Their fertilized eggs need sheltered, freshwater gravel beds to develop into fry. Eggs are deposited in the gravel of streams in nests called redds and will incubate for approximately 45-70 days depending on species and water temperatures (OSU Extension Service 2000). Increased water temperatures can accelerate development. Likewise, turbidity lowers water's capacity to carry dissolved oxygen (DO) to eggs deposited in gravel.

Once fry emerge from the gravel sites, they need specific stream habitat conditions to be met in order to ensure their survival. The primary conditions are an adequate food supply, cool or cold sediment-free water that contains lots of oxygen, and cover (OSU Extension Service 2000). During their first month, juveniles are especially vulnerable to predation by birds, amphibians, reptiles, and other fish. Depending on the species, juvenile anadromous salmonids grow 1-3 years before migrating to the sea as smolts.

To adapt to saltwater they must undergo complex physiological changes by spending transition time in the estuary. After rearing in the ocean, they return to their natal stream to spawn and then die. Their corpses nourish the habitat, which serves to support the next generation of salmonids. Because these fish travel across the landscape and into many different environments, many factors contribute to their mortality.

Figure 9-1. The Salmon Life Cycle.



Source: Portland Multnomah Progress Board (2000)

Table 9-2. Summary of Life History Pattern for Salmonids Found in the Mid-Willamette Basin

Species	Juveniles	Adult s	Spawning
Fall Chinook	Emerge from gravel in winter (February – March). Stay in stream about 90 days. Migrate into estuary or lower main stem river by spring (April-June). Spend next 3-4 months in estuary, and then migrate to ocean with fall rains.	Migrate early July - September.	Return from ocean in late August and September. Spawn late September – early October in Willamette. Prefer main river channels and low gradient tributaries. Spawn once then die. • Not native; introduced through result of hatchery program in N. Santiam River and Mill Creek.
Spring Chinook	Emerge from gravel in late winter or early spring. Juveniles will rear up to one year or longer in basin; juveniles can migrate year-round in basin. Out-migration to ocean occurs in spring and, to a lesser extent, fall. Life history more variable than fall chinook.	Migrate April – September. Return to rivers in the spring and early summer, then spend summer in deep pools.	Spawn late August – October in Willamette. Spawn once and then die. • Native to upper Willamette and Santiam basin.
Winter Steelhead	Juveniles emerge by late spring/early summer. First year, live in riffles / edges of stream channels and pools. • Affected by low water conditions. Spend 2-3 yrs. in a stream then migrate to ocean during the spring. • Long freshwater residence makes them vulnerable to degraded habitat.	Return from the ocean December-April, allowing them to move into headwaters during winter flows. • Prefer faster-moving water, a stream gradient > 5%, and a stream channel containing large woody debris	Spawn February- June. About 30% of adults survive and spawn again. • Native to upper Willamette and Santiam basin. .
Summer Steelhead	Juvenile life history is similar to that of winter fish.	Enter river systems from April-August. Need deep, cool pools to reside in until they spawn.	Spawn January-February. • Not native; introduced through result of hatchery program in the Santiam basin
Cutthroat Trout	Highly variable: Juveniles typically emerge anytime from late winter to July. Juveniles migrate downstream fall through spring. Peak migration in fall and spring.	Highly variable: Typically, migrate upstream in the fall, winter and spring.	Spawn in fall, winter and spring (depending on life history pattern). • Native to upper Willamette and Salem area streams.

Chinook Salmon

Both spring and fall chinook salmon live in the upper Willamette basin. Spring chinook are the only salmon native to the basin while the fall chinook are the result of past hatchery introductions. Although hatchery fall chinook are no longer released in the upper Willamette basin, the population is able to sustain itself at a much reduced level through natural production. Typically, fall chinook adult migration in the Willamette occurs from August through October and spawning September through early October. Compared to the habitat preferences of other salmonids, chinook prefer deeper water and larger gravel substrate (Johnson and O'Neil 2000).

In March 1999, upper Willamette River spring chinook was listed as "Threatened" under the federal Endangered Species Act (ESA) by the National Marine Fisheries Service (NMFS). Historically, spring chinook were able to clear the Willamette Falls migration barrier during higher flows (Collins 1951) and are a native anadromous fish in the upper Willamette River. Adult spring chinook migrate into the Willamette Basin from April to September. They spawn in the larger rivers and tributaries between August and October. Although there is no spawning observed in Salem, juveniles will rear either seasonally or year-round in some of the area's streams. A decline in the numbers of these fish is attributed to several factors, including the loss of, or reduction in, available habitat due to habitat destruction and the construction of migration barriers such as dams on the Santiam River. Researchers believe that the status of local chinook salmon populations depends on both the restoration of the valley floor streams and headwater spawning areas. According to Jim Martin, former ODFW fish specialist, the recovery of spring chinook appears unlikely without protecting productive spawning habitats and reconnecting the fish to their headwater streams (Martin 2001).

Although spawning occurs far upstream of the Salem area, juvenile spring chinook can migrate within the basin at a very early age. Spring chinook fry and fingerlings only a few months or even weeks old, have been documented as moving downstream from spawning areas to rear in the larger rivers, including the Willamette. Out-migration from the basin to the ocean as smolts occurs primarily during the spring and, to a lesser extent, the fall (Galovich pers. comm).

Steelhead trout

In the Upper Willamette River, winter steelhead trout are considered "sensitive/critical" by ODFW, and as of March 1999, NMFS listed this species as "Threatened" under the Federal ESA. In the Pacific Northwest, winter steelhead enter fresh water between November and mid-May. Summer steelhead enter fresh water between mid-May and October.

Winter steelhead

Winter steelhead prefer faster- moving water, higher-gradient east slope streams flowing from the western Cascades, and a stream channel containing large woody debris. Like spring chinook, winter steelhead are native above the Willamette Falls. Steelhead are considered by many to have the greatest diversity of life history patterns of any Pacific salmonid species (Busby et al. 1996). Spawning occurs from February through June and juveniles typically rear in freshwater from one to two years. Winter steelhead return to rivers between December and April, after staying approximately one to three years in the ocean. Winter flows enable these fish to move into headwater streams. A recent document prepared by the Willamette Restoration Initiative reports that approximately 60 percent of wild winter steelhead in the Willamette are produced from the Santiam sub-basins (Institute for the Northwest 1999). The report also indicates that steelhead populations are in decline for both the North and South Santiam Rivers. NMFS concludes that these particular species of salmonids are at risk of extinction primarily due to such human activities as over-fishing, past and ongoing habitat destruction, hydropower development, hatchery practices and degraded water quality (NMFS 2000).

Summer steelhead

Summer steelhead need deep, cool pools to reside in until spawning in January-February. Historically, summer steelhead were stocked in the North and South Santiam. The hatchery program is mitigation for fishing opportunity lost when historic native winter steelhead habitat was severely reduced by construction of dams on the North and South Santiam. The first successful returns to the upper Willamette occurred in the early 1970's. The program is ongoing, with summer steelhead smolts being released into the North and South Santiam. The returning adults provide a sport fishery in the spring, summer, and fall.

Cutthroat Trout

Three subspecies of cutthroat trout are documented in Oregon, but only one, the coastal cutthroat trout, occurs in the Willamette Valley. Although it has no legal ramifications, the ODFW refers to Coastal cutthroat existing in the upper Willamette as a "Stock of Concern." This status reflects ODFW's concern for the fish's population trend and thus, they give cutthroat and issues that may affect their habitat additional attention. Unlike those in the lower Willamette and Columbia, upper Willamette cutthroat are not anadromous. The Salem area supports two varieties of cutthroat resident trout that reside in a stream or stream reach throughout their entire lives and fluvial cutthroat that migrate between streams or stream systems. (Galovich 2001).

Resident cutthroat trout populations appear to be stable but are most likely lower in abundance than historic levels due to habitat loss (ODFW 1997). Fluvial cutthroat are also widely distributed throughout the upper Willamette but are prevented from accessing waters that lie above migration barriers. Their life history is highly variable; spawning and migration have been observed several months of the year. Upstream migration to spawning areas, however, typically occurs during the fall, winter and spring. Spawning can take place from late fall through late spring. Much like the anadromous steelhead, juveniles will then rear for about two years before beginning their downstream migration. Some juveniles are also reported to move downstream during the winter months and into flood plain tributaries to over-winter (Johnson and O'Neil 2000). Wetland habitats associated with streams support Willamette River cutthroat trout populations (OSU Extension Service 2001).

Other Native Fish Species

In addition to those listed above, there are many other species of fish native to the Salem area and Mid-Willamette basin. These include lamprey, chub, northern pikeminnow, peamouth, chiselmouth, sculpin, redside shiner, dace, largescale sucker, and sticklebacks (ODFW 2000; ONHP 2000). While some of these fish prey upon salmonids, others serve as an important food source. Many can be somewhat tolerant of poorer water quality conditions, such as high water temperature and low dissolved oxygen.

Pacific Lamprey

The National Marine Fisheries Service (NMFS) considers Willamette River Basin Pacific lamprey a "Species of Concern" under the Federal ESA. Lampreys are commonly referred to as "eels" and considered one of the most primitive of the living fishes. Similar to salmon, Pacific lamprey live most of their adult life in the ocean and then return to rivers to spawn and die. The spawning migration usually starts in late fall and continues into late spring. Spawning occurs in riffle areas where the current is swift. Eggs are laid in small dug out gravel cavities then hatch into blind larva called ammocoetes. The larvas live for several years in mud or sand bottom pools and filter-feed on microorganisms in the water. In the ocean, adult lampreys are parasitic and feed on the body fluids of a host fish.

Oregon Chub

In 1993, the USFWS listed the Oregon chub as a federally "Endangered" species under the ESA. A recovery plan was approved in 1998 (USFWS 1998). Once widely distributed in the Willamette Valley, this non-game, "minnow-like" species now only occupies about two percent of its original territory. Oregon Chub prefer floodplain habitat and were historically found in sloughs, beaver ponds, oxbows and side channels located in the Willamette Valley. Much of this habitat has been degraded as a result of stream channel modifications, introduction of non-native fish species, runoff from pesticides and diversions. These practices have led to an increase in predation and limited availability of zooplankton, their primary food source.

Oregon Chub spawn in May and June in warm shallow water with vegetative cover. The ODFW rearing pond at Aumsville is fed by Mill Creek and provides habitat for this listed species. There are 24 populations that exist in many tributaries of the mainstem Willamette River. Twelve of these documented populations contain fewer than 100 individuals and are a primary focus of the 1998 Recovery Plan. Through reintroductions and/or habitat enhancement, the plan expects to establish new populations (Institute for the Northwest 1999).

Non-native Fish Species

A 1997 U.S. Geological Survey claims that approximately 54 species of fish are present in the Willamette Basin. About half (48 percent) are introduced. As a general rule, species richness tends to increase from high elevation, steep gradient, cold-water headwaters areas to the larger, low elevation, low gradient, warm water main stem channels (USGS 1997). Warm-water fish such as bass, catfish, and sunfish typically dominate the low elevation reaches of the major rivers of the Willamette Valley (**Table 9-3**). The Willamette River is presently dominated by non-native fish species. In mountain streams there is better representation of native species (USGS 1997). Many warm-water fish are found in the Salem area. Exotic species can compete with and prey upon native fish.

Table 9-3. Introduced species found in the Willamette River Basin

Bullhead catfishes Black, Brown, Yellow, Channel
Herrings American shad
Minnows Goldfish, Common carp, Tench
Perches Yellow perch, Walleye
Sunfishes Pumpkinseed, Warmouth Bluegill, Redear sunfish, Largemouth bass, Smallmouth Bass, White crappie, Black crappie
Topminnows Banded killifish
Salmon and Trout Fall Chinook

Source: USGS (1997)

Documentation of Fish Presence

Information on fish presence and fish habitat were compiled from several sources including City of Salem, ODFW, ODSL, Water Work Consulting, and McNary High School. Although a great deal of information has been gathered over the years, there has not been an effort to document seasonal changes in species distribution or to identify local population trends in most of the streams. A sampling effort continuous throughout the year in a given stream would be necessary to provide such information. Many times this is not feasible or cost-effective. Instead, biologists often rely on data that has been collected in similar systems and extrapolate their findings to streams that are physically, geographically and biologically similar. This technique was used to some extent when trying to determine historic populations of fish species. In other words, we took some educated guesses when data was lacking.

The lower reaches of Pringle Creek and Mill Creek are considered “essential indigenous anadromous salmonid habitat.” Essential Salmonid Habitat is defined as the habitat necessary to prevent the depletion of native salmon species, in this case spring chinook salmon and winter steelhead, during their life history stages of spawning and rearing. The designation applies only to those species that have been listed as Sensitive, Threatened or Endangered by a state or federal authority. Rivers and creeks that have this designation receive special attention by state regulatory agencies and are protected by state law and administrative rule (ODSL 2001).

Methods

A variety of methods has been used to gather information on fish distribution in the Salem area. Depending on the location and intent of the sampling, methods have included the use of nets (seining), electrofishing, snorkeling, the operation of fish traps and visual surveys such as those used to inventory spawning salmon. Few efforts have attempted to systematically survey an entire area at any one time. More often, the sampling has been driven by the need to inventory a single species, investigate habitat issues, or respond to spill events.

The most comprehensive effort to date was conducted by the City of Salem (City of Salem 1999). The City contracted with the Oregon Department of Fish & Wildlife to look at fish presence and distribution in all Salem area streams in April and May. The study was conducted in the spring or at times when, due to water quality and fish life history, salmonids would most likely be encountered. Fish distribution survey maps were created for the Pringle, Glenn-Gibson, Claggett, and Mill Creek watersheds.

With the exception of annual redd counts by ODFW in Mill Creek, sampling efforts conducted by both public agencies and private consultants in local streams are small in scope. Results of these sampling efforts are presented in the following watershed summaries.

Pringle Creek

The 1999 City of Salem Fish Distribution Survey concentrates on four tributaries within the Pringle Creek watershed (**Map 9-1**). Salmon were not found in any of the 21 sample sites in the Pringle Creek tributaries. This should not imply that salmon or steelhead do not use the stream throughout the year as ODFW has mentioned that one-time sampling does not allow the City to either map distribution of fish or determine upstream limits of fish usage (Taylor, 2002). Resident cutthroat trout were found at the mouth of Clark Creek, Pringle Creek's West Fork, West Middle Fork and up into the East Fork headwaters. Although the observation crew noted trout fry in Clark Creek they did not observe a distribution of trout upstream of Commercial Street. Low numbers of lamprey were distributed in the main tributaries of Pringle Creek, although a more recent survey has indicated otherwise (Hunt 2000). A high abundance of sculpin, dace, and shiners were widely distributed throughout the watershed. No fish were found in the headwaters of the West Middle Fork and some parts of the East Fork appeared dry or stagnant.

Two separate fish surveys in the spring of 2000 provide additional documentation of cutthroat trout, lamprey, sculpin, and shiners in portions of the Pringle Creek system. A survey conducted by the Oregon Governor's School documented several species of fish, but no salmonids in the summer of 2000 (**Table 9-4**) (City of Salem 2000). In contrast, three adult and one juvenile cutthroat trout were found at the mouth of Clark Creek and one adult cutthroat trout was found in Pringle Creek, upstream of Clark Creek tributary in May of 2000 (**Table 9-5**) (Andrus 2000). All adult trout resided in deep pools just downstream of riffles. During mid-day sampling, the water temperature for Pringle Creek was reported as six degrees warmer than Clark Creek. Sculpins were the dominant fish in each reach (**Table 9-5**). Relative densities of sculpin were highest in the Clark Creek tributary at Bush's Pasture Park and lowest in both Pringle Creek at Bush's Pasture Park and the Fairview Training Center. Cutthroat trout were not found in the West Middle Fork of Pringle Creek that flows through the Fairview Training Center (**Table 9-5**). There were two earlier sightings. In 1997 summer school students at Willamette University found cutthroat near the west bank of Pringle Creek in Bush's Pasture Park. In the fall of 1995, passersby watched salmon spawn under the High Street bridge over Pringle Creek near City Hall.

Table 9-4. Fish Presence and Relative Abundance in Pringle Creek at Bush Pasture Park, 2000.

Name	Total Number
Dace	7
Red Side Shiner	212
Sculpin	10
Crayfish	15
Chiselmouth	1
Unidentifiable Fish	30

Source: City of Salem (2000)

Table 9-5. Fish Presence and Relative Abundance in Pringle Creek at Bush's Pasture Park and Fairview, May 2000.

Stream	Reach	Reach Length (ft.)	# Sculpin	# Cutthroat Trout	# Redside Shiners	# Lamprey	# Dace	# Crawfish
Pringle Cr., Bush Park, downstream of footbridge, west	1	85	19	0	0	1	0	0
Pringle Cr., Bush Park downstream of footbridge, east	2	55	12	0	1	0	0	1
Pringle Cr., Bush Park, upstream of footbridge, west	3	70	15	0	0	1	1	1
Pringle Cr., Bush Park, upstream of Clark Trib., west	4	70	9	1	1	0	0	7
Clark Trib., Bush Park, upstream of Pringle Cr.	5	75	33	4	0	0	0	0
Pringle Trib., Fairview, big bend to bridge	6	232	22	0	10	0	0	3
Pringle Trib., Fairview, bridge to middle school fence	7	447	45	0	25	0	0	8

Source: Andrus (2000)

In the summer of 1996 and spring of 2000, toxic spills resulted in two separate fish kills in Pringle Creek. ODFW surveyed several miles of stream flowing from the Fairview/Hillcrest District to Bush's Pasture Park. The fish species impacted in the 1996 spill included cottids, dace, adult and juvenile lamprey, redside shiners, threespine sticklebacks and crayfish (Hunt 1996). On April 3, 2000, several fish species were reported killed, including nine juvenile steelhead trout (Hunt 2000) (**Table 9-6**). Investigators determined that SumcoUSA (formerly Mitsubishi Silicon America) was the source of both spills. An evaluation reported that on March 29, 2000 groundwater "impacted" by sulfuric acid was inadvertently discharged to the SumcoUSA stormwater retention pond and then released into the West Middle Fork (WMF) of Pringle Creek (MSA 2000). All information compiled for the SumcoUSA evaluation indicates that no acute or chronic impacts to the physical water quality or the biological resources in the WMF Pringle Creek resulted from the sulfate release (MSA 2000). The ODFW survey concluded that based on varying stages of decomposition of the fish bodies, more than one cause for the fish kill was possible. Additional reports about the March 2000 spill speculate that inappropriate pesticide use may have been a factor, since several miles of railroad tracks run parallel to the Middle Fork of Pringle Creek. The railroad right-of-way is sprayed annually for weeds.

Table 9-6. Pringle Creek Fish Carcass Survey for April 3, 2000.

Species Found	Total
Redside shiner	865
Cottid (spp.)	2,533
Speckled dace	62
Large-scaled sucker (adult)	5
Large-scaled sucker (juvenile)	7
Pacific lamprey (adult)	36
Pacific lamprey (ammocoetes)	2,464
Brook lamprey	21
Northern pikeminnow	2
Cutthroat trout	20
Steelhead (juvenile)	9
Hatchery rainbow legals	2
Hatchery rainbow brood trout	2
Crayfish	11

Source: ODFW (2000)

Glenn and Gibson Creeks

The Glenn-Gibson watershed is located on the west slope of the Willamette River. Glenn and Gibson creeks flow through the hilly terrain of West Salem. Gibson Creek flows into Glenn Creek near the Salemtowne Golf Course. Glenn Creek then flows across the Willamette River floodplain through intensively farmed land. ODFW did not locate any chinook or steelhead during the 1999 City of Salem Fish Distribution Survey, but cutthroat trout were found throughout the watershed (**Map 9-2**). Cutthroat trout were more widely distributed in the Glenn-Gibson watershed than the other three watersheds. According to ODFW, sampling prior to the construction of the fish ladder extension at the Salemtowne Pond documented the presence of juvenile winter steelhead in lower Glenn Creek.

Eight sample sites were located on Glenn Creek and its tributaries. Cutthroat trout were observed at all sample sites with the exception of the Michigan Swale tributary, located in the northern portion of the watershed just below Wallace Road (**Map 9-2**). No fish species were found at this location.

Nine sample sites were located on Gibson Creek and its tributaries. Cutthroat trout were observed in the North Fork of Gibson Creek downstream of a pond located near Brush College Brook. Likewise, cutthroat trout were found in South Gibson Creek up to a point just upstream from its confluence with Eagle Crest Swale. The upstream limit of fish species was not determined in this stream. Yet, ODFW assumes that if suitable habitat exists that is not being blocked by a natural barrier, that fish presence/distribution continues upstream. "A conservative method to address this issue is to assume that fish use this area and that it is necessary to protect the upstream habitat" (Taylor, 2002).

Cutthroat trout were observed at both sample sites on Winslow Creek. The upper limit of cutthroat distribution appears to occur at a pond west of the intersection of Orchard Heights Rd. NW and 36th Ave, where the ODFW crew noted splash boards at the outlet of a pond. Through personal communication with local landowners, the crew found that there were perch and bass in the pond. No sampling was conducted in Dahlia Swale, Brush College Swale, or Emerald Swale because of dry conditions at the time of the survey.

Claggett Creek

Claggett Creek flows over flat terrain in east Salem and Keizer. It empties into Clear Lake just west of Wheatland Road and flows into the Willamette River at the north end of Windsor Island. Historical information about the fish community in Claggett Creek is scarce. Several landowners along Claggett Creek do remember fishing for or seeing trout in Claggett Creek when they were kids.

During the 1999 survey, ODFW did not observe any salmon, trout, or lamprey at any sample points in Claggett Creek (**Map 9-3**). ODFW states "Claggett Creek provides habitat to cutthroat trout and very likely seasonal habitat for spring Chinook salmon and winter steelhead as evidenced by previous ODFW sampling efforts (Taylor, 2002). The fish kill of July 1992 resulted in the observation that Labish Ditch provides habitat for cutthroat trout (Taylor, 2002). Unlike the three other sub-basins, three-spine stickleback fish were observed in the 1999 City of Salem Fish Distribution Survey. This species was also documented by McNary High School students from 1993-1996 (**Table 9-7**). Sticklebacks typically prefer slow moving, backwater streams, which allow them to easily establish their nests (Runyon pers. comm.).

Table 9-7. Fish presence and Relative Abundance in Claggett Creek at Dearborn Blvd, 1993-1996.

Species	Total
Dace	3
Pumpkin Seed	3
Shiner	6
Sculpin	5
Mosquito	6
Stickleback	180

Source: McNary High School (1993-1996)

Two additional sample sites in the Claggett Creek watershed were located in Labish Ditch; the first site was located near the ditch's confluence with Claggett Creek and the second site was located just downstream of Portland Road. Redside shiners, sculpin, and speckled dace were the dominant fish species observed. Upstream of Portland Road, the ODFW survey crew noted that the ditch was slow-moving, warm and filled with thigh-deep mud. During the survey, a local resident mentioned historical accounts of trout in this basin. The 1992 fish kill resulted in documentation of cutthroat trout in Labish Ditch (Galovich 2002).

Mill Creek

It is documented that in the late 1970s, Mill Creek had minor runs of winter steelhead and some spring chinook (Mill Creek Watershed Task Force 1983). Cutthroat trout are considered native to the system. According to the drainage study, Mill Creek also contained squawfish, suckers, shiners, dace, cottids (sculpin), and other species. Hatchery-raised rainbow trout from Cascades Gateway Park were also present.

The 1999 City of Salem Fish Distribution Survey sampled points on Mill Creek, the Mill Race, Shelton Ditch, Battle Creek tributaries, and the headwaters of Mill Creek (**Map 9-4**). As for "sensitive" species, the survey crew did find cutthroat trout and lamprey in the tributaries located in the western and upper eastern portions of the watershed. The lower reach of Mill Creek in the City of Salem contains several in-stream structures for salmonids, including rock weirs and large woody debris. The structures were placed in the stream by ODFW and North Salem High School in 1989, 1990 and 1991.

Other fish species found in the lower reaches of Mill Creek at the Summer and Center Street crossings include sculpin, speckled dace, redside shiners, and suckers. The observers reported that the water level was too high to effectively electroshock at this location, so it is possible that some species were missed. ODFW states "The Mill Race currently provides habitat to winter steelhead, summer steelhead, spring Chinook, cutthroat trout and will continue to provide habitat to cold water species in the Mill Race until a screen is constructed at the confluence of the Mill Race and Mill Creek" (Taylor, 2002). The fish screen is planned for the fiscal year of 2003-2004.

The Mill Race is a diversion from Mill Creek that runs through downtown to supply power to Mission Mill located at 14th Street and Mill Street. Sculpin, northern pikeminnow, and redside shiners were recorded at this sample site.

Shelton Ditch is another waterway that diverts water from Mill Creek into Pringle Creek. Sculpin, redside shiners, dace, and suckers were observed at two sample sites along the Ditch.

Battle Creek is a major tributary to Mill Creek. Cutthroat trout were observed at all sample sites along the mainstem of Battle Creek. Dace, suckers and shiners were observed where Commercial Street crosses Battle Creek. Sculpin and pumpkinseed sunfish were located at Rees Hill Road and Elmhurst Ave. In the Powell Creek tributary, trout were observed in the lowest reach, located downstream of Sunnyside

Road, while sculpin and crayfish occupied the upper reach of this creek. Cutthroat trout, lamprey, sculpin and crayfish were observed at sample points downstream of the Liberty Road culvert in Jory Creek. Sculpin was the only species observed upstream from the Liberty Road culvert in Jory Creek. In the Waln Creek tributary, cutthroat trout and sculpin were found at the Lone Oak Road and Liberty Road sites. No fish species were recorded above the Liberty Road culvert crossing in this tributary. Crew observations indicate that undesirable fish habitat in Waln Creek may account for the lack of fish observed upstream from this road crossing.

The crew surveyed the headwaters of Mill Creek, located north and west of Stayton, to determine the upstream limits of salmonids. In both the North and South Forks, cutthroat trout were observed within a few kilometers of the headwaters. It is interesting to note that an unidentified trout species and a giant pacific salamander were also found in the North Fork.

Fall Chinook

Historically, ODFW artificially reared and stocked fall chinook in the Mill Creek system. Fall chinook were first introduced in Mill Creek in 1968 when 1.7 million were released from Cascades Gateway Pond where they had been artificially reared (Mill Creek Watershed Task Force 1983). The first adult return in 1970 was estimated at 3,075 fish. From 1970 to 1979 approximately 51,139 fish returned to Mill Creek. A peak of 10,873 adult fish was reached in Mill Creek in 1975, with a ten-year average of 5,114 fish. The 1982 Mill Creek Drainage Study reports that since fall chinook releases were shifted to larger tributaries of the Willamette River, the Mill Creek run reported 1,000 fish or less.

A subsequent study conducted from 1970 to 1994 indicates that fall chinook redd counts were highest in 1975 and lowest in 1990 (**Table 9-8**) (ODFW 1995). For some years the data is not categorized by stream reach in **Table 9-8**. For example, from 1977-1983 data was compiled at a stream level rather than a reach level, with the exception of Shelton Ditch.

Because the presence of fall chinook in Mill Creek is the result of a hatchery program, declining returns are the direct result of fewer fish stocked and the subsequent termination of the program in 1995. Fall chinook are apparently unable to sustain themselves in any large numbers through natural production in Mill Creek due to poor habitat and water quality (Galovich pers. comm). Fall chinook were never stocked in the Shelton Ditch, but apparently utilized it for spawning grounds after using it as a downstream migration route. Because fall chinook were introduced, they are not protected under the ESA.

In October 1999, ODFW conducted fall chinook spawning surveys on Mill Creek. No live chinook, carcasses, or redds were observed from the mouth of Mill Creek up to the Shelton Ditch diversion. However, the surveyors did note potentially good habitat in this stream reach. The report indicates a diversity of in-stream habitat (i.e., deep pools, scour along the margins, gravel and cobble riffles, although the stream gravel near the penitentiary was highly embedded with silt and sand), adequate riparian cover and no passage problems other than the ladder at the Duck Inn. These habitat features suggest good holding and hiding habitat for salmonids (ODFW 1999). Trout and a variety of non-game species were also recorded in this reach. As part of the same survey, two fish biologists floated from Turner bridge (located 1/3 mile south of Kuebler Road) downstream to the Willamette River and surveyed approximately six miles of stream. Two redds were found on a gravel bar in the reach between Turner bridge and the Shelton Ditch diversion near I-5.

Table 9-8. Summary of Fall Chinook Redd Counts in Mill Creek, 1970-1994.

	River Miles	**Total Miles**
Site 1: Shelton Ditch	0.0-3.2	**3.2**
Site 2: Mouth to 19th St. Bridge	0.0-2.2	**2.2**
Site 3: 19th St. Bridge to Cascades Gateway Park Bridge	2.2-4.8	**2.6**
Site 4: Cascades Gateway Park Bridge to Turner Fire Station Bridge	4.8-10.3	**5.5**
Site 5: Turner Fire Station Bridge to Aumsville Park Bridge	10.3-15.4	**5.1**
Site 6: Aumsville Park Bridge to Junction of North Santiam River (Mill Creek joins the N. Santiam via the Salem Ditch)	15.4-22.0	**6.6**
Total:		**25.2**

Year[1]	**Site 1**[2]	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 6**	**Total**
1970[3]							**961**
1971							**600**
1972	186	119	180	462	366	41	**1,354**
1973							**1,992**
1974							**1,990**
1975							**2,819**
1976							**1,656**
1977	265						**1,410**
1978	230						**1,261**
1979	87						**305**
1980	133						**214**
1981	247						**357**
1982	137						**183**
1983	126						**173**
1984	304	*[4]	42	31	*	*	**377**
1985	*	*	*	*	*	*	*
1986	209	*	80	73	0	4	**366**
1987	61	*	70	16	8	2	**157**
1988	47	*	50	136	159	*	**392**
1989	38	*	130	31	15	*	**214**
1990							**105**
1991	83	*	44	72	38	*	**237**
1992	155	*	81	152	175	*	**563**
1993	144	*	77	186	273	*	**680**
1994	22	*	27	79	91	*	**219**
Total	**2,474**	**119**	**781**	**1,238**	**1,125**	**47**	**18,585**

[1] Counts given by stream reach for: 1972, 1984, 1986-1989 and 1991-1994. All other years only give total count for Mill Creek up to its confluence with the North Santiam River.
[2] Shelton Ditch counts kept separate but included in totals for 1972 and 1977-1983.
[3] 1970 was the first year of adult returns.
[4] * Indicates no surveys were conducted along reach.
Source: ODFW (1995)

Carcass Surveys

In the fall of 1989 Mill Creek experienced a gasoline spill west of the Kuebler Boulevard Mill Creek crossing, downstream from the dam site. Reports indicate a pipeline was ruptured at a construction site, spilling gasoline into the creek. The Oregon Department of Fish and Wildlife's initial assessment estimated a complete kill of all aquatic life along a seven-mile reach of Mill Creek and three miles of Shelton Ditch. The fish mortalities totaled over 400 fall chinook, 200-300 juvenile trout/steelhead and numerous non-game species (Wetherbee 1989).

In spring of 1991, the Deluxe Quality Ice Cream Company was responsible for ammonia vapor entering into a city storm drain. A carcass survey along 2.1 miles of Mill Creek resulted in a count of 75 dead salmonids (ODFW 1991). Two thirds of those species were approximately six to ten inch rainbow and steelhead trout (**Table 9-9**).

When a fish kill occurs along a waterway, ODFW staff survey selected sites in the affected area and count dead fish by species. The sampling totals are multiplied according to a formula to estimate total fish kill impacts for the waterbody.

Table 9-9. Mill Creek Fish Kill Assessment, April 1 and 2, 1991.

Sample Site	Distance/ft.	Cutthroat	Rainbow/ Steelhead	Chinook	CSU	SQ	Red Shiners	CRC	Dace
Mouth to Front St.	280'	0	1	0	61	0	0	16	0
Liberty St.	250'	0	0	0	21	0	1	0	0
Church St.	100'	0	0	0	2	0	0	0	0
Cottage St.	100'	0	0	0	12	0	0	0	0
Winter to Capitol St.	900'	0	3	2	108	5	11	1	20
14th St. to RR	900'	0	1	0	19	1	7	0	4
Chemeketa St.	75'	0	1	0	13	0	0	0	0
18th St.	130'	0	1	1	10	4	17	0	0
Center St.	250'	2	5	2	68	35	70	0	25
Court St.	100'	0	2	0	13	3	30	0	0
Totals	3,085'	2	14	5	327	48	136	17	49
Expanded Totals	11,088'	7	50	18	1,175	172	489	61	176

Source: ODFW (1991)

Barriers to Fish Passage and Notes on Fish Habitat

Structures or conditions that obstruct, interfere with or harm migrating fish are classified as fish passage barriers. A basin-wide migration barrier survey is important since adult and juvenile migrating salmon and other fish move extensively upstream and downstream to seek food, shelter, better water quality, and spawning habitat. Fish passage problems in the Mid-Willamette include: (1) culvert barriers at road crossings; (2) delay or poor function at fish ladders; (3) dams, other impoundment or water control structures without fish ladders; (4) sections of stream that have been piped or put underground; and (5) unfavorable water quality or other habitat conditions.

Structures can create a migration barrier for fish in a variety of ways. First, a culvert can increase water velocities so that the current is too fast for the fish to overcome. Second, the water depth in a culvert may be too low to provide a sufficient swimming depth for fish. In addition, the height between culvert outlet and water surface may be too great a distance, making it impossible for a fish to jump from the stream into the culvert and continue swimming upstream. Another barrier to fish passage are shallow pools at the base of the culvert that do not give fish room to maneuver and jump. Note, any of these factors listed may not be a barrier to adults while they are barriers to juveniles (Fromm, 2003).

As of March 16, 1999, the National Marine Fisheries Service (NMFS) designated spring chinook and winter steelhead as threatened under the Endangered Species Act (ESA). ESA section 4 (d) rules covering threatened salmon in the upper Willamette were adopted in July 2000. The 4(d) rules took effect on September 9, 2000 for winter steelhead and January 9, 2001 for spring chinook (City of Salem 2001). The 4(d) rule expands the protective shield, making it illegal for individuals, businesses and the local and state governments that regulate them to kill or hurt salmon or steelhead, or to harm important salmonid habitat (see sidebar). Because violations of "take" prohibitions may result in civil or criminal penalties, Marion County and the City of Salem initiated independent surveys to assess structures and conditions on fish-sensitive streams that may prevent proper fish passage. The Marion County survey primarily evaluated road crossings along public rights-of-way, thus excluding infrastructure such as private roads and dams. The City of Salem's Fish Passage Survey included both public and private facilities. Culvert inventory maps for Pringle, Glenn-Gibson, Claggett, and Mill Creek basins are used to identify which structures are not "fish-friendly."

***4(d)rule**: This rule prohibits anyone from "taking" a listed salmon or steelhead, except in cases where the "take" is associated with an approved program (NMFS 2000).*

*To **"take"** means to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect" the listed species.*

*To **"harm**" means modifying or degrading habitat where it actually kills or injures a protected species by significantly impairing its ability to breed, spawn, rear, migrate, feed, or shelter.*

Methods

Data was collected and/or compiled by the City of Salem, ODFW, and Marion County. Both Marion County and the City of Salem incorporated ODFW guidelines to develop their own set of criteria. ODFW classified culverts as either high, medium, or low priority for repair based on whether a culvert was a "partial or complete barrier, the fish species impacted, and the quality/amount of habitat upstream from the culvert." (Thorburn pers. comm.). Data collected using ODFW guidelines includes culvert location, size, height of outlet drop, culvert slope, type of culvert, priority level and specific comments for some sites. As a result of the culvert survey, Marion County prioritized culverts on a county-wide scale for replacement or retrofit to improve fish passage. It is important to recognize that the area surveyed influences the priority ranking. While Marion County may rank specific culverts as lower priorities, the City of Salem may rate these same culverts as high priority projects their city limits (Galovich 2002).

City of Salem Fish Passage Survey

In 2001, the City of Salem conducted a fish passage survey within the urban growth boundary (City of Salem 2001). The citywide fish passage survey studied 167 culverts, 60 dams/weirs and 46 bridges. Approximately 40% of the culverts and 77% of the dams/weirs were found to be barriers. No bridges were determined to be barriers (**Table 9-10**). The survey included both public and private facilities.

Table 9-10. Summary of Results for Fish Passage Survey

	Culverts				Bridges				Dams			
Basin	Total	Passable	Juvenile Barriers	Adult & Juvenile Barriers	Total	Passable	Juvenile Barriers	Adult & Juvenile Barriers	Total	Passable	Juvenile Barriers	Adult & Juvenile Barriers
Pringle Creek	73	38	7	28	14	14	0	0	31	5	2	24
Mill Creek	0	0	0	0	41	41	0	0	5	3	1	1
Battle Creek	28	20	1	7	3	3	0	0	2	0	0	2
Glenn/Gibson	31	22	3	6	2	2	0	0	12	0	0	12
Croisan	18	11	1	6	2	2	0	0	6	0	0	6
Pettyjohn	8	3	2	3	0	0	0	0	0	0	0	0
Upper Claggett	7	4	2	1	2	2	0	0	0	0	0	0
Little Pudding	4	3	0	1	0	0	0	0	0	0	0	0

Source: City of Salem (2001).

The City also collected some general information on habitat during the fish passage survey. Information on fish habitat was rated using a scale developed from Clackamas County habitat descriptions. The scale ranges from **0** (highly developed) to **10** (pristine). The detailed habitat descriptions are as follows.

1. **0-1 Habitat**. Highly degraded habitat: concrete streambed or bank, no riparian corridor, high sedimentation in creek bed, no gravel evident. Invasive species, if present, dominate stream bank vegetation, little to no fish cover or protection, little to no shading of creek. Highly landscaped or unnatural stream banks (lawn and unnatural vegetation) will not qualify as valuable riparian corridor.

2. **2-5 Habitat**. Degraded habitat: sparse riparian corridor, non-native or invasive vegetation present (blackberry, teasel, Scotch Broom), light shading of creek and little fish protection. Sedimentation evident in streambed, but some gravel is evident.

3. **5-8 Habitat**. Average to good habitat: riparian corridor consists of some mature trees, some native, and some non-native. Shading from trees partially keeps invasive vegetation out of riparian corridor. Sedimentation is evident, but about equals the clean gravel in streambed. Development outside of a 50-foot buffer of creek banks.

4. **8-9 Habitat**. High quality habitat: strong riparian corridor consists of mostly mature trees and shrubs, with very little invasive species in corridor. Creek about 80 percent shaded by mature trees, very little sedimentation, much clean gravel. Development impacts outside of a 100-foot buffer zone.

5. **10 Habitat**. Very high quality habitat: basically undisturbed. Riparian corridor consists only of mature trees and shrubs, no invasive species present. No sedimentation evident in creek-bed and creek is 90 percent + shaded. Development impacts outside of a 200-foot buffer.

Information collected during this survey is only a rough estimate of habitat quality. This information will be used in conjunction with other more intensive surveys to evaluate fish habitat throughout Salem's drainage basins. This information will be used to prioritize the removal and/or replacement of fish passage barriers in key areas (Mauldin pers. comm.).

Watershed Summaries of Fish Presence and Fish Habitat Conditions

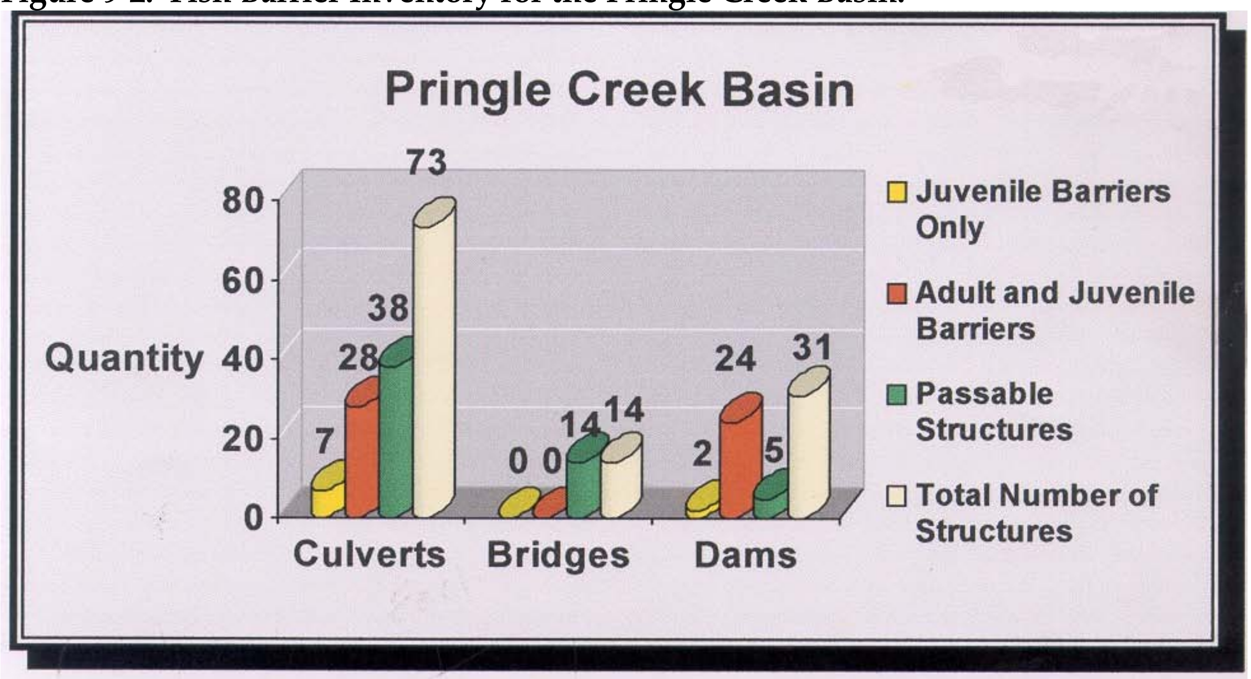
Barriers to fish passage and associated fish habitat are summarized by watershed below. Information provided is from several sources including City of Salem, Marion County Public Works and ODFW.

Pringle Creek

Barriers

The Pringle Creek watershed, which lies entirely within Salem's urban growth boundary, includes over ten miles of waterways. According to the City of Salem's Fish Passage Survey, 48% of the 73 culverts surveyed were classified as barriers. Thirty-one dams/weirs were surveyed, of which 77% were found to be barriers. No bridges surveyed were classified as barriers (**Figure 9-2**). The identified barriers for the Pringle Creek basin are shown on **Map 9-5**. Culverts that serve as barriers to adult and juvenile fish are located at the mouth of Clark Creek, along the Middle Fork of Pringle Creek and at the confluence of the East Fork of Pringle Creek. The main stem of Pringle Creek appears free of barriers until the street crossing north of Madrona. The city survey crew noted that rock has been placed in the creek at this location, which creates a barrier to all fish, except perhaps during high flow conditions.

Figure 9-2. Fish Barrier Inventory for the Pringle Creek Basin.



Source: City of Salem (2001).

Fish barrier information for Pringle Creek was also collected during the 1999 City of Salem Fish Distribution Survey. The crew noted a small impassable barrier downstream from the Commercial Street Bridge, which they suggest is an upstream migration barrier for cutthroat trout. In the Clark Creek tributary the survey crew noted that the long, steep culvert under Commercial Street appeared to be a fish passage barrier for all fish species. In the East Fork Pringle Creek tributary, the crew did observe check dams (water or grade control structures) right below the Kuebler Blvd. crossing, which may effect upstream migration for salmon and trout.

Habitat

While conducting the 2001 survey, the city crew evaluated habitat adjacent to culverts in the Pringle Creek watershed (**Table 9-11**). According to this survey, a significant portion of the Clark Creek basin has been channelized and covered as an underground waterway for hydraulic purposes. The free-flowing areas have some areas of good cover and creek bed habitat. Much of this creek is small, has relatively low flows, and may not be suitable for significant adult fish populations (City of Salem 2001).

Pringle Creek aquatic habitat conditions vary. The upper reaches are mainly developed and received a lower rating. There is spawning and year-round rearing habitat for cutthroat in upper Pringle Creek. The downstream areas near Bush's Pasture Park has good quality habitat (City of Salem 2001).

Table 9-11. Habitat Evaluation on Sections of Pringle Creek.

Habitat	Location / Rating Range	Notes
Clark Creek	Convergence of Clark/Pringle: 2.5 or less	Much of this area is channelized, has little cover, and poor streambed quality. Residential areas influence the waterway.
	Hoyt Street to 12th Street:: 5	Relatively good habitat.
	12th Street to 13th Street: 3	Little canopy.
	Upstream until Summer Street:: 3.5 to 4	Some good cover, though much of this creek bed has an unnatural channelized bottom.
	Above Summer Street:: 2 to 2.5	Habitat is poor. It's steep and rocky and sections are channelized.
	Upper part of the waterway: 2.5 to 3.5	The pristine nature of the creek had been altered due to residential development.
Pringle Creek	Mouth of the Willamette to railroad: 4.5 to 6	Significant flow, some canopy cover, most of creek bed graveled.
	As creek parallels railroad tracks: 2.5 to 3.5	Canopy cover decreases, invasive species increase.
	As creek leaves railroad tracks: 3 to 4.5	Canopy increases, areas of better habitat.
	Upstream of Commercial Street:: 2 to 3.5	Development and channeling of waterway increases.
	Woodmansee Park: 4	Only this area had a rating higher than 4.
West Middle Fork Pringle Creek	Upstream from RR to Strong Rd.: 3 to 3.5	Channelized and canopy is light.
	Above Strong Rd. to Battle Cr. Rd.: 3.5 to 4	Flow becomes light, nutria in dams back up water and create pools for aquatic life and passage barrier. Some canopy and fish cover.
	Above Battle Creek Road: 2.5	Less favorable due to lack of cover and low flows.
Middle Fork Pringle Creek	Area parallel to railroad tracks: 2.5 to 3.5	Channelized waterway with significant infestation of non-native brush. Creek canopy is limited. Flow is reduced due to culvert blockage.
East Fork Pringle Creek	Oxford Street to McGilchrist St.: 4 to 4.5	Some canopy and good streambed gravel.
	Above McGilchrist St. to RR tracks: 3 to 4	Cover is limited.
	Upstream to I-5: 2.5 to 3	Habitat is poor due to channelization, lack of canopy, and invasive brush.
	Above I-5: 2 to 3	Little cover, canopy, or flow. Appears to have low fish habitat quality.

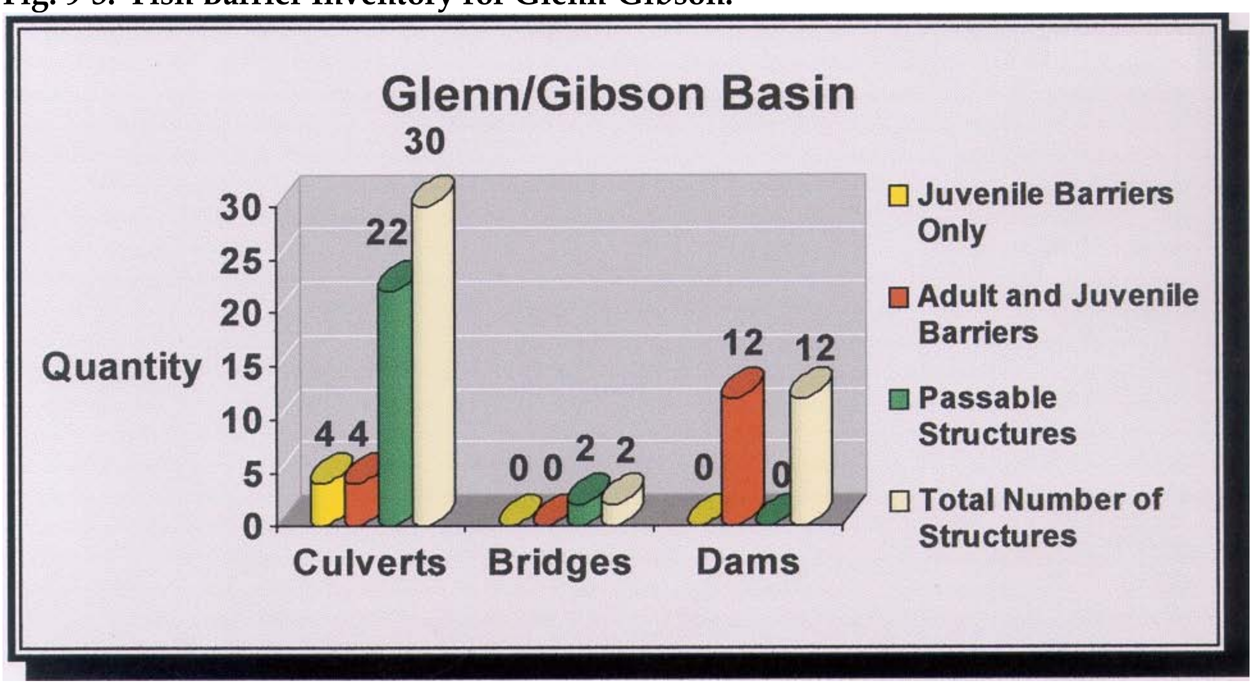
Source: City of Salem (2001)

Glenn and Gibson Creeks

Barriers

The Glenn-Gibson watershed includes over nine miles of waterways within the Salem urban growth boundary. Thirty culverts were surveyed in the Glenn-Gibson basin, of which 27% were classified as barriers. All twelve dams/weirs surveyed were classified as barriers. The two bridges surveyed were classified as passable by fish (**Figure 9-3**). The identified barriers for the Glenn-Gibson basin (south) are shown on **Map 9-6.** Culverts that serve as barriers to adult and juvenile fish are found towards the headwaters of Glenn Creek and on the Turnage Brook tributary entering into the Willamette River. Barriers caused by dams and weirs are found in several places along the main stem of Glenn Creek.

Fig. 9-3. Fish Barrier Inventory for Glenn-Gibson.



Source: City of Salem (2001)

The identified barriers for the Glenn-Gibson basin (north) are shown on **Map 9-7**. Gibson Creek does not appear to have many fish passage barriers. Fish barriers impassable by both adults and juveniles are found at the mouth of Willark Brook.

Fish barrier information in the Glenn-Gibson basin was also reported in the 1999 City of Salem Fish Distribution Survey. In the Michigan Swale tributary, the crew noted a stand pipe located approximately 0.2 miles upstream from the main stem of Glenn Creek. No fish were found at this site. Along the Winslow Creek tributary, the surveyors observed splash boards at the outlet of the pond that may be a possible upstream barrier.

Neither the Fish Passage Survey nor 1999 City of Salem Fish Distribution Survey mention the barrier attributed to the Salemtowne pond, located where the mouth of Gibson Creek enters Glenn Creek. A fish ladder was installed to help aid adult fish passage. According to ODFW, the ladder is functioning as designed. It is intended to provide passage only for adult trout, not juvenile fish, during high flow. In other words, the ladder was designed for upstream migration of trout in fall, winter and spring. To bring the ladder up to the standard that would allow for juvenile passage entails much more work in and below the existing ladder to reduce the approach and jump heights (Galovich pers. comm.). This would add significant cost and affect downstream habitat, since it would require removing mature vegetation cover and disturbing in-stream habitat and channel stability. ODFW has documented adult cutthroat at and above the ladder and juvenile steelhead were documented in lower Glenn Creek prior to the construction of the ladder.

Habitat

Whil e conducting the 2001 Fish Passage Survey, the city crew evaluated habitat adjacent to culverts in the Glenn-Gibson basin (**Table 9-12**). Glenn Creek travels through agricultural land with several irrigation diversions as it flows onto the Willamette River floodplain. This pattern of use can alter stream flows and affect habitat quality in the lower reaches of Glenn Creek. Overall, Gibson Creek has some good canopy and good fish cover (City of Salem 2001).

Table 9-12. Habitat Evaluation on Sections of Glenn and Gibson Creeks.

Habitat	Location / Rating Range	Notes
Glenn Creek	Upstream of Wallace Rd. to Glenn Creek Rd: 4 to 5.5	Some canopy and fish cover.
	Above Glenn Creek Rd: 3 to 4	Decrease in flows, canopy and fish cover.
Gibson Creek	Salem urban growth boundary to Doaks Ferry Road: 4.5 to 6	Some good canopy and good fish cover.
	Above this area: 3 to 4	Flow decreases.

Source: City of Salem (2001)

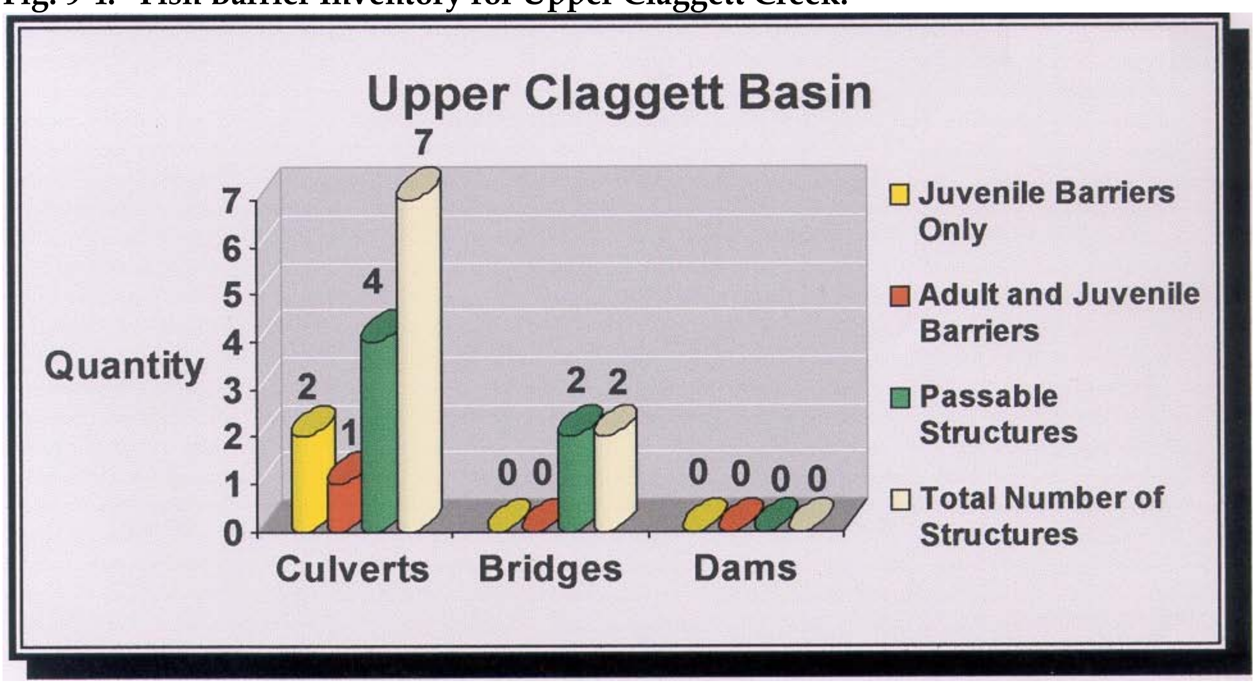
Additional habitat data was provided by ODFW at a Glenn-Gibson Watershed Council meeting in August of 2001. According to ODFW, Glenn and Gibson Creeks are good cutthroat trout habitat, but the creeks do not provide adequate spawning grounds for chinook or steelhead due to shallow water and a lack of gravels in the stream. However, juvenile steelhead do use the lower reaches of Glenn Creek for winter refuge and rearing. It is probable that juvenile chinook also use the lower reach of Glenn Creek for the same purposes. Since chinook and steelhead use this system only as seasonal rearing, rather than spawning habitat, juvenile fish would be less likely to migrate up into those areas. Gradient appears to be somewhat of a deterrent to juvenile upstream migration (Galovich, 2002).

<u>Claggett Creek</u>

Barriers

The City of Salem's Fish Passage Survey focused on the upper Claggett Creek basin from Salem Parkway to Fisher Road. The total drainage area for Claggett Creek is approximately twenty miles and the upper Claggett basin includes 8.1 miles of waterways within the City of Salem's urban growth boundary. The survey was performed approximately on the lower two miles of the upper portion of Claggett Creek. No survey information was collected for Claggett Creek within Keizer city limits. The crew found few culverts, dams, and bridges to survey (**Figure 9-4**). The barriers identified for the Upper Claggett basin are shown on **Map 9-8**. Three culverts were classified as barriers.

Fig. 9-4. Fish Barrier Inventory for Upper Claggett Creek.



Source: City of Salem (2001)

Habitat

While conducting the 2001 Fish Passage Survey, the city crew evaluated habitat adjacent to culverts in the Claggett Creek basin (**Table 9-13**). Upper Claggett Creek is a small drainageway with very low flows during dry periods. Stagnant creek flows are typical in Claggett Creek, which suggest poor habitat for most fish (City of Salem 2001). Although canopy cover is good in some areas, the low flows, predominance of silty areas and turbid, stagnant water probably make the upper reaches of Claggett Creek marginal habitat for some species of fish. It is not necessarily marginal for seasonal rearing of juvenile chinook and steelhead (Galovich 2002).

Table 9-13. Habitat Evaluation on Sections of Claggett Creek

Habitat	Location / Rating
Upper Claggett Creek Basin	Claggett Creek at Candlewood Drive: 1.5
	Claggett Creek at Southern Pacific RR, near Wayside Terrace: 2.5
	Claggett Creek at Portland Rd: 1
	Claggett Creek at Deer Haven Drive: 3

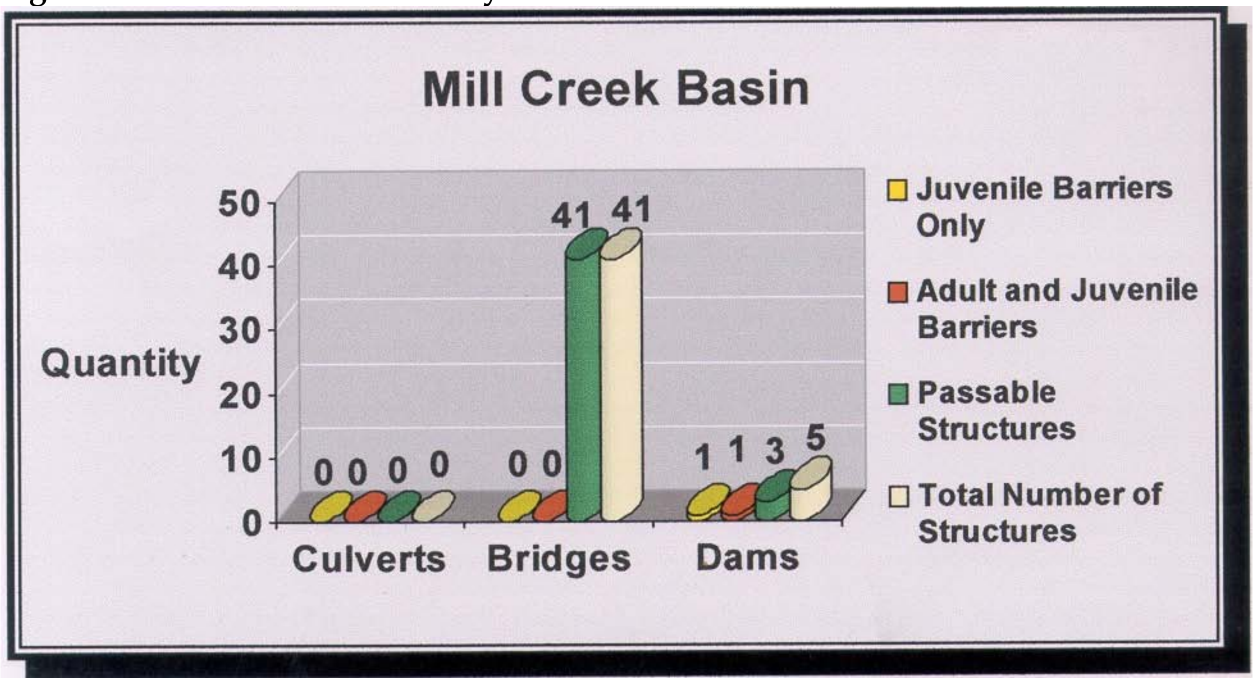
Source: City of Salem (2001)

Mill Creek

Barriers

Mill Creek basin includes over 10 miles of waterways within the city's boundaries. It enters Salem's UGB from the southeast and flows through downtown Salem until it enters the Willamette River. Mill Creek is culvert-free through town. The crew surveyed 41 bridges and five dams (**Figure 9-5**). Two of the dams/weirs appeared to be barriers (**Map 9-9** and **Map 9-10**). The City of Salem budgeted in Fiscal Year 2001/2002 for the reconstruction of the fish ladder at Waller Dam, whose current waterfall length appears to be too high for juveniles to pass upstream.

Figure 9-5. Fish Barrier Inventory for Mill Creek

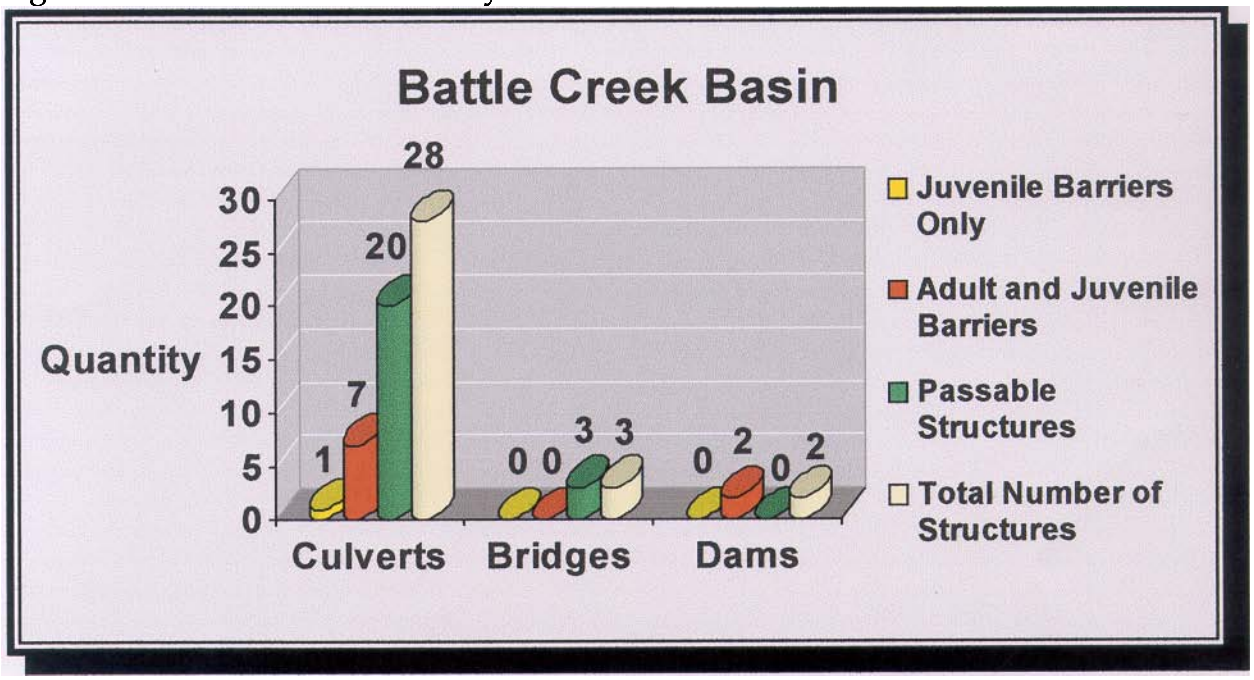


Source: City of Salem (2001)

The second barrier near Kuebler Blvd. is an irrigation dam with another fish ladder. This was an adult and juvenile barrier due to jump height and lack of pool depth. The survey indicates that many adult fish may not be able to clear the waterfall. During the growing season, the Santiam Water Control District (SWCD) operates the irrigation dam. The SWCD has the irrigation dam in place from April/ early May to the end of September/early October (Trosi pers. comm.). The City of Salem recommends that the ladders located at both dams should receive further study (Mauldin pers. comm.). Ultimately, it would be the SWCD's responsibility to have the fish ladder at their irrigation diversion evaluated for adequate passage.

Battle Creek is a tributary to Mill Creek. The Battle Creek basin includes over 7.5 miles of waterways within the Salem urban growth boundary, including the tributaries of Waln, Jory and Powe1l Creeks. According to the survey, all dams and 29% of the culverts are fish barriers (**Figure 9-6**). Two passage barriers to Battle Creek were observed near I-5. (**Map 9-11**). No barriers were found on the Jory Creek passage. Weir barriers were identified near the downstream end of the Waln Creek tributary and on the Sunnyside Road crossing at Powell Creek.

Figure 9-6. Fish Barrier Inventory for Battle Creek



Source: City of Salem (2001)

ODFW noted a fish passage barrier at the confluence of the Mill Race and Pringle Creek while conducting the 1999 City of Salem Fish Distribution Survey (City of Salem 1999). No barriers or fish screens were present on the upstream end of the Race at the time of the survey, thus indicating that fish could access the Mill Race from Mill Creek. A recent article indicates that there are many obstacles to safe fish passage on the Mill Race, including the turbine at Mission Mill and piping that leads to the final concrete drop into Pringle Creek (Geniesse 2000). ODFW has recommended that the Mill Race be screened to prevent fish from accessing the system (Galovich pers. comm.). The City of Salem has also proposed screening the Mill Race. The project is scheduled for 2003 (Downs pers. comm.).

ODFW noted a private pond on Powell Creek upstream from Elkins Way while conducting the Fish Distribution Survey in 1999. They observed a two-plus meter drop that would most likely be an upstream migration barrier for all species at this location. Additional observations were made in the Waln Creek tributary at Liberty Road. The crew reported the Liberty Road culvert does not appear to be an upstream migration barrier and attributed passage problems to undesirable habitat conditions.

Marion County consulted with ODFW to identify and prioritize culvert barriers in the Mill Creek watershed. ODFW rated all the culverts in Marion County as either medium or low priority based on criteria discussed in the Methods section of this chapter. In March and April 1999, the Pavement Management section inspected all the culverts in Marion County earlier identified as medium priority and field-verified all the ODFW data (**Map 9-12**). Of the 17 culverts surveyed in the Mill Creek basin, six priority culverts in Battle, McKinney, and Simpson Creek sub-basins were identified

(**Table 9-14**). Since outlet jump is the most obvious constraint to fish passage, **Table 9-14** is sorted according to the jump at the outlet. Suitable jump heights vary among salmonid species and between adults and juveniles. Six inches or less is recommended for trout and juvenile anadromous species. ODFW recommends jumps of 12 inches or less for adult salmon.

Marion County Public Works has replaced two 0f six priority culverts as of April 2003. (Thorburn pers. comm.). Additional culvert repairs include clearing out debris at the outlet or the inlet, creating deeper outlet pools and fixing fences that collect debris in the channel **(Maps 9-13 to 9-17)**.

Habitat

While conducting the 2001 Fish Passage Survey, the city crew evaluated habitat adjacent to culverts in the Mill Creek Basin (**Table 9-15**). Habitat in Mill Creek, from its mouth at the Willamette River up to 21st Street, received a good rating. Shelton Ditch scored relatively well for providing adequate shade and flow. Canopy and fish cover varied for Battle, Waln and Powell Creeks. Flows in Waln Creek above Lone Oak Road, and in Powell Creek above Sunnyside Road, appear to be too low to support significant populations of fish (City of Salem 2001).

Table 14. Priority Culverts in Mill Creek Watershed, Marion County, OR.[1,2]

Priority #	Road Name	Named Body	OFFSET Inlet (ft)	OFFSET Outlet (ft)	Rise/Height (in)	Span/Width (in)	Length (ft)	Cover Depth (ft)	Slope(%)	Skew(^{0})	Shape X-sec	# of Culverts	Condition	Date Insp.	Comments	STREAM SLOPE Inlet (0)	STREAM SLOPE Outlet (0)	OUTLET POOL Length (ft)	OUTLET POOL Depth (in)	Drop to Pool (in)	Desc. Baffl
2	SUNNYSIDE RD	BATTLE CK	4	10	7	44	62	3	1.0	0	Arch	1	G-Good	4/7/99	N/C	1	3	6	10	**12**	SMALL ROCKS
					*	-	200	*	same as stream	-	-	-	-	-		*	*	*	10	**6**	-
4	BROWNELL RD	SIMPSON CK	17	10	48	48	51	5	0.5	5	Circular	1	G-Good	4/8/99	GPS OUTLET/CL	2	3	12	24	6	INVISIBLE
					*	-	200	*	0.5	-	-	-	-	-		*	*	*	12	6	-
5	SIMPSON RD	UNNAMED	11	7	48	48	37	2	0.5	5	Circular	1	G-Good	4/8/99	**INLET BLOCKED BY FENCE ETC**	2	3	20	24	0	INVISIBLE
					*	-	200	*	0.5	-	-	-	-	-		*	*	*	10	6	-
6	SHERMAN RD	UNNAMED	11	15	36	36	66	1	0.3	30	Circular	2	G-Good	4/8/99	**OUTLET BLOCKED BY FENCE**	3	3	5	12	**12**	ROCKS
					*	-	200	*	0.5	-	-	-	-	-		*	*	*	10	**6**	-
13	PARRISH GAP RD	RODGERS CK	9	4	40	40	37	2	**2.0**	5	Circular	2	G-Good	4/9/99	**INLET BLOCKED BY FENCE/DEBRIS ROCKS BLOCK OUTLET**	4	5	6	**6**	0	ROCKS/SAND
					*	-	200	*	**0.5**	-	-	-	-	-		*	*	*	**10**	6	-
20	HUNSACKER RD	MCKINNEY CK	8	8	48	48	39	3	**2.0**	0	Circular	1	P-Poor	4/9/99	ADDITIONAL JUMP 20FT UPSTREAM	4	3	20	24	0	INVISIBLE
					*	-	200	*	**0.5**	-	-	-	-	-		*	*	*	10	6	-

Source: Marion County Public Works Culvert Survey (1999).

[1] Table modified from original version. ODFW classified culverts as either **high, medium, or low priority** for repair based on whether a culvert was a "partial or complete barrier, the fish species impacted, and the quality/amount of habitat upstream from the culvert." Because the outlet jump is the most obvious constraint to fish passage, Table 10 is sorted according to the jump at the outlet.

[2] Numbers in **bold** represent culverts that do not follow the specifications for adequate fish passage.

Un-shaded rows show existing conditions. Shaded rows indicate desired conditions or conditions that would be necessary for safe fish passage.

Table 9-15. Habitat Evaluation on Sections of Mill Creek

Habitat	Location / Rating Range	Notes
Shelton Ditch	Shelton Ditch at Kettle Ct.: 3.5 Shelton Ditch at 17th. Street:: 4 Shelton Ditch at Winter St.: 4.5 Shelton Ditch at 12th Street;: 5	High flows and substantial canopy. Over the years its width has grown, contributing to past erosion problems.
Mill Creek	Willamette River to 21st Street::4 to 6	Some canopy, significant flows and mostly developed.
	Above 21st Street:: 3 to 4	Flows and amount of canopy decrease.
	Mission St. to Kuebler Blvd: 4 to 5	Canopy increases, development decreases and habitat quality increases.
	Above Kuebler Blvd.: 3.5 to 4	Creek widens with little cover and lower flows and habitat values.
Battle Creek	Salem UGB to Fairway Ave.:4 to 5.5	Some good canopy, channelized with little fish cover and turbid, silty water.
	Above Fairway Ave.: 3.5	Sparse creek canopy or fish cover.
Waln Creek	Battle Creek Golf Course: 2.5 to 3	Channelized , little canopy or fish cover.
	Upstream at Wiltsey Road: 3.5 to 4.5	Canopy increases, fish cover improves.
Powell Creek	Below 13th Ave.: 3 or below	Channelized, little canopy cover.
	Above this area: 3.5 to 5	More canopy or fish cover.

Source: City of Salem (2001)

Wildlife And Plants

The Oregon Natural Heritage Program has assembled records of rare, threatened and endangered plant and animals located in the four watersheds (Kagan et al. 2000). Sixteen different species currently have either state or federal listing status (**Table 9-16**).

Table 9-16. Summary of Federally and State Listed Plant and Animal Species that Historically or Currently Exist in Salem Area Watersheds.

Common Name	Location	Habitat Information	Population Status	ODFW Status	USFWS Status	Notes
Bald Eagle	W. of Windsor Island		Breeding site	Listed threatened	Listed threatened	1998 nesting failure
Oregon Spotted Frog	Aumsville, along Mill Creek	Low, emergent marsh	One female collected	Sensitive critical	Candidate	Last collected in 1937
Painted turtle	Mill Creek near Salem	Privately owned		Sensitive critical		Species recorded by Alan St. John in 1984.
	Finney-Eagan Lake	Privately owned	In 1991 one turtle observed; 1988 three turtles observed; 1963 75 turtles observed	Sensitive critical		Species observed by Lyle Wilhemi. Source: Charlie Bruce, ODFW.
Northwestern Pond Turtle	Finney-Eagan Lake	Oxbow Lake	In 1993 one turtle observed; 1991 one turtle observed	Sensitive critical	Species of concern	Source: Holland, D.C. 1994. Draft Report on the Western Pond Turtle Project. Unpubl. Rept. For ODFW.
Oregon Giant Earthworm	At or near Salem	Privately owned	Single specimen collected in 1903		Species of concern	
Bradshaw's Lomatium	Salem	Dry soil on riverbank, managed area on Willamette River Greenway		Listed endangered	Listed endangered	Source: USFWS Endangered Species Herbarium Card File. ca. 1979. Assumed extirpated.
	Sublimity	Shallow, rocky, vernally wet soils in drainage channels over basalt bedrock.	About 120 plants, in flower. Geese grazing causing low growth and lowered reproduction. Very unusual habitat for these species.	Listed endangered	Listed endangered	Sublimity grassland is managed by The Nature Conservancy.
White-Topped Aster	Aumsville	Area of natural vegetation, surrounded by cultivated fields in Oak Savannah and Stayton silt loam	Four patches seen of about 50 shoots each; plants not vigorous	Listed threatened	Species of concern	Considerable grazing disturbance in the past suggested by abundance of introduced species.
	Salem	Gravelly soil		Listed threatened	Species of concern	Collected by Piper in 1918. Area now likely developed and plant extirpated.
Willamette Valley Daisy	Salem, various locations	Gravelly pasture(Nelson 1916); Open ground in Bush's Pasture (Thompson, 1927).		Listed endangered	Listed endangered	Herbarium Collections: Johnson, C. 1890.
	Sublimity	Red fescue grassland-moist site, soils are mix of allluvial silts and fluvial clays; Flat area with very dense fern cover; Privately owned	Approximately 20 plants seen in flower, in small fern prairie area	Listed endangered	Listed endangered	Sublimity grassland is managed by The Nature Conservancy.

Common Name	Location	Habitat Information	Population Size	ODFW Status	USFWS Status	Notes
Willamette Valley Daisy	N.W. of Sublimity	In gravel of road; Associated with grasses; County-owned	76 plants on site, 12 in vegetative state, 60 in flower and 4 in fruit; Elevation of 450-50 ft.	Listed endangered	Listed endangered	1991 BLM Sighting Report; M. Woodbridge, Observer; Collection made and housed at OSU.
Howellia	Mission Bottom, near Salem		1977 sighting; recent attempts to relocate this plant here have failed.		Listed threatened	Source: Bluhm, Wilbur. Bluhm 1977 sighting. Area is now largely developed and plant extirpated at site. Reported in 1978 USFWS Endangered Species Report, Siddall et al.
	Near Salem; Painter's Woods, bog and pond one mile north of Salem	Stagnant pond in shaded woods			Listed threatened	Herbarium Collections: Thompson Collections; housed at several herbaria in Oregon. This site is now developed and plant extirpated
Kincaid's Lupine	S.W. Salem	Roadside, dry hills	First observed in 1884, last observed in 1916	Listed threatened	Listed threatened	Peck Collections
Nelson's Sidalcea	Salem - (in approximately 11 areas)	Grasslands, Dayton silt loam soil type, clay, roadside ditch, wet meadow, managed lawn, weedy woods edge and alongside freeway; City, state and privately owned	See annual observations: ONHP 2000 Report	Listed threatened	Listed threatened	Major threats and disturbances are: spraying, mowing, ditching, recreationalists and bulldozers from housing development projects.
Tall Bugbane	Joryville Park near Battle Creek, South of Salem	Cut banks and moist forested slopes; With few hardwoods present; County-owned	32 plants; in leaf and bud; 10% immature; 90% mature; 10-100 sq. meter area	Critical	Species of concern	1994 ONHP Plant Sightings Report; Richard Brainerd, reporter.
Peacock Larkspur	Salem - Mill Creek		In flower	Listed endangered	Species of concern	Herbarium Collections
Willamette Valley Larkspur	Aumsville-Turner on Mill Creek	Crowded by weedy species and large thicket of Rosa; County owned	Approximately 20 individuals on both sides of fence; all flowering	Critical		Rosa may eventually crowd out WV Larkspur
Shaggy Horkelia	Turner			Critical	Species of concern	Nelson Collection
	Salem and six miles S.E. of Salem			Critical	Species of concern	Clemens Collection
Golden Indian Paintbrush	Salem	Wet pasture		Listed endangered	Listed threatened	Nelson Herbarium Collection
	Salem	Wet meadow, damp open ground		Listed endangered	Listed threatened	Peck Collection

Source: Oregon Natural Heritage Program (2000)

Bird Use in the Claggett Creek Watershed

Curly's Dairy Wetland is a wetland mitigation site located along Labish Ditch in northeast Keizer. It is just north of Rock Ledge Drive. A list of birds that use this emergent marsh and surrounding fallow fields has been compiled (**Table 9-17**). The list is a good example of the bird communities associated with wetlands and open grasslands/brushy fields in the four watersheds.

Table 9-17. Birds Seen in the Curly's Dairy Wetland and Adjoining Field Since July 1996

Water Birds	**Field (Grassland and Shrubland Birds)**
Great Blue Heron	House Finch
Red-winged blackbird	House Sparrow
Canada Goose	Tree Swallow
Mallard	American Goldfinch
Green-backed Heron	Barn Swallow
Pied-billed Grebe	Rufous Hummingbird
Common Merganser	Downy Woodpecker
Bank Swallow	Scrub Jay
Belted Kingfisher	Turkey Vulture
Great White Egret	Black-headed Grosbeak
Hooded Merganser	Black-capped Chickadee
Greater White-fronted Goose	Rock Dove
American Coot	Golden Eagle
Bufflehead	Brewer's Blackbird
Cinnamon Teal	Swainson's Hawk
	Ruby-crowned Kinglet
	White-throated Sparrow
	American Robin
	Northern Flicker
	Oregon Junco
	Rufous-sided Towhee
	Mourning Dove
	Killdeer
	Cooper's Hawk
	Cedar Waxwing
	Ring-necked Pheasant
	Yellow-rumped Warbler

Source: Daniels (pers. comm.)

Bird Use in the Mill Creek Watershed

Shorebird use has been observed in the Aumsville area. According to a recent study in winter of 2000, as many as 10-12,000 Dunlin, including multiply radio-marked birds, have been observed during aerial and ground surveys of the Aumsville sewage pond complex (Sanzenbacher pers. comm.; Haig pers. comm.). Large groups of Dunlin use the pond each winter starting in late February/early March. It appears that the majority of birds roost at the site during daylight hours and depart in large groups (250+ birds) at dusk, moving into flooded/wet agriculture fields. One local destination site in 2000 was a set of fields directly north of the Hunsaker Rd./Marion Rd. intersection. Large numbers of shorebirds were also observed traveling south to the Santiam River and then following the river channel downstream. The destination of radio-marked birds included fields near Stutzman Drive, south of Highway 20, and fields southeast and adjacent to the Highway 34/I-5 junction. These birds remained in the fields for the night and then frequently made a return trip to the Aumsville ponds the following morning.

It's not clear why these birds will travel such great distances every day. One interpretation may be that the shorebirds only use the Aumsville area as a roosting site (Sanzenbacher pers. comm.) Other habitat needs, such as foraging areas, must be satisfied elsewhere in the surrounding landscape. The Aumsville sewage ponds appear to be an important roost site during late winter months and a potential explanation for the extensive distances that individuals travel to/from sites is that preferred foraging areas occur in other areas (e.g., further south).

Shorebird foraging habitat is generally unvegetated, or with short vegetation areas having exposed saturated/wet soils. Wetland restoration efforts in the Willamette Valley often focus on waterfowl such as ducks and geese. The characteristics of these restored sites (deep water with tall, standing vegetation) may exclude shorebird use. Thus, restoration efforts should attempt to provide a range of habitats, including areas of open, shallow water and exposed saturated soils. Shorebirds don't swim and their legs aren't very long (Dunlin legs are 1-2 inches), so deeper water excludes many/most shorebirds. It's best if ponds at restored sites include both deep and shallow waters. The addition of roosting islands in the wetlands would also benefit shorebirds.

Data Gaps

1. Habitat conditions for the fish-bearing streams in the Salem area watersheds.
2. (Information on pools, riffles, substrate condition, riparian vegetation and large woody debris.)
3. Historical and seasonal fish distribution information specific to the Salem area watersheds. Current information is limited to periodic surveys instead of year-round sampling.

4. Fish passage barrier (i.e. dams, weirs) information outside of the Salem urban growth boundary. Specifically, lack of data for the City of Keizer, which corresponds to portions of the Claggett Creek watershed.
5. Information on species other than aquatic wildlife and plants is limited.

Summary

Both natural factors and human activities contribute to the availability and quality of aquatic and terrestrial habitats found in the Mid-Willamette basin. Competitive pressures from introduced species, and loss and degradation of available habitat have all contributed to declines in several native fish species in the four watersheds.

Habitat loss and degradation include construction of migration barriers, removal of riparian vegetation, reduction in large woody debris in stream channels, loss of side channel habitats due to channelization, alteration of low flows due to water use and alteration of high flows due to urbanization. Many of these degradations also lower stream water quality by increasing stream temperatures, sediment loads and pollution and decreasing dissolved oxygen.

Chinook salmon have been documented in Pringle, Glenn-Gibson, Claggett and Mill Creeks. Native cutthroat trout appear to be widely distributed. Though their use of Claggett Creek is less well documented, all of the Salem-Keizer area watersheds should be managed for steelhead habitat. Sculpin, crayfish and redside shiners are also found in all four watersheds. Mill Creek is considered "essential salmonid habitat" by the Division of State Lands. Pringle Creek has the same designation from its mouth upstream to its intersection with Cross Street.

In some of these waters, fish may move in and out multiple times during a season. ODFW finds that anadromous fish use lower elevation or valley floor streams as seasonal rearing habitat. Anadromous fish may move from the Willamette and into and out of streams like Mill Creek, Claggett Creek or Glenn Creek several times during the fall winter and spring depending on flow conditions (Galovich 2002). Hence, when a particular survey does not indicate the presence of a species, it does not necessarily mean the species does not use the creek during its life cycle. In light of this, the local creeks can be considered important habitat for salmonids.

Recent studies in the four watersheds indicate that fish passage problems in the Salem area include culverts, dams, inadequate fish ladders, water diversions, unfavorable water quality (e.g., thermal barriers), and other poor habitat conditions. A City of Salem fish passage survey documented 167 culverts, 60 dams/weirs and 46 bridges. Approximately 40% of the culverts and 77% of the dams/weirs were found to be barriers. Pringle Creek has many small weirs that may pose problems for fish passage. The Glenn-Gibson watershed has many impoundments in its streams that restrict fish passage. Most of Claggett Creek was not surveyed for fish passage barriers. Culverts restricting fish passage have been prioritized by Marion County Public Works and are currently being replaced or retrofitted in order to provide adequate passage.

A rough survey of fish habitat in the four watersheds was conducted in conjunction with the fish passage survey. On a scale of 1 to 10, with ten being the best habitat, fish habitat ranked from a high of six in a reach of Gibson Creek to a low of one in the upper reaches of Claggett Creek. A more thorough and intensive survey is needed to adequately assess fish habitat quality in local streams.

In addition, records indicate that sixteen plant and animal species in the Salem area are federally or state listed due to declining populations.

Further information gathered at the watershed level, including fish presence, distribution, habitat conditions, and the status of wildlife and plant species, will provide a better understanding of how to best care for the species dispersed throughout the four watersheds.

Recommendations

All Basins

1. Conduct a fish habitat survey to determine the condition of suitable spawning, rearing and holding habitat. Protect areas that have suitable habitat and develop restoration plans for areas in which the habitat is degraded.

2. Support the City of Salem's Stream Biomonitoring project that collects detailed information on stream morphology, vegetation, invertebrates and other parameters. Analyze biomonitoring data collected in all creeks and make information available to the public.

3. Conduct more comprehensive fish surveys. Collect data year around, especially during times when fish are migrating, rearing, and spawning. Identify fish species using both perennial and seasonal streams for rearing, spawning, and refuge.

4. Prioritize and set timetables for culverts and other passage barriers for replacement or retrofit within the City of Salem's urban growth boundary.

5. Prioritize and set timetables to remove check dams and weirs that are no longer in use.

6. Support regular programs that remove trash in streams that may be fish passage barriers.

7. Monitor the use of pesticides along or near streams. Support IPM and "Salmon Safe"™ procedures on public lands.

8. Gather and share information on the condition of "sensitive" species found in the watersheds, especially their location, population status and survival challenges. Provide protection for "sensitive" species using a combination of land acquisition, conservation easements, public outreach and education, and local regulation.

9. Determine sites where sewer lines and streams intersect and high bacterial levels are present.

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Appendix A: Glossary of Selected Terms

Glossary of Selected Terms

Acid Rain: Rainfall with a pH of less than 7.0. Long-term deposition of these acids is linked to adverse effects on aquatic organisms and plant life in areas with poor neutralizing (buffering) capacity.

Adfluvial: Possessing a life history trait of migrating between lakes or rivers and streams.

Alevin: The developmental life stage of young salmonids and trout that are between the egg and fry stage. The alevin has not absorbed its yolk sac and has not emerged from the spawning gravels.

Algal Bloom: Excessive growth of algae that depletes water of oxygen. Usually caused by excess nutrients in a body of water.

Ambient (Water Quality): Existing conditions of air, water, and other media at a particular time.

Anadromous: A species that spends a portion of its life cycle in fresh water, and a portion in salt water.

Appropriation Doctrine: In western states, the water rights are based on the principle of prior-appropriation, or "first in time, first in right." This means that older claims take precedence over newer ones and the first person to obtain a water right ion a stream is the last to be shut off in times of low stream flows.

Attentuation: Flood levels lowered by water storage in wetlands, lakes or reservoirs.

Bank armouring: Reinforcing the banks of a creek or lining a stream channel with impervious material such as retaining walls, riprap or gabions.

Bankfull Width: Stage or elevation at which water overflows the natural banks of streams and begins to flood the upland, also known as the 2-year event level.

Bioaccumulate: The retention and concentration of a substance by an organism. Aquatic vegetation can also bioaccumulate chemicals.

Benthic Zone: The bottom surfaces of aquatic environments.

Biochemical Oxygen Demand (BOD): The dissolved oxygen required to decompose organic matter in water. It is a measure of pollution, since heavy waste loads have a high oxygen demand.

Bioengineering: Restoration efforts primarily aimed at stabilizing waterway banks through the use of mostly natural materials such as ground covers, burlap or coconut fiber blankets, closely planted and densely rooted trees, or low-growing hardy native species; placement of tree trunks, larger rocks or small constructed flow-diverting structures at critical erosion-prone locations; velocity dissipaters or meanders in the waterway bed.

Biomagnification: The serial accumulation of a substance (e.g., a chemical) by organisms in the food chain, with higher concentrations of the substance in each succeeding level.

Canopy: A layer of foliage in a forest stand. This most often refers to the uppermost layer of foliage, but it can be used to describe lower layers in a multistoried stand. Leaves, branches and vegetation that are above ground and/or water that provide shade and cover for fish and wildlife.
Channel Morphology: Shape of the stream channel.

Channelized: The process of changing and straightening the natural path of a waterway.

Chlorinated Hydrocarbons: Halogenated hydrocarbons in which the halogen in the molecular structure is chlorine, such as pesticides.

Cobble: Substrate particles that are smaller than boulders and are generally 64-256 mm in diameter. Can be further classified as small and large cobble. Cobble is commonly used by salmon in the construction of the redd.

Conductivity: A measure of the ability of material to conduct an electrical charge. It is a broad measure of pollution. The more polluted streams are, the higher the conductivity values.

Cottid: A marine or freshwater fish of the family Cottidae, with a large flattened head and prominent spines.

Dendritic pattern: A pattern characterized by formations that look like tree branches.

Detention facilities: A structure or place that temporarily holds water to lessen flooding impacts downstream and allow enough time for sediments in the water to settle out. Can include stormwater ponds, wetlands and floodplains.

Dieldrin: An insecticide that was widely used form the 1950s to the 1970s. It was used in agriculture for soil and seed treatment and in public health to control disease vectors such as mosquitoes.

Diurnal: Recurring every day; having a daily cycle.

Diversion: The transfer of water from a stream, lake, aquifer, or other source of water by a canal, pipe, well, or other conduit to another watercourse or to the land, as in the case of an irrigation system.

Drainage basin: An area from which surface runoff is carried away by a single drainage system; also called catchment area, watershed or drainage area.
E. coli: The *Escheria coli* bacterium is an indicator of human or animal feces.

Effluent: (1) Something that flows out, especially a stream flowing out of a body of water. (2) (Water Quality) Discharged wastewater such as the treated wastes from municipal sewage plants, brine wastewater from desalting operations, and coolant waters from a nuclear power plant.

Electrofishing: A method for estimating fish populations. Fish are stunned by electrical current, netted before they recover, and released after species and length data are collected.

Emulsion: A liquid dispersed in, though not always mixed with, another liquid; suspension.

Endangered Species Act (ESA): A 1973 Act of Congress mandating that endangered and threatened species of fish, wildlife, and plants be protected and restored.

Essential salmonid habitat: The habitat necessary to prevent the depletion of native salmon species during their life history stages of spawning and rearing.

Estuarine: Area where freshwater of a river or wetland meets and mixes with saltwater of the ocean.
Estuary: A coastal body of water that is semi-enclosed, openly connected with the ocean, and mixes with freshwater drainage from land.

Evaporation: To expel moisture from.

Fecal Coliform Bacteria: Bacteria group used as an indicator of human or animal feces.

Flashy: A flow of water in streams which is intense and of short duration.

Flush Grab Sample: A sample taken either during or just after a "first-flush" storm event. Typically, it is the most polluted portion of the discharge, because it contains pollutants lying on the surface of the drainage area and accumulating over a long period of time.

Fluvial: Fish that rear in larger rivers and spawn in smaller tributaries.

Fry: A stage of development in young salmon or trout. During this stage the fish is usually less than one year old, has absorbed its yolk sac, is rearing in the stream, and is between the alevin and parr stage of development.

Groundwater: Water beneath the earth's surface that fills in and flows through spaces in rocks and soil.

Hilsenhoff Biotic Index (HBI): An index of a taxon's sensitivity to organic enrichment that typically occurs as a result of excessive nutrients.

Hydric soil: A soil that is saturated, flooded or ponded long enough during the growing season to develop anaerobic (no oxygen) conditions in the upper levels of soil.

Hydrocarbons: Compounds found in fossil fuels that contain carbon and hydrogen in various combinations. They are major pollutants and some may be carcinogenic. Fossils fuels, glues, paints, and solvents contain hydrocarbons. Most people use the terms "hydrocarbon" and "volatile organic compounds" as synonyms.

Hydrologic Cycle: The cyclical movement of water from the ocean to the atmosphere, by evaporation through rain to the earth's surface, through runoff and groundwater to streams and back to sea.

Hydrologic regime: Properties, distribution and interaction of water or liquid on the surface of land or underlying soil.

Hydrophobic Organic Compounds: Organic compounds that don't dissolve in water.

Hydrophyte: Any plant growing in water or soil that is at least periodically deficient in oxygen as a result of excess water. Hydrophyte can also mean plants typically found in wetland habitats.
Impacted stream: Stream classification for sub-watersheds with 11% to 25% impervious cover due to urbanization. It leads to permanent degradation of stream quality.

Impervious surface: Surface (such as pavement) that does not allow, or greatly decreases, the infiltration of precipitation into the ground.

Impoundment: A pond, lake, basin or other space, either natural or constructed, for storage, regulation, and control of water.

Industrial Effluent: Industrial waste material discharged into the environment, either treated or untreated.

Infiltration: The rate at which a given volume of water can move into the soil surface.

Kjeldahl Nitrogen: A measurement of the amount of free ammonia and organic nitrogen in a substance.

Macroinvertebrate: An organism that lacks a backbone and is large enough to be seen with the naked eye; an important source of food for fish.

Marine: Of or relating to the sea.

Metamorphosis: The resurgence of development in an animal larva that transforms it into a sexually mature adult.

Micro-Climate: The climate in a localized area. For example, the climate produced under a forest canopy in a riparian area in the Willamette Valley will be different than the climate in an open field in the same area, due to different types of vegetation present in each locality. The plant diversity and vegetative structure will influence temperature, moisture retention, humidity and other factors in a localized area**.**

Natal stream: Stream of birth.

National Pollutant Discharge Elimination System (NPDES): Established by Section 402 of the Clean Water Act, this federally-mandated system is used for regulating point source pollution and stormwater discharge.

Non-point Source Pollution: Pollution that does not originate from a clear or discrete source. Variable and dispersed pollution sources from agriculture, silviculture, mining, construction, waste disposal and pollution from urban-industrial areas.

Non-supporting Stream: Stream classification for sub-watersheds with more than 25% total impervious cover. These streams are not candidates for restoration.

Nutrient Load: The amount of phosphorus and nitrogen entering a stream. High nutrient loads can cause excessive algal growth, which in turn leads to lower dissolved oxygen levels.

Outfall: The mouth or outlet of a river, stream, lake, drain or sewer.

Overland flow: Water from precipitation that moves over the ground surface (i.e., surface runoff).

Oxbow: A U-shaped bend in a river that sometimes becomes an isolated lake/wetland due to changes in the main river channel.

Parr: The developmental life stage of salmon and trout between alevin and smolt, when the young are actively feeding in fresh water.

Peak discharge: The maximum flow in a stream during a flood event.

Perched water body: Layer of saturated soil separated from the main water table by an impermeable geologic barrier.

Perennial creek: Stream that flows year-round.

Persistent emergents: Plants such as cattails that last past maturity and remaining standing upright even though the plant material is dead.

Phenol: A compound derived from benzene and used in resins, disinfectants, plastics and pharmaceuticals.

Phthalates: Chemicals derived from naphthalene that are used in the synthesis of dyes, perfumes and medicines or in the manufacture of plasticizers, insecticides and resins.

Point Source: (1) A stationary or clearly identifiable source of a large individual water or air pollution emission, generally of an industrial nature. (2) Any discernible, confined, or discrete conveyance from which pollutants are or may be discharged, including (but not limited to) pipes, ditches, channels, tunnels, conduits, wells, containers, rolling stock, concentrated animal feeding operations, or vessels. Point source is also legally and more precisely defined in federal regulations. Contrast with Non-point Source (NPS) Pollution.

Point Source Pollution: Pollutants discharged from any identifiable point, including pipes, ditches, channels, sewers, tunnels, and containers of various types. See Non-point Source (NPS) Pollution.

Point of diversion (POD): A location, surface or ground, where water is diverted (i.e., pump station, well, reservoir) for use by the water right-holder under the terms of his water right.

Place of Use (POU): Areas, usually fields, where water is applied under the terms of the water right. Therefore, they are represented by polygons on the map. The polygons can overlap one another, as in the case of one water right being supplemental to another water right for the same area of land.

Precipitation: Water from the atmosphere that reaches plants, the ground or water bodies.

Predation: Hunting and killing another animal for food.

Redd: A nest of fish eggs covered with gravel.

Resident fish: Non-migratory fish that remain in the same stream network their entire lives.

Riffle: Shallow section of stream or river with rapid current and a surface broken by gravel, rubble, or boulders.

Riparian (Riparian cover/vegetation): Land immediately adjacent to water, usually streams or rivers, which is subject to occasional flooding. Also, plants that grow in the wetland area, such as a river, stream, reservoir, pond, spring, marsh, bog or meadow.

Riprap: Stones or other energy-absorbing material used to stabilize a road bank, stream bank, or stream channel.

Permeability: The amount of water that can be absorbed by the soil over time.

Precipitation: Water from the atmosphere that reaches plants, the ground, or water bodies. Depending on local weather conditions, precipitation may be deposited in many forms, including rain, snow, sleet, hail, and condensation (e.g., dew or frost).

Rock Weir: An enclosure made of rocks and set in a stream to capture fish.

Salmonid: Fish of the family Salmonidae, including salmon, trout, char, whitefish, ciscoes and grayling. Generally, the term refers mostly to salmon, trout, char and steelhead.

Sculpin: A marine or freshwater fish of the family Cottidae, with a large flattened head and prominent spines.

Sedge: A grass-like herb with inconspicuous flowers and three-sided, solid stems.

Seining: A fish survey technique using large nets to catch fish, which are measured, identified and released.

Sensitive stream: Stream classification for sub-watershed with less than 10% impervious cover, and which is still capable of supporting stable channels and good biodiversity.

Sensitive Taxa: The number of taxa identified that are known to be very sensitive to stream disturbance.

Sheet Flow: The flow of rainwater over the land surface toward stream channels.

Smolt: The salmonid or trout developmental life stage between parr and adult, when the juvenile is at least one year old and has adapted to the marine environment.

Stream reach: A section of stream possessing similar physical features such as gradient, flow and confinement.

Stormwater Outfall: The mouth of a sewer, drain or conduit where effluent is discharged into receiving waters.

Substrate: The composition of a streambed, including mineral or organic materials.

Surface Water: The water of ponds, lakes, rivers and streams.

Suspended Sediment: Particles floating in a fluid by the upward motion of turbulent currents, moving ice, or wind. Most suspended sediments come from accelerated erosion of agricultural land, logging operations (especially where clear-cutting is practiced), surface mines and construction sites.

Swale: A low tract of marsh-like land.

Taxa: Plural of taxon. A group classified together in a scientific naming system.

Taxa Richness: The total number of invertebrate taxa identified from a sample.

Taxonomy: The branch of biology concerned with naming and classifying the life forms based on their natural relationships

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Terrestrial: Of or relating to the earth or its inhabitants. Typically refers to habitat that is not aquatic.

Thalweg: (1) The lowest part of a valley or stream channel. (2) A subsurface, groundwater stream percolating beneath and in the general direction of a surface stream or valley. (3) The middle, chief, or deepest part of a navigable channel or waterway.

Time-Based Composite Sample: Multiple samples collected at different times and combined to achieve one large "composite" sample. This is done to get a representative sample of water over a period of time, to account for changes in its constituents.

Total Maximum Daily Loads (TMDLs): The maximum amount of point and non-point source pollution a stream can take in during a single day and still support its designated uses. Designated uses include things such as fish habitat, recreation and drinking water.

Total Suspended Solids (TSS): A measure of how much sediment a stream is carrying in the water. Suspended solids consist of inorganic (silts and clays) and organic (algae, zooplankton, bacteria and detritus) matter carried along by water as it runs off the land. There is usually a higher concentration of inorganic matter. Both contribute to turbidity, or cloudiness, of the water.

Turbidity: Turbid waters contain suspended matter that interferes with the passage of light so that visual depth is restricted.

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Understory: The plant community that grows under the canopy of trees in a forest.

Vertical Complexity: The different layers of vegetation in a forest that results from the diversity of plant species and age classes.

Volatile Solids (TVS): Those solids that vaporize at a temperature of 550 degrees Celsius. Volatile solids are usually considered to be organic. Their presence can be used to estimate the organic/inorganic ratio of the solids.

Water column: The upper limit of the soil or underlying rock material that is wholly saturated with water.

Water Pollution Control Facilities (WPCF): State requirement for the discharge of wastewater to the ground only. Permits are issued for land irrigation of wastewater, wastewater lagoons, on-site disposal systems, and underground injection control systems (e.g., dry wells and sumps). The primary purpose of the WPCF permit is to prevent discharges to surface waters and to protect groundwater from contamination.

Weir (dam): A dam in a river raise the water level for diversions such as a mill race, forming a fishpond, or the like.

Wetland: those areas inundated or saturated by surface or ground water at a frequency and duration sufficient to support vegetation typically adapted for life in saturated soil conditions.

Zooplankton: Small aquatic animals suspended or suspended or swimming in water.

Appendix B: Maps

Open "Maps" folder to view map files.

List of Maps

MAPS

List of Maps

6 – Riparian and Wetland Habitat

List of Maps

7 – Sediment Sources

List of Maps

List of Maps

9 – Fish and Wildlife

List of Maps